



EUROPEAN COMMISSION
Directorate-General for Research and Innovation
Energy
Fission Energy



GRANT AGREEMENT

NUMBER 847593 — EURAD

This **Agreement** ('the Agreement') is **between** the following parties:

on the one part,

the **European Union** ('the EU'), represented by the European Commission ('the Commission'),

represented for the purposes of signature of this Agreement by the Acting Director, Directorate-General for Research and Innovation, Patrick CHILD,

and

on the other part,

1. 'the coordinator':

AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS (ANDRA), established in 1-7 rue Jean Monnet - Parc de la Croix Blanche, CHATENAY MALABRY 92298, France, VAT number: FR12390199669, represented for the purposes of signing the Agreement by CEO, Pierre-Marie ABADIE

and the following other beneficiaries, if they sign their 'Accession Form' (see Annex 3 and Article 56):

2. **ARAO-AGENCIJA ZA RADIOAKTIVNE ODPADKE LJUBLJANA ZAVOD (ARAO)**, established in CELOVSKA C. 182, LJUBLJANA 1000, Slovenia, VAT number: SI32495854,

3. **BEL V (BEL V)**, established in RUE WALCOURT 148, BRUXELLES 1070, Belgium, VAT number: BE0892419202,

4. **BUNDES-GESELLSCHAFT FUR ENDLAGERUNGMBH (BGE) (BGE)**, established in ESCHENSTRASSE 55, PEINE 31224, Germany, VAT number: DE308282389,

5. **COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES (CEA)**, established in RUE LEBLANC 25, PARIS 15 75015, France, VAT number: FR43775685019,

6. **CENTRO DE INVESTIGACIONES ENERGETICAS, MEDIOAMBIENTALES Y TECNOLOGICAS-CIEMAT (CIEMAT)**, established in Avenida Complutense 40, MADRID 28040, Spain, VAT number: ESQ2820002J,

7. **PUBLIC UNION CHORNOBYL RESEARCH AND DEVELOPMENT INSTITUTE (ChRDI)**, established in PECHERSKIY DISTRICT, STARONAVODNITSKA ST. 6B OFFICE 272, KYIV 01015, Ukraine, VAT number: UA403675526559,

8. **CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS (CNRS)**, established in RUE MICHEL ANGE 3, PARIS 75794, France, VAT number: FR40180089013,
9. **CENTRALE ORGANISATIE VOOR RADIOACTIEF AFVAL NV (COVRA)**, established in SPANJEWEG 1 HAVEN 8601, NIEUWDORP ZLD 4455 TW, Netherlands, VAT number: NL008836309B01,
10. **VALSTYBINIS MOKSLINIŲ TYRIMŲ INSTITUTAS FIZINIŲ IR TECHNOLOGIJOS MOKSLŲ CENTRAS (FTMC)**, established in Savanorių 231, VILNIUS 02300, Lithuania, VAT number: LT100005300110,
11. **CENTRUM VÝZKUMU REZ S.R.O. (CV REZ)**, established in HUSINEC-REZ 130, HUSINEC-REZ 250 68, Czech Republic, VAT number: CZ26722445,
12. **DANSK DEKOMMISSIONERING (Dekom)**, established in FREDERIKSBORGVEJ 399, Roskilde 4000, Denmark, VAT number: DK26144744,
13. **ELLINIKI EPITROPI ATOMIKIS ENERGEIAS (EEAE)**, established in NEAPOLEOS 4 PATRIARCHOU GRIGORIOU, AGHIA PARASKEVI 15310, Greece, VAT number: EL090085792,
14. **EMPRESA NACIONAL DE RESIDUOS RADIOACTIVOS S.A. (ENRESA)**, established in Calle Emilio Vargas 7, MADRID 28043, Spain,
15. **FORSCHUNGSZENTRUM JULICH GMBH (JUELICH)**, established in WILHELM JOHNNEN STRASSE, JULICH 52428, Germany, VAT number: DE122624631,
16. **GESELLSCHAFT FÜR ANLAGEN UND REAKTORSICHERHEIT (GRS) gGmbH (GRS)**, established in SCHWERTNERGASSE 1, KÖLN 50667, Germany, VAT number: DE122792708,
17. **VALSTYBES IMONĖ IGNALINOS ATOMINĖ ELEKTRINĖ (IAE)**, established in ELEKTRINĖS G. 4, K47, DRUKSINIŲ, VISAGINAS 31152, Lithuania, VAT number: LT554500811,
18. **INSTYTUT CHEMII I TECHNIKI JADROWEJ (INCT)**, established in ul. Dorodna 16, WARSZAWA 03-195, Poland, VAT number: PL5250008330,
19. **INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLEAIRE (IRSN)**, established in AV DE LA DIVISION LECLERC 31, FONTENAY AUX ROSES 92260, France, VAT number: FR68440546018,
20. **INSTITUTO SUPERIOR TECNICO (IST)**, established in AVENIDA ROVISCO PAIS 1, LISBOA 1049-001, Portugal, VAT number: PT501507930,
21. **ASSOCIACAO DO INSTITUTO SUPERIOR TECNICO PARA A INVESTIGACAO E DESENVOLVIMENTO (IST ID)**, established in AVENIDA ROVISCO PAIS 1, LISBOA 1049 001, Portugal, VAT number: PT509830072,
22. **INSTITUT JOZEF STEFAN (JSI)**, established in Jamova 39, LJUBLJANA 1000, Slovenia, VAT number: SI55560822,

24. **KARLSRUHER INSTITUT FÜR TECHNOLOGIE (KIT)**, established in KAISERSTRASSE 12, KARLSRUHE 76131, Germany, VAT number: DE266749428,
25. **LIETUVOS ENERGETIKOS INSTITUTAS (LEI)**, established in Breslaujos g. 3, KAUNAS LT-44403, Lithuania, VAT number: LT119552113,
26. **MAGYAR TUDOMÁNYOS AKADEMIA ENERGIATUDOMÁNYI KUTATÓKÖZPONT (MTA EK)**, established in KONKOLY THEGE MIKLÓS UT 29-33, Budapest 1121, Hungary, VAT number: HU 15327040,
27. **NATIONALE GENOSSENSCHAFT FÜR DIE LAGERUNG RADIOAKTIVER ABFÄLLE (NAGRA)**, established in Hardstrasse 73, WETTINGEN 5430, Switzerland, VAT number: CH270953,
28. **NATIONAL CENTER FOR SCIENTIFIC RESEARCH "DEMOKRITOS" (NCSR)**, established in END OF PATRIARCHOU GRIGORIOU E AND 27 NEAPOLEOS STREET, AGIA PARASKEVI 15341, Greece, VAT number: EL090085651,
29. **NUCLEAR ENGINEERING SEIBERSDORF GMBH (NES)**, established in FORSCHUNGSZENTRUM, SEIBERSDORF 2444, Austria, VAT number: ATU57207427,
30. **NARODNÝ JADROVÝ FOND (NJF)**, established in MIEROVA 19, BRATISLAVA 821 05, Slovakia, VAT number: SK2022216988,
31. **NUCLEAR RESEARCH AND CONSULTANCY GROUP (NRG)**, established in WESTERDUINWEG 3, PETTEN 1755 LE, Netherlands, VAT number: NL807320316B01,
32. **NATIONALE INSTELLING VOOR RADIOACTIEF AFVAL EN VERRIJKTE SPLIJSTOFFEN (ONDRAF/NIRAS)**, established in KUNSTLAAN 14, SAINT-JOSSE-TEN-NOODE 1210, Belgium, VAT number: BE0222116241,
33. **POSIVA OY (POSIVA)**, established in OLKILUOTO, EURAJOKI 27160, Finland, VAT number: FI10292588,
34. **PAUL SCHERRER INSTITUT (PSI)**, established in FORSCHUNGSTRASSE 111, VILLIGEN PSI 5232, Switzerland, VAT number: CHE116133392MWST,
35. **RADIOAKTIV HULLÁDEKOKAT KEZELO KOZHASZNU NONPROFIT KORLATOLT FELELOSÉGU TARSASAG (PURAM)**, established in PUSKAS TIVADAR UTCA 11, BUDAPEST 2040, Hungary, VAT number: HU18680188,
36. **REGIA AUTONOMA TEHNOLOGII PENTRU ENERGIA NUCLEARĂ - RATEN (RATEN)**, established in STRADA CAMPULUI 1, MIOVENI 115400, Romania, VAT number: RO32306920,
37. **RADIOACTIVE WASTE MANAGEMENT LIMITED (RWM)**, established in HERDUS HOUSE INGWELL DRIVE WESTLAKES SCIENCE AND TECHNOLOGY PARK MOOR ROW, CUMBRIA CA24 3HU, United Kingdom, VAT number: GB902183358,
38. **STUDIECENTRUM VOOR KERNENERGIE / CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE (SCK•CEN)**, established in AVENUE HERRMANN DEBROUX 40, BRUXELLES 1160, Belgium, VAT number: BE0406568867,

39. **SVENSK KARNBRANSLEHANTERING AKTIEBOLAG (SKB)**, established in BOX 3091, SOLNA 169 03, Sweden, VAT number: SE556175201401,

40. **STATE ENTERPRISE STATE SCIENTIFIC AND TECHNICAL CENTER FOR NUCLEAR AND RADIATION SAFETY (SSTC NRS)**, established in VASYLYA STUSA STREET 35 - 37, KYIV 03142, Ukraine, VAT number: UA142823326578,

41. **SLOVENSKA TECHNICKA UNIVERZITA V BRATISLAVE (STUBA)**, established in VAZOVOVA 5, BRATISLAVA 81243, Slovakia, VAT number: SK2020845255,

42. **Radioactive Waste Repository Authority (SÚRAO)**, established in Dlazdena 6, Praha 110000, Czech Republic, VAT number: CZ-66000769,

43. **STATNI USTAV RADIACNI OCHRANY v.v.i. (SURO)**, established in BARTOSKOVA 28, Praha 14000, Czech Republic,

44. **NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO (TNO)**, established in ANNA VAN BUERENPLEIN 1, DEN HAAG 2595 DA, Netherlands, VAT number: NL002875718B01,

45. **TS ENERCON MERNOKIRODA KFT (TS Enercon)**, established in CSALOGANY UTCA 23-33, BUDAPEST 1027, Hungary, VAT number: HU12165986,

46. **TECHNICAL UNIVERSITY OF SOFIA (TUS)**, established in Kliment Ohridsky Bd 8, SOFIA 1000, Bulgaria, VAT number: BG831917834,

47. **UNIVERSITY OF CYPRUS (UCyprus)**, established in KALLIPOLEOS STREET 75, NICOSIA 1678, Cyprus, VAT number: CY90001673W,

48. **HELSINGIN YLIOPISTO (UHelsinki)**, established in FABIANINKATU 33, HELSINGIN YLIOPISTO 00014, Finland, VAT number: FI03134717,

49. **UNITED KINGDOM RESEARCH AND INNOVATION (UKRI)**, established in POLARIS HOUSE NORTH STAR AVENUE, SWINDON SN2 1FL, United Kingdom, VAT number: GB287461957,

50. **Teknologian tutkimuskeskus VTT Oy (VTT)**, established in VUORIMIEHENTIE 3, Espoo 02150, Finland, VAT number: FI26473754,

51. **VUJE AS (VUJE)**, established in Okružna 5, TRNAVA 91864, Slovakia, VAT number: SK2020392539,

and 23. the **Joint Research Centre (JRC)** established in Rue de la Loi 200, BRUSSELS 1049, Belgium, if it signs the ‘Administrative Arrangement’ (see Annex 3b).

Unless otherwise specified, references to ‘beneficiary’ or ‘beneficiaries’ include the coordinator and the Joint Research Centre (JRC).

The parties referred to above have agreed to enter into the Agreement under the terms and conditions below.

By signing the Agreement or the Accession Form or the Administrative Arrangement, the beneficiaries

accept the grant and agree to implement it under their own responsibility and in accordance with the Agreement, with all the obligations and conditions it sets out.

The Agreement is composed of:

Terms and Conditions

Annex 1	Description of the action
Annex 2	Estimated budget for the action
	2a Additional information on the estimated budget
Annex 3	Accession Forms
	3b Administrative Arrangement
Annex 4	Model for the financial statements
Annex 5	Model for the certificate on the financial statements
Annex 6	Model for the certificate on the methodology
Annex 7	Annual work plan for the next year
Annex 8	Model for the statement on the use of the previous pre-financing payment

TERMS AND CONDITIONS

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CHAPTER 1 GENERAL

ARTICLE 1 — SUBJECT OF THE AGREEMENT

This Agreement sets out the rights and obligations and the terms and conditions applicable to the grant awarded to the beneficiaries for implementing the action set out in Chapter 2.

CHAPTER 2 ACTION

ARTICLE 2 — ACTION TO BE IMPLEMENTED

The grant is awarded for the action entitled ‘**European Joint Programme on Radioactive Waste Management**’ — ‘**EURAD**’ (**‘action’**), as described in Annex 1.

ARTICLE 3 — DURATION AND STARTING DATE OF THE ACTION

The duration of the action will be **60 months** as of the first day of the month following the date the Agreement enters into force (see Article 58) (**‘starting date of the action’**).

ARTICLE 4 — ESTIMATED BUDGET AND BUDGET TRANSFERS

4.1 Estimated budget

The ‘**estimated budget**’ for the action is set out in Annex 2.

It contains the estimated eligible costs and the forms of costs, broken down by beneficiary (and linked third party) and budget category (see Articles 5, 6, and 14).

4.2 Budget transfers

The estimated budget breakdown indicated in Annex 2 may be adjusted — without an amendment (see Article 55) — by transfers of amounts between beneficiaries, budget categories and/or forms of costs set out in Annex 2, if the action is implemented as described in Annex 1.

However, the beneficiaries may not add costs relating to subcontracts not provided for in Annex 1, unless such additional subcontracts are approved by an amendment or in accordance with Article 13.

CHAPTER 3 GRANT

ARTICLE 5 — GRANT AMOUNT, FORM OF GRANT, REIMBURSEMENT RATES AND FORMS OF COSTS

5.1 Maximum grant amount

The ‘**maximum grant amount**’ is **EUR 32 500 000.00** (thirty two million five hundred thousand EURO).

5.2 Form of grant, reimbursement rates and forms of costs

The grant reimburses **55% of the action's eligible costs** (see Article 6) (**'reimbursement of eligible costs grant'**) (see Annex 2).

The estimated eligible costs of the action are EUR **59 922 246.61** (fifty nine million nine hundred and twenty two thousand two hundred and forty six EURO and sixty one eurocents).

Eligible costs (see Article 6) must be declared under the following forms (**'forms of costs'**):

(a) for **direct personnel costs**:

- as actually incurred costs (**'actual costs'**) or
- on the basis of an amount per unit calculated by the beneficiary in accordance with its usual cost accounting practices (**'unit costs'**).

Personnel **costs for SME owners or beneficiaries that are natural persons** not receiving a salary (see Article 6.2, Points A.4 and A.5) must be declared on the basis of the amount per unit set out in Annex 2a (**unit costs**);

(b) for **direct costs for subcontracting**: as actually incurred costs (**actual costs**);

(c) for **direct costs of providing financial support to third parties**: not applicable;

(d) for **other direct costs**:

- for costs of internally invoiced goods and services: on the basis of an amount per unit calculated by the beneficiary in accordance with its usual cost accounting practices (**'unit costs'**);
- for all other costs: as actually incurred costs (**actual costs**);

(e) for **indirect costs**: on the basis of a flat-rate applied as set out in Article 6.2, Point E (**'flat-rate costs'**);

(f) **specific cost category(ies)**: not applicable.

5.3 Final grant amount — Calculation

The **'final grant amount'** depends on the actual extent to which the action is implemented in accordance with the Agreement's terms and conditions.

This amount is calculated by the Commission — when the payment of the balance is made (see Article 21.4) — in the following steps:

Step 1 — Application of the reimbursement rates to the eligible costs

Step 2 — Limit to the maximum grant amount

Step 3 — Reduction due to the no-profit rule

Step 4 — Reduction due to substantial errors, irregularities or fraud or serious breach of obligations

5.3.1 Step 1 — Application of the reimbursement rates to the eligible costs

The reimbursement rate(s) (see Article 5.2) are applied to the eligible costs (actual costs, unit costs and flat-rate costs; see Article 6) declared by the beneficiaries and linked third parties (see Article 20) and approved by the Commission (see Article 21).

5.3.2 Step 2 — Limit to the maximum grant amount

If the amount obtained following Step 1 is higher than the maximum grant amount set out in Article 5.1, it will be limited to the latter.

5.3.3 Step 3 — Reduction due to the no-profit rule

The grant must not produce a profit.

‘**Profit**’ means the surplus of the amount obtained following Steps 1 and 2 plus the action’s total receipts, over the action’s total eligible costs.

The ‘**action’s total eligible costs**’ are the consolidated total eligible costs approved by the Commission.

The ‘**action’s total receipts**’ are the consolidated total receipts generated during its duration (see Article 3).

The following are considered **receipts**:

- (a) income generated by the action; if the income is generated from selling equipment or other assets purchased under the Agreement, the receipt is up to the amount declared as eligible under the Agreement;
- (b) financial contributions given by third parties to the beneficiary or to a linked third party specifically to be used for the action, and
- (c) in-kind contributions provided by third parties free of charge and specifically to be used for the action, if they have been declared as eligible costs.

The following are however not considered receipts:

- (a) income generated by exploiting the action’s results (see Article 28);
- (b) financial contributions by third parties, if they may be used to cover costs other than the eligible costs (see Article 6);
- (c) financial contributions by third parties with no obligation to repay any amount unused at the end of the period set out in Article 3.

If there is a profit, it will be deducted from the amount obtained following Steps 1 and 2.

5.3.4 Step 4 — Reduction due to substantial errors, irregularities or fraud or serious breach of obligations — Reduced grant amount — Calculation

If the grant is reduced (see Article 43), the Commission will calculate the reduced grant amount by deducting the amount of the reduction (calculated in proportion to the seriousness of the errors,

irregularities or fraud or breach of obligations, in accordance with Article 43.2) from the maximum grant amount set out in Article 5.1.

The final grant amount will be the lower of the following two:

- the amount obtained following Steps 1 to 3 or
- the reduced grant amount following Step 4.

5.4 Revised final grant amount — Calculation

If — after the payment of the balance (in particular, after checks, reviews, audits or investigations; see Article 22) — the Commission rejects costs (see Article 42) or reduces the grant (see Article 43), it will calculate the ‘**revised final grant amount**’ for the beneficiary concerned by the findings.

This amount is calculated by the Commission on the basis of the findings, as follows:

- in case of **rejection of costs**: by applying the reimbursement rate to the revised eligible costs approved by the Commission for the beneficiary concerned;
- in case of **reduction of the grant**: by calculating the concerned beneficiary’s share in the grant amount reduced in proportion to the seriousness of the errors, irregularities or fraud or breach of obligations (see Article 43.2).

In case of **rejection of costs and reduction of the grant**, the revised final grant amount for the beneficiary concerned will be the lower of the two amounts above.

ARTICLE 6 — ELIGIBLE AND INELIGIBLE COSTS

6.1 General conditions for costs to be eligible

‘**Eligible costs**’ are costs that meet the following criteria:

(a) for **actual costs**:

- (i) they must be actually incurred by the beneficiary;
- (ii) they must be incurred in the period set out in Article 3, with the exception of costs relating to the submission of the periodic report for the last reporting period and the final report (see Article 20);
- (iii) they must be indicated in the estimated budget set out in Annex 2;
- (iv) they must be incurred in connection with the action as described in Annex 1 and necessary for its implementation;
- (v) they must be identifiable and verifiable, in particular recorded in the beneficiary’s accounts in accordance with the accounting standards applicable in the country where the beneficiary is established and with the beneficiary’s usual cost accounting practices;
- (vi) they must comply with the applicable national law on taxes, labour and social security, and

- (vii) they must be reasonable, justified and must comply with the principle of sound financial management, in particular regarding economy and efficiency;

(b) for **unit costs**:

- (i) they must be calculated as follows:

{amounts per unit set out in Annex 2a or calculated by the beneficiary in accordance with its usual cost accounting practices (see Article 6.2, Point A and Article 6.2.D.5)}

multiplied by

the number of actual units};

- (ii) the number of actual units must comply with the following conditions:

- the units must be actually used or produced in the period set out in Article 3;
- the units must be necessary for implementing the action or produced by it, and
- the number of units must be identifiable and verifiable, in particular supported by records and documentation (see Article 18);

(c) for **flat-rate costs**:

- (i) they must be calculated by applying the flat-rate set out in Annex 2, and

- (ii) the costs (actual costs or unit costs) to which the flat-rate is applied must comply with the conditions for eligibility set out in this Article.

6.2 Specific conditions for costs to be eligible

Costs are eligible if they comply with the general conditions (see above) and the specific conditions set out below for each of the following budget categories:

- A. direct personnel costs;
- B. direct costs of subcontracting;
- C. not applicable;
- D. other direct costs;
- E. indirect costs;
- F. not applicable.

‘Direct costs’ are costs that are directly linked to the action implementation and can therefore be attributed to it directly. They must not include any indirect costs (see Point E below).

‘Indirect costs’ are costs that are not directly linked to the action implementation and therefore cannot be attributed directly to it.

A. Direct personnel costs

Types of eligible personnel costs

A.1 Personnel costs are eligible, if they are related to personnel working for the beneficiary under an employment contract (or equivalent appointing act) and assigned to the action (**‘costs for employees (or equivalent)’**). They must be limited to salaries (including during parental leave), social security contributions, taxes and other costs included in the **remuneration**, if they arise from national law or the employment contract (or equivalent appointing act).

Beneficiaries that are non-profit legal entities¹ may also declare as personnel costs **additional remuneration** for personnel assigned to the action (including payments on the basis of supplementary contracts regardless of their nature), if:

- (a) it is part of the beneficiary’s usual remuneration practices and is paid in a consistent manner whenever the same kind of work or expertise is required;
- (b) the criteria used to calculate the supplementary payments are objective and generally applied by the beneficiary, regardless of the source of funding used.

‘Additional remuneration’ means any part of the remuneration which exceeds what the person would be paid for time worked in projects funded by national schemes.

Additional remuneration for personnel assigned to the action is eligible up to the following amount:

- (a) if the person works full time and exclusively on the action during the full year: up to EUR 8 000;
- (b) if the person works exclusively on the action but not full-time or not for the full year: up to the corresponding pro-rata amount of EUR 8 000, or
- (c) if the person does not work exclusively on the action: up to a pro-rata amount calculated as follows:

$$\left\{ \begin{array}{l} \text{EUR 8 000} \\ \text{divided by} \\ \text{the number of annual productive hours (see below)}, \\ \text{multiplied by} \\ \text{the number of hours that the person has worked on the action during the year} \end{array} \right\}.$$

A.2 The **costs for natural persons working under a direct contract** with the beneficiary other than an employment contract are eligible personnel costs, if:

- (a) the person works under conditions similar to those of an employee (in particular regarding the way the work is organised, the tasks that are performed and the premises where they are performed);
- (b) the result of the work carried out belongs to the beneficiary (unless exceptionally agreed otherwise), and

¹ For the definition, see Article 2.1(14) of Regulation (EU) No 1290/2013 of the European Parliament and of the Council of 11 December 2013 laying down the rules for the participation and dissemination in “Horizon 2020 – the Framework Programme for Research and Innovation (2014-2020)” (**‘Rules for Participation Regulation No 1290/2013’**) (OJ L 347, 20.12.2013 p.81): **‘non-profit legal entity’** means a legal entity which by its legal form is non-profit-making or which has a legal or statutory obligation not to distribute profits to its shareholders or individual members.

- (c) the costs are not significantly different from those for personnel performing similar tasks under an employment contract with the beneficiary.

A.3 The **costs of personnel seconded by a third party against payment** are eligible personnel costs, if the conditions in Article 11.1 are met.

A.4 **Costs of owners** of beneficiaries that are small and medium-sized enterprises ('**SME owners**') who are working on the action and who do not receive a salary are eligible personnel costs, if they correspond to the amount per unit set out in Annex 2a multiplied by the number of actual hours worked on the action.

A.5 **Costs of 'beneficiaries that are natural persons'** not receiving a salary are eligible personnel costs, if they correspond to the amount per unit set out in Annex 2a multiplied by the number of actual hours worked on the action.

Calculation

Personnel costs must be calculated by the beneficiaries as follows:

{ {hourly rate
multiplied by
the number of actual hours worked on the action},
plus
for non-profit legal entities: additional remuneration to personnel assigned to the action under the
conditions set out above (Point A.1)}.

The number of actual hours declared for a person must be identifiable and verifiable (see Article 18).

The total number of hours declared in EU or Euratom grants, for a person for a year, cannot be higher than the annual productive hours used for the calculations of the hourly rate. Therefore, the maximum number of hours that can be declared for the grant are:

{the number of annual productive hours for the year (see below)
minus
total number of hours declared by the beneficiary, for that person for that year, for other EU or Euratom
grants}

The '**hourly rate**' is one of the following:

- (a) for personnel costs declared as **actual costs** (i.e. budget categories A.1, A.2 and A.3): the hourly rate is calculated *per full financial year*, as follows:

{actual annual personnel costs (excluding additional remuneration) for the person
divided by
number of annual productive hours}.

using the personnel costs and the number of productive hours for each full financial year covered by the reporting period concerned. If a financial year is not closed at the end of the

reporting period, the beneficiaries must use the hourly rate of the last closed financial year available.

For the ‘number of annual productive hours’, the beneficiaries may choose one of the following:

- (i) ‘fixed number of hours’: 1 720 hours for persons working full time (or corresponding pro-rata for persons not working full time);
- (ii) ‘individual annual productive hours’: the total number of hours worked by the person in the year for the beneficiary, calculated as follows:

{annual workable hours of the person (according to the employment contract, applicable collective labour agreement or national law)

plus

overtime worked

minus

absences (such as sick leave and special leave)}.

‘Annual workable hours’ means the period during which the personnel must be working, at the employer’s disposal and carrying out his/her activity or duties under the employment contract, applicable collective labour agreement or national working time legislation.

If the contract (or applicable collective labour agreement or national working time legislation) does not allow to determine the annual workable hours, this option cannot be used;

- (iii) ‘standard annual productive hours’: the ‘standard number of annual hours’ generally applied by the beneficiary for its personnel in accordance with its usual cost accounting practices. This number must be at least 90% of the ‘standard annual workable hours’.

If there is no applicable reference for the standard annual workable hours, this option cannot be used.

For all options, the actual time spent on **parental leave** by a person assigned to the action may be deducted from the number of annual productive hours.

As an alternative, beneficiaries may calculate the hourly rate *per month*, as follows:

{actual monthly personnel cost (excluding additional remuneration) for the person

divided by

{number of annual productive hours / 12}}}

using the personnel costs for each month and (one twelfth of) the annual productive hours calculated according to either option (i) or (iii) above, i.e.:

- fixed number of hours or
- standard annual productive hours.

Time spent on parental leave may not be deducted when calculating the hourly rate per month. However, beneficiaries may declare personnel costs incurred in periods of parental leave in proportion to the time the person worked on the action in that financial year.

If parts of a basic remuneration are generated over a period longer than a month, the beneficiaries may include only the share which is generated in the month (irrespective of the amount actually paid for that month).

Each beneficiary must use only one option (per full financial year or per month) during each full financial year;

(b) for personnel costs declared on the basis of **unit costs** (i.e. budget categories A.1, A.2, A.4 and A.5): the hourly rate is one of the following:

- (i) for SME owners or beneficiaries that are natural persons: the hourly rate set out in Annex 2a (see Points A.4 and A.5 above), or
- (ii) for personnel costs declared on the basis of the beneficiary's usual cost accounting practices: the hourly rate calculated by the beneficiary in accordance with its usual cost accounting practices, if:
 - the cost accounting practices used are applied in a consistent manner, based on objective criteria, regardless of the source of funding;
 - the hourly rate is calculated using the actual personnel costs recorded in the beneficiary's accounts, excluding any ineligible cost or costs included in other budget categories.

The actual personnel costs may be adjusted by the beneficiary on the basis of budgeted or estimated elements. Those elements must be relevant for calculating the personnel costs, reasonable and correspond to objective and verifiable information;

and

- the hourly rate is calculated using the number of annual productive hours (see above).

B. Direct costs of subcontracting (including related duties, taxes and charges such as non-deductible value added tax (VAT) paid by the beneficiary) are eligible if the conditions in Article 13.1.1 are met.

C. Direct costs of providing financial support to third parties

Not applicable

D. Other direct costs

D.1 Travel costs and related subsistence allowances (including related duties, taxes and charges such as non-deductible value added tax (VAT) paid by the beneficiary) are eligible if they are in line with the beneficiary's usual practices on travel.

D.2 The depreciation costs of equipment, infrastructure or other assets (new or second-hand) as recorded in the beneficiary's accounts are eligible, if they were purchased in accordance with

Article 10.1.1 and written off in accordance with international accounting standards and the beneficiary's usual accounting practices.

The **costs of renting or leasing** equipment, infrastructure or other assets (including related duties, taxes and charges such as non-deductible value added tax (VAT) paid by the beneficiary) are also eligible, if they do not exceed the depreciation costs of similar equipment, infrastructure or assets and do not include any financing fees.

The costs of equipment, infrastructure or other assets **contributed in-kind against payment** are eligible, if they do not exceed the depreciation costs of similar equipment, infrastructure or assets, do not include any financing fees and if the conditions in Article 11.1 are met.

The only portion of the costs that will be taken into account is that which corresponds to the duration of the action and rate of actual use for the purposes of the action.

D.3 Costs of other goods and services (including related duties, taxes and charges such as non-deductible value added tax (VAT) paid by the beneficiary) are eligible, if they are:

- (a) purchased specifically for the action and in accordance with Article 10.1.1 or
- (b) contributed in kind against payment and in accordance with Article 11.1.

Such goods and services include, for instance, consumables and supplies, dissemination (including open access), protection of results, certificates on the financial statements (if they are required by the Agreement), certificates on the methodology, translations and publications.

D.4 Capitalised and operating costs of 'large research infrastructure'² directly used for the action are eligible, if:

- (a) the value of the large research infrastructure represents at least 75% of the total fixed assets (at historical value in its last closed balance sheet before the date of the signature of the Agreement or as determined on the basis of the rental and leasing costs of the research infrastructure³);
- (b) the beneficiary's methodology for declaring the costs for large research infrastructure has been positively assessed by the Commission ('**ex-ante assessment**');
- (c) the beneficiary declares as direct eligible costs only the portion which corresponds to the duration of the action and the rate of actual use for the purposes of the action, and
- (d) they comply with the conditions as further detailed in the annotations to the H2020 grant agreements.

² '**Large research infrastructure**' means research infrastructure of a total value of at least EUR 20 million, for a beneficiary, calculated as the sum of historical asset values of each individual research infrastructure of that beneficiary, as they appear in its last closed balance sheet before the date of the signature of the Agreement or as determined on the basis of the rental and leasing costs of the research infrastructure.

³ For the definition see Article 2(6) of the H2020 Framework Programme Regulation No 1291/2013: '**Research infrastructure**' are facilities, resources and services that are used by the research communities to conduct research and foster innovation in their fields. Where relevant, they may be used beyond research, e.g. for education or public services. They include: major scientific equipment (or sets of instruments); knowledge-based resources such as collections, archives or scientific data; e-infrastructures such as data and computing systems and communication networks; and any other infrastructure of a unique nature essential to achieve excellence in research and innovation. Such infrastructures may be 'single-sited', 'virtual' or 'distributed'.

D.5 Costs of internally invoiced goods and services directly used for the action are eligible, if:

- (a) they are declared on the basis of a unit cost calculated in accordance with the beneficiary's usual cost accounting practices;
- (b) the cost accounting practices used are applied in a consistent manner, based on objective criteria, regardless of the source of funding;
- (c) the unit cost is calculated using the actual costs for the good or service recorded in the beneficiary's accounts, excluding any ineligible cost or costs included in other budget categories.

The actual costs may be adjusted by the beneficiary on the basis of budgeted or estimated elements. Those elements must be relevant for calculating the costs, reasonable and correspond to objective and verifiable information;

- (d) the unit cost excludes any costs of items which are not directly linked to the production of the invoiced goods or service.

'Internally invoiced goods and services' means goods or services which are provided by the beneficiary directly for the action and which the beneficiary values on the basis of its usual cost accounting practices.

E. Indirect costs

Indirect costs are eligible if they are declared on the basis of the flat-rate of 25% of the eligible direct costs (see Article 5.2 and Points A to D above), from which are excluded:

- (a) costs of subcontracting and
- (b) costs of in-kind contributions provided by third parties which are not used on the beneficiary's premises;
- (c) not applicable;
- (d) not applicable.

Beneficiaries receiving an operating grant⁴ financed by the EU or Euratom budget cannot declare indirect costs for the period covered by the operating grant, unless they can demonstrate that the operating grant does not cover any costs of the action.

F. Specific cost category(ies)

Not applicable

6.3 Conditions for costs of linked third parties to be eligible

⁴ For the definition, see Article 121(1)(b) of Regulation (EU, Euratom) No 966/2012 of the European Parliament and of the Council of 25 October 2012 on the financial rules applicable to the general budget of the Union and repealing Council Regulation (EC, Euratom) No 1605/2002 ('**Financial Regulation No 966/2012**') (OJ L 218, 26.10.2012, p.1): '**operating grant**' means direct financial contribution, by way of donation, from the budget in order to finance the functioning of a body which pursues an aim of general EU interest or has an objective forming part of and supporting an EU policy.

Costs incurred by linked third parties are eligible if they fulfil — *mutatis mutandis* — the general and specific conditions for eligibility set out in this Article (Article 6.1 and 6.2) and Article 14.1.1.

6.4 Conditions for in-kind contributions provided by third parties free of charge to be eligible

In-kind contributions provided free of charge are eligible direct costs (for the beneficiary or linked third party), if the costs incurred by the third party fulfil — *mutatis mutandis* — the general and specific conditions for eligibility set out in this Article (Article 6.1 and 6.2) and Article 12.1.

6.5 Ineligible costs

‘**Ineligible costs**’ are:

- (a) costs that do not comply with the conditions set out above (Article 6.1 to 6.4), in particular:
 - (i) costs related to return on capital;
 - (ii) debt and debt service charges;
 - (iii) provisions for future losses or debts;
 - (iv) interest owed;
 - (v) doubtful debts;
 - (vi) currency exchange losses;
 - (vii) bank costs charged by the beneficiary’s bank for transfers from the Commission;
 - (viii) excessive or reckless expenditure;
 - (ix) deductible VAT;
 - (x) costs incurred during suspension of the implementation of the action (see Article 49);
- (b) costs declared under another EU or Euratom grant (including grants awarded by a Member State and financed by the EU or Euratom budget and grants awarded by bodies other than the Commission for the purpose of implementing the EU or Euratom budget); in particular, indirect costs if the beneficiary is already receiving an operating grant financed by the EU or Euratom budget in the same period, unless it can demonstrate that the operating grant does not cover any costs of the action.

6.6 Consequences of declaration of ineligible costs

Declared costs that are ineligible will be rejected (see Article 42).

This may also lead to any of the other measures described in Chapter 6.

CHAPTER 4 RIGHTS AND OBLIGATIONS OF THE PARTIES

SECTION 1 RIGHTS AND OBLIGATIONS RELATED TO IMPLEMENTING THE ACTION

ARTICLE 7 — GENERAL OBLIGATION TO PROPERLY IMPLEMENT THE ACTION

7.1 General obligation to properly implement the action

The beneficiaries must implement the action as described in Annex 1 and in compliance with the provisions of the Agreement and all legal obligations under applicable EU, international and national law.

7.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 8 — RESOURCES TO IMPLEMENT THE ACTION — THIRD PARTIES INVOLVED IN THE ACTION

The beneficiaries must have the appropriate resources to implement the action.

If it is necessary to implement the action, the beneficiaries may:

- purchase goods, works and services (see Article 10);
- use in-kind contributions provided by third parties against payment (see Article 11);
- use in-kind contributions provided by third parties free of charge (see Article 12);
- call upon subcontractors to implement action tasks described in Annex 1 (see Article 13);
- call upon linked third parties to implement action tasks described in Annex 1 (see Article 14);
- call upon international partners to implement action tasks described in Annex 1 (see Article 14a).

In these cases, the beneficiaries retain sole responsibility towards the Commission and the other beneficiaries for implementing the action.

ARTICLE 9 — IMPLEMENTATION OF ACTION TASKS BY BENEFICIARIES NOT RECEIVING EU FUNDING

Not applicable

ARTICLE 10 — PURCHASE OF GOODS, WORKS OR SERVICES

10.1 Rules for purchasing goods, works or services

10.1.1 If necessary to implement the action, the beneficiaries may purchase goods, works or services.

The beneficiaries must make such purchases ensuring the best value for money or, if appropriate, the lowest price. In doing so, they must avoid any conflict of interests (see Article 35).

The beneficiaries must ensure that the Commission, the European Court of Auditors (ECA) and the European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards their contractors.

10.1.2 Beneficiaries that are ‘contracting authorities’ within the meaning of Directive 2004/18/EC⁵ (or 2014/24/EU⁶) or ‘contracting entities’ within the meaning of Directive 2004/17/EC⁷ (or 2014/25/EU⁸) must comply with the applicable national law on public procurement.

10.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under Article 10.1.1, the costs related to the contract concerned will be ineligible (see Article 6) and will be rejected (see Article 42).

If a beneficiary breaches any of its obligations under Article 10.1.2, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 11 — USE OF IN-KIND CONTRIBUTIONS PROVIDED BY THIRD PARTIES AGAINST PAYMENT

11.1 Rules for the use of in-kind contributions against payment

If necessary to implement the action, the beneficiaries may use in-kind contributions provided by third parties against payment.

The beneficiaries may declare costs related to the payment of in-kind contributions as eligible (see Article 6.1 and 6.2), up to the third parties’ costs for the seconded persons, contributed equipment, infrastructure or other assets or other contributed goods and services.

The third parties and their contributions must be set out in Annex 1. The Commission may however approve in-kind contributions not set out in Annex 1 without amendment (see Article 55), if:

- they are specifically justified in the periodic technical report and
- their use does not entail changes to the Agreement which would call into question the decision awarding the grant or breach the principle of equal treatment of applicants.

The beneficiaries must ensure that the Commission, the European Court of Auditors (ECA) and the

⁵ Directive 2004/18/EC of the European Parliament and of the Council of 31 March 2004 on the coordination of procedures for the award of public work contracts, public supply contracts and public service contracts (OJ L 134, 30.04.2004, p. 114).

⁶ Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement and repealing Directive 2004/18/EC. (OJ L 94, 28.03.2014, p. 65).

⁷ Directive 2004/17/EC of the European Parliament and of the Council of 31 March 2004 coordinating the procurement procedures of entities operating in the water, energy, transport and postal services sectors (OJ L 134, 30.04.2004, p. 1)

⁸ Directive 2014/25/EU of the European Parliament and of the Council of 26 February 2014 on procurement by entities operating in the water, energy, transport and postal services sectors and repealing Directive 2004/17/EC (OJ L 94, 28.03.2014, p. 243).

European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards the third parties.

11.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the costs related to the payment of the in-kind contribution will be ineligible (see Article 6) and will be rejected (see Article 42).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 12 — USE OF IN-KIND CONTRIBUTIONS PROVIDED BY THIRD PARTIES FREE OF CHARGE

12.1 Rules for the use of in-kind contributions free of charge

If necessary to implement the action, the beneficiaries may use in-kind contributions provided by third parties free of charge.

The beneficiaries may declare costs incurred by the third parties for the seconded persons, contributed equipment, infrastructure or other assets or other contributed goods and services as eligible in accordance with Article 6.4.

The third parties and their contributions must be set out in Annex 1. The Commission may however approve in-kind contributions not set out in Annex 1 without amendment (see Article 55), if:

- they are specifically justified in the periodic technical report and
- their use does not entail changes to the Agreement which would call into question the decision awarding the grant or breach the principle of equal treatment of applicants.

The beneficiaries must ensure that the Commission, the European Court of Auditors (ECA) and the European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards the third parties.

12.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the costs incurred by the third parties related to the in-kind contribution will be ineligible (see Article 6) and will be rejected (see Article 42).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 13 — IMPLEMENTATION OF ACTION TASKS BY SUBCONTRACTORS

13.1 Rules for subcontracting action tasks

13.1.1 If necessary to implement the action, the beneficiaries may award subcontracts covering the implementation of certain action tasks described in Annex 1.

Subcontracting may cover only a limited part of the action.

The beneficiaries must award the subcontracts ensuring the best value for money or, if appropriate, the lowest price. In doing so, they must avoid any conflict of interests (see Article 35).

The tasks to be implemented and the estimated cost for each subcontract must be set out in Annex 1 and the total estimated costs of subcontracting per beneficiary must be set out in Annex 2. The Commission may however approve subcontracts not set out in Annex 1 and 2 without amendment (see Article 55), if:

- they are specifically justified in the periodic technical report and
- they do not entail changes to the Agreement which would call into question the decision awarding the grant or breach the principle of equal treatment of applicants.

The beneficiaries must ensure that the Commission, the European Court of Auditors (ECA) and the European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards their subcontractors.

13.1.2 The beneficiaries must ensure that their obligations under Articles 35, 36, 38 and 46 also apply to the subcontractors.

Beneficiaries that are ‘contracting authorities’ within the meaning of Directive 2004/18/EC (or 2014/24/EU) or ‘contracting entities’ within the meaning of Directive 2004/17/EC (or 2014/25/EU) must comply with the applicable national law on public procurement.

13.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under Article 13.1.1, the costs related to the subcontract concerned will be ineligible (see Article 6) and will be rejected (see Article 42).

If a beneficiary breaches any of its obligations under Article 13.1.2, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 14 — IMPLEMENTATION OF ACTION TASKS BY LINKED THIRD PARTIES

14.1 Rules for calling upon linked third parties to implement part of the action

14.1.1 The following **affiliated entities**¹⁰ and **third parties with a legal link to a beneficiary**¹¹ (**‘linked third parties’**) may implement the action tasks attributed to them in Annex 1:

¹⁰ For the definition see Article 2.1(2) Rules for Participation Regulation No 1290/2013: ‘**affiliated entity**’ means any legal entity that is:

- under the direct or indirect control of a participant, or
- under the same direct or indirect control as the participant, or
- directly or indirectly controlling a participant.

‘Control’ may take any of the following forms:

- (a) the direct or indirect holding of more than 50% of the nominal value of the issued share capital in the legal entity concerned, or of a majority of the voting rights of the shareholders or associates of that entity;
- (b) the direct or indirect holding, in fact or in law, of decision-making powers in the legal entity concerned.

However the following relationships between legal entities shall not in themselves be deemed to constitute controlling relationships:

- (a) the same public investment corporation, institutional investor or venture-capital company has a direct or indirect holding of more than 50% of the nominal value of the issued share capital or a majority of voting rights of the shareholders or associates;
- (b) the legal entities concerned are owned or supervised by the same public body.

- BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES (BRGM), affiliated or linked to ANDRA
- ELECTRICITE DE FRANCE (EDF), affiliated or linked to CEA
- ORANO CYCLE (Orano), affiliated or linked to CEA
- UNIVERSITAT POLITECNICA DE CATALUNYA (UPC), affiliated or linked to CIEMAT
- AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS (CSIC), affiliated or linked to CIEMAT
- IDOM INGENIERIA Y CONSULTORIA S.A. (IDOM), affiliated or linked to CIEMAT
- UNIVERSIDAD POLITECNICA DE MADRID (UPM), affiliated or linked to CIEMAT
- UNIVERSIDAD AUTONOMA DE MADRID (UAM), affiliated or linked to CIEMAT
- NATIONAL SCIENCE CENTER KHARKOV INSTITUTE OF PHYSICS AND TECHNOLOGY (KIPT), affiliated or linked to ChRDI
- INSTITUTE OF ENVIRONMENTAL GEOCHEMISTRY OF THE NATIONAL ACADEMY OF SCIENCES OF UKRAINE (SIIGNASU), affiliated or linked to ChRDI
- UNIVERSITE DE LORRAINE (ULorraine), affiliated or linked to CNRS
- UNIVERSITE D'ORLEANS (UOrléans), affiliated or linked to CNRS
- UNIVERSITE DE NICE SOPHIA ANTIPOLIS (UNice), affiliated or linked to CNRS
- UNIVERSITE GRENOBLE ALPES (UGrenoble), affiliated or linked to CNRS
- UNIVERSITE DE LILLE (ULille), affiliated or linked to CNRS
- UNIVERSITE DE MONTPELLIER (UMontpellier), affiliated or linked to CNRS
- UNIVERSITE DE POITIERS (UPoitiers), affiliated or linked to CNRS
- INSTITUT MINES-TELECOM (IMT Atlantique), affiliated or linked to CNRS
- TECHNISCHE UNIVERSITEIT DELFT (TU Delft), affiliated or linked to COVRA
- HELMHOLTZ-ZENTRUM DRESDEN-ROSSENDORF EV (HZDR), affiliated or linked to JUELICH
- HELMHOLTZ-ZENTRUM FUR UMWELTFORSCHUNG GMBH - UFZ (UFZ), affiliated or linked to JUELICH
- ECOLE NATIONALE SUPERIEURE DES MINES DE PARIS (MINES ParisTech), affiliated or linked to IRSN

¹¹ ‘**Third party with a legal link to a beneficiary**’ is any legal entity which has a legal link to the beneficiary implying collaboration that is not limited to the action.

- MUTADIS CONSULTANTS SARL (MUTADIS), affiliated or linked to IRSN
- NUCLEAR TRANSPARENCY WATCH (NTW), affiliated or linked to IRSN
- ZAVOD ZA GRADBENISTVO SLOVENIJE (ZAG), affiliated or linked to JSI
- Elektrotehniški inštitut Milan Vidmar (EIMV), affiliated or linked to JSI
- AMPHOS 21 CONSULTING SL (AMPHOS 21), affiliated or linked to KIT
- PREUSSENELEKTRA GMBH (PEL), affiliated or linked to KIT
- JOHANNES GUTENBERG-UNIVERSITÄT MAINZ (Uni Mainz), affiliated or linked to KIT
- BUNDESANSTALT FÜR MATERIALFORSCHUNG UND -PRÜFUNG (BAM), affiliated or linked to KIT
- UNIVERSITÄT POTSDAM (Uni Potsdam), affiliated or linked to KIT
- TECHNISCHE UNIVERSITÄT CLAUSTHAL (Uni Clausthal), affiliated or linked to KIT
- BUNDESANSTALT FÜR GEOWISSENSCHAFTEN UND ROHSTOFFE (BGR), affiliated or linked to KIT
- RADIOÖKOLOGIAI TISZTASÁGÉRT TÁRSADALMI SZERVEZET (SORC), affiliated or linked to MTA EK
- ZÜRCHER HOCHSCHULE FÜR ANGEWANDTE WISSENSCHAFTEN (ZHAW), affiliated or linked to NAGRA
- UNIVERSITÄT BERN (UBERN), affiliated or linked to NAGRA
- ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE (EPFL), affiliated or linked to NAGRA
- CENTRE INTERNACIONAL DE MÈTODES NUMÈRIQUES EN ENGINYERIA (CIMNE), affiliated or linked to NAGRA
- DMT GmbH & Co. KG (DMT), affiliated or linked to NCSR
- European Underground Research Infrastructure for Disposal of Nuclear Waste in Clay Environment (EURIDICE), affiliated or linked to ONDRAF/NIRAS
- UNIVERSITÉ DE LIÈGE (ULiège), affiliated or linked to ONDRAF/NIRAS
- YMPARISTOTUTKIMUS JA- ARVIOINTI ENVIROCASE OY (Envirocase), affiliated or linked to POSIVA
- Eidgenössische Materialprüfungs- und Forschungsanstalt (EMPA), affiliated or linked to PSI
- UPPSALA UNIVERSITET (UU), affiliated or linked to SKB
- UNIVERZITA KARLOVA (CU), affiliated or linked to SÚRAO

- CESKE VYSOKE UCENI TECHNICKE V PRAZE (CTU), affiliated or linked to SÚRAO
- UJV REZ, a. s. (ÚJV), affiliated or linked to SÚRAO
- TECHNICKA UNIVERZITA V LIBERCI (TUL), affiliated or linked to SÚRAO
- Institute of Geonics of the AS CR, v.v.i. (IGN), affiliated or linked to SÚRAO
- JYVASKYLAN YLIOPISTO (JYU), affiliated or linked to UHelsinki
- TAMPEREEN KORKEAKOULUSAATIO SR (TUT), affiliated or linked to UHelsinki
- AALTO KORKEAKOULUSAATIO SR (Aalto), affiliated or linked to UHelsinki
- GEOLOGIAN TUTKIMUSKESKUS (GTK), affiliated or linked to UHelsinki
- GALSON SCIENCES LIMITED (GSL), affiliated or linked to VTT

The linked third parties may declare as eligible the costs they incur for implementing the action tasks in accordance with Article 6.3.

The beneficiaries must ensure that the Commission, the European Court of Auditors (ECA) and the European Anti-Fraud Office (OLAF) can exercise their rights under Articles 22 and 23 also towards their linked third parties.

14.1.2 The beneficiaries must ensure that their obligations under Articles 18, 20, 35, 36 and 38 also apply to their linked third parties.

14.2 Consequences of non-compliance

If any obligation under Article 14.1.1 is breached, the costs of the linked third party will be ineligible (see Article 6) and will be rejected (see Article 42).

If any obligation under Article 14.1.2 is breached, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 14a — IMPLEMENTATION OF ACTION TASKS BY INTERNATIONAL PARTNERS

Not applicable

ARTICLE 15 — FINANCIAL SUPPORT TO THIRD PARTIES

15.1 Rules for providing financial support to third parties

Not applicable

15.2 Financial support in the form of prizes

Not applicable

15.3 Consequences of non-compliance

Not applicable

ARTICLE 16 — PROVISION OF TRANS-NATIONAL OR VIRTUAL ACCESS TO RESEARCH INFRASTRUCTURE

Not applicable

SECTION 2 RIGHTS AND OBLIGATIONS RELATED TO THE GRANT ADMINISTRATION

ARTICLE 17 — GENERAL OBLIGATION TO INFORM

17.1 General obligation to provide information upon request

The beneficiaries must provide — during implementation of the action or afterwards and in accordance with Article 41.2 — any information requested in order to verify eligibility of the costs, proper implementation of the action and compliance with any other obligation under the Agreement.

17.2 Obligation to keep information up to date and to inform about events and circumstances likely to affect the Agreement

Each beneficiary must keep information stored in the Participant Portal Beneficiary Register (via the electronic exchange system; see Article 52) up to date, in particular, its name, address, legal representatives, legal form and organisation type.

Each beneficiary must immediately inform the coordinator — which must immediately inform the Commission and the other beneficiaries — of any of the following:

- (a) **events** which are likely to affect significantly or delay the implementation of the action or the EU's financial interests, in particular:
 - (i) changes in its legal, financial, technical, organisational or ownership situation or those of its linked third parties and
 - (ii) changes in the name, address, legal form, organisation type of its linked third parties;
- (b) **circumstances** affecting:
 - (i) the decision to award the grant or
 - (ii) compliance with requirements under the Agreement.

17.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 18 — KEEPING RECORDS — SUPPORTING DOCUMENTATION

18.1 Obligation to keep records and other supporting documentation

The beneficiaries must — for a period of five years after the payment of the balance — keep records and other supporting documentation in order to prove the proper implementation of the action and the costs they declare as eligible.

They must make them available upon request (see Article 17) or in the context of checks, reviews, audits or investigations (see Article 22).

If there are on-going checks, reviews, audits, investigations, litigation or other pursuits of claims under the Agreement (including the extension of findings; see Article 22), the beneficiaries must keep the records and other supporting documentation until the end of these procedures.

The beneficiaries must keep the original documents. Digital and digitalised documents are considered originals if they are authorised by the applicable national law. The Commission may accept non-original documents if it considers that they offer a comparable level of assurance.

18.1.1 Records and other supporting documentation on the scientific and technical implementation

The beneficiaries must keep records and other supporting documentation on scientific and technical implementation of the action in line with the accepted standards in the respective field.

18.1.2 Records and other documentation to support the costs declared

The beneficiaries must keep the records and documentation supporting the costs declared, in particular the following:

- (a) for **actual costs**: adequate records and other supporting documentation to prove the costs declared, such as contracts, subcontracts, invoices and accounting records. In addition, the beneficiaries' usual cost accounting practices and internal control procedures must enable direct reconciliation between the amounts declared, the amounts recorded in their accounts and the amounts stated in the supporting documentation;
- (b) for **unit costs**: adequate records and other supporting documentation to prove the number of units declared. Beneficiaries do not need to identify the actual eligible costs covered or to keep or provide supporting documentation (such as accounting statements) to prove the amount per unit.

In addition, for **unit costs calculated in accordance with the beneficiary's usual cost accounting practices**, the beneficiaries must keep adequate records and documentation to prove that the cost accounting practices used comply with the conditions set out in Article 6.2.

The beneficiaries and linked third parties may submit to the Commission, for approval, a certificate (drawn up in accordance with Annex 6) stating that their usual cost accounting practices comply with these conditions (**'certificate on the methodology'**). If the certificate is approved, costs declared in line with this methodology will not be challenged subsequently, unless the beneficiaries have concealed information for the purpose of the approval.

- (c) for **flat-rate costs**: adequate records and other supporting documentation to prove the eligibility

of the costs to which the flat-rate is applied. The beneficiaries do not need to identify the costs covered or provide supporting documentation (such as accounting statements) to prove the amount declared at a flat-rate.

In addition, for **personnel costs** (declared as actual costs or on the basis of unit costs), the beneficiaries must keep **time records** for the number of hours declared. The time records must be in writing and approved by the persons working on the action and their supervisors, at least monthly. In the absence of reliable time records of the hours worked on the action, the Commission may accept alternative evidence supporting the number of hours declared, if it considers that it offers an adequate level of assurance.

As an exception, for **persons working exclusively on the action**, there is no need to keep time records, if the beneficiary signs a **declaration** confirming that the persons concerned have worked exclusively on the action.

For costs declared by linked third parties (see Article 14), it is the beneficiary that must keep the originals of the financial statements and the certificates on the financial statements of the linked third parties.

18.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, costs insufficiently substantiated will be ineligible (see Article 6) and will be rejected (see Article 42), and the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 19 — SUBMISSION OF DELIVERABLES

19.1 Obligation to submit deliverables

The coordinator must submit:

- 90 days before the end of each reporting period:
 - (a) the '**annual work plan for the next year**' (see Annex 7), for approval by the Commission and
 - (b) a **summary progress report** on the activities carried out during the on-going reporting period.

This report must show how the activities proposed in the annual work plan for the next year ensure continuity with the work already carried out.

If the Commission considers that the annual work plan for the next year does not comply with Annex 1, the coordinator must submit a revised version within 30 days from receiving formal notification.

If the Commission considers that the revised annual work plan for the next year still does not comply with Annex 1, it may terminate the Agreement (see Article 50.3).

- the other '**deliverables**' identified in Annex 1, in accordance with the timing and conditions set out in it.

19.2 Consequences of non-compliance

If the coordinator breaches any of its obligations under this Article, the Commission may apply any of the measures described in Chapter 6.

ARTICLE 20 — REPORTING — PAYMENT REQUESTS

20.1 Obligation to submit reports

The coordinator must submit to the Commission (see Article 52) the technical and financial reports set out in this Article. These reports include the requests for payment and must be drawn up using the forms and templates provided in the electronic exchange system (see Article 52).

20.2 Reporting periods

The action is divided into the following '**reporting periods**':

- RP1: from month 1 to month 12
- RP2: from month 13 to month 24
- RP3: from month 25 to month 36
- RP4: from month 37 to month 48
- RP5: from month 49 to month 60

20.2a Request for a second pre-financing payment

Not applicable

20.3 Periodic reports — Requests for interim payments

The coordinator must submit a periodic report within 60 days following the end of each reporting period.

The **periodic report** must include the following:

- (a) a '**periodic technical report**' containing:
 - (i) an **explanation of the work carried out** by the beneficiaries;
 - (ii) an **overview of the progress** towards the objectives of the action, including milestones and deliverables identified in Annex 1 and the annual work plan for the year (see Annex 7).

This report must include explanations justifying the differences between work expected to be carried out in accordance with Annex 1 and the annual work plan for the year (see Annex 7) and that actually carried out.

The report must also detail the exploitation and dissemination of the results and — if required in Annex 1 — an updated '**plan for the exploitation and dissemination of the results**';

The report must indicate the communication activities.

- (iii) a **summary** for publication by the Commission;
 - (iv) the answers to the ‘**questionnaire**’, covering issues related to the action implementation and the economic and societal impact, notably in the context of the Horizon 2020 key performance indicators and the Horizon 2020 monitoring requirements;
- (b) a ‘**periodic financial report**’ containing:
- (i) an ‘**individual financial statement**’ (see Annex 4) from each beneficiary and from each linked third party, for the reporting period concerned.

The individual financial statement must detail the eligible costs (actual costs, unit costs and flat-rate costs; see Article 6) for each budget category (see Annex 2).

The beneficiaries and linked third parties must declare all eligible costs, even if — for actual costs, unit costs and flat-rate costs — they exceed the amounts indicated in the estimated budget (see Annex 2). Amounts which are not declared in the individual financial statement will not be taken into account by the Commission.

If an individual financial statement is not submitted for a reporting period, it may be included in the periodic financial report for the next reporting period.

The individual financial statements of the last reporting period must also detail the **receipts of the action** (see Article 5.3.3).

Each beneficiary and each linked third party must **certify** that:

- the information provided is full, reliable and true;
 - the costs declared are eligible (see Article 6);
 - the costs can be substantiated by adequate records and supporting documentation (see Article 18) that will be produced upon request (see Article 17) or in the context of checks, reviews, audits and investigations (see Article 22), and
 - for the last reporting period: that all the receipts have been declared (see Article 5.3.3);
- (ii) an **explanation of the use of resources** and the information on subcontracting (see Article 13) and in-kind contributions provided by third parties (see Articles 11 and 12) from each beneficiary and from each linked third party, for the reporting period concerned;
 - (iii) information on the amount of each interim payment and payment of the balance to be paid by the Commission to the Joint Research Centre (JRC);
 - (iv) a ‘**periodic summary financial statement**’, created automatically by the electronic exchange system, consolidating the individual financial statements for the reporting period concerned and including — except for the last reporting period — the **request for interim payment**.

20.4 Final report — Request for payment of the balance

In addition to the periodic report for the last reporting period, the coordinator must submit the final report within 60 days following the end of the last reporting period.

The **final report** must include the following:

- (a) a '**final technical report**' with a **summary** for publication containing:
 - (i) an overview of the results and their exploitation and dissemination;
 - (ii) the conclusions on the action, and
 - (iii) the socio-economic impact of the action;
- (b) a '**final financial report**' containing:
 - (i) a '**final summary financial statement**', created automatically by the electronic exchange system, consolidating the individual financial statements for all reporting periods and including the **request for payment of the balance** and
 - (ii) a '**certificate on the financial statements**' (drawn up in accordance with Annex 5) for each beneficiary and for each linked third party, if it requests a total contribution of EUR 325 000 or more, as reimbursement of actual costs and unit costs calculated on the basis of its usual cost accounting practices (see Article 5.2 and Article 6.2).

20.5 Information on cumulative expenditure incurred

Not applicable

20.6 Currency for financial statements and conversion into euro

Financial statements must be drafted in euro.

Beneficiaries and linked third parties with accounting established in a currency other than the euro must convert the costs recorded in their accounts into euro, at the average of the daily exchange rates published in the C series of the *Official Journal of the European Union*, calculated over the corresponding reporting period.

If no daily euro exchange rate is published in the *Official Journal of the European Union* for the currency in question, they must be converted at the average of the monthly accounting rates published on the Commission's website, calculated over the corresponding reporting period.

Beneficiaries and linked third parties with accounting established in euro must convert costs incurred in another currency into euro according to their usual accounting practices.

20.7 Language of reports

All reports (technical and financial reports, including financial statements) must be submitted in the language of the Agreement.

20.8 Consequences of non-compliance

If the reports submitted do not comply with this Article, the Commission may suspend the payment deadline (see Article 47) and apply any of the other measures described in Chapter 6.

If the coordinator breaches its obligation to submit the reports and if it fails to comply with this obligation within 30 days following a written reminder, the Commission may terminate the Agreement (see Article 50) or apply any of the other measures described in Chapter 6.

ARTICLE 21 — PAYMENTS AND PAYMENT ARRANGEMENTS

21.1 Payments to be made

The following payments will be made to the coordinator:

- a **pre-financing payment**;
- one or more **interim payments**, on the basis of the request(s) for interim payment (see Article 20), and
- one **payment of the balance**, on the basis of the request for payment of the balance (see Article 20).

21.2 Pre-financing payment — Amount — Amount retained for the Guarantee Fund

The aim of the pre-financing is to provide the beneficiaries with a float.

It remains the property of the EU until the payment of the balance.

The Commission will — within 30 days, either from the entry into force of the Agreement (see Article 58) or from 10 days before the starting date of the action (see Article 3), whichever is the latest — make a pre-financing payment to the coordinator of EUR **6 500 000.00** (six million five hundred thousand EURO), except if Article 48 applies.

From this amount, an amount of EUR **1 625 000.00** (one million six hundred and twenty five thousand EURO), corresponding to 5% of the maximum grant amount (see Article 5.1), is retained by the Commission and transferred into the '**Guarantee Fund**'.

The parts of the pre-financing payments related to the Joint Research Centre (JRC) **94 230.10** (ninety four thousand two hundred and thirty EURO and ten eurocents) are not paid to the coordinator, but kept by the Commission for the JRC.

21.3 Interim payments — Amount — Calculation

Interim payments reimburse the eligible costs incurred for the implementation of the action during the corresponding reporting periods.

The Commission will pay to the coordinator the amount due as interim payment within 90 days from receiving the periodic report (see Article 20.3), except if Articles 47 or 48 apply.

Payment is subject to the approval of the periodic report. Its approval does not imply recognition of the compliance, authenticity, completeness or correctness of its content.

The **amount due as interim payment** is calculated by the Commission in the following steps:

Step 1 – Application of the reimbursement rates

Step 2 – Limit to 90% of the maximum grant amount

21.3.1 Step 1 — Application of the reimbursement rates

The reimbursement rate(s) (see Article 5.2) are applied to the eligible costs (actual costs, unit costs and flat-rate costs; see Article 6) declared by the beneficiaries and the linked third parties (see Article 20) and approved by the Commission (see above) for the concerned reporting period.

21.3.2 Step 2 — Limit to 90% of the maximum grant amount

The total amount of pre-financing and interim payments must not exceed 90% of the maximum grant amount set out in Article 5.1. The maximum amount for the interim payment will be calculated as follows:

{90% of the maximum grant amount (see Article 5.1)

minus

{pre-financing and previous interim payments}}.

21.4 Payment of the balance — Amount — Calculation — Release of the amount retained for the Guarantee Fund

The payment of the balance reimburses the remaining part of the eligible costs incurred by the beneficiaries for the implementation of the action.

If the total amount of earlier payments is greater than the final grant amount (see Article 5.3), the payment of the balance takes the form of a recovery (see Article 44).

If the total amount of earlier payments is lower than the final grant amount, the Commission will pay the balance within 90 days from receiving the final report (see Article 20.4), except if Articles 47 or 48 apply.

Payment is subject to the approval of the final report. Its approval does not imply recognition of the compliance, authenticity, completeness or correctness of its content.

The **amount due as the balance** is calculated by the Commission by deducting the total amount of pre-financing and interim payments (if any) already made, from the final grant amount determined in accordance with Article 5.3:

{final grant amount (see Article 5.3)

minus

{pre-financing and interim payments (if any) made}}.

At the payment of the balance, the amount retained for the Guarantee Fund (see above) will be released and:

- if the balance is positive: the amount released will be paid in full to the coordinator together with the amount due as the balance;

- if the balance is negative (payment of the balance taking the form of recovery): it will be deducted from the amount released (see Article 44.1.2). If the resulting amount:
 - is positive, it will be paid to the coordinator
 - is negative, it will be recovered.

The amount to be paid may however be offset — without the beneficiaries' consent — against any other amount owed by a beneficiary to the Commission or an executive agency (under the EU or Euratom budget), up to the maximum EU contribution indicated, for that beneficiary, in the estimated budget (see Annex 2).

21.5 Notification of amounts due

When making payments, the Commission will formally notify to the coordinator the amount due, specifying whether it concerns a interim payment or the payment of the balance.

For the payment of the balance, the notification will also specify the final grant amount.

In the case of reduction of the grant or recovery of undue amounts, the notification will be preceded by the contradictory procedure set out in Articles 43 and 44.

21.6 Currency for payments

The Commission will make all payments in euro.

21.7 Payments to the coordinator — Distribution to the beneficiaries

Payments will be made to the coordinator.

Payments to the coordinator will discharge the Commission from its payment obligation.

The coordinator must distribute the payments between the beneficiaries without unjustified delay.

Pre-financing may however be distributed only:

- (a) if the minimum number of beneficiaries set out in the call for proposals has acceded to the Agreement (see Article 56) and
- (b) to beneficiaries that have acceded to the Agreement (see Article 56).

21.8 Bank account for payments

All payments will be made to the following bank account:

Name of bank: BNP-PARIBAS SA (FORMERLY BANQUE NATIONALE DE PARIS S.A.)
 Full name of the account holder: ANDRA HAVL
 IBAN code: FR7630004025520001051217607

21.9 Costs of payment transfers

The cost of the payment transfers is borne as follows:

- the Commission bears the cost of transfers charged by its bank;
- the beneficiary bears the cost of transfers charged by its bank;
- the party causing a repetition of a transfer bears all costs of the repeated transfer.

21.10 Date of payment

Payments by the Commission are considered to have been carried out on the date when they are debited to its account.

21.11 Consequences of non-compliance

21.11.1 If the Commission does not pay within the payment deadlines (see above), the beneficiaries are entitled to **late-payment interest** at the rate applied by the European Central Bank (ECB) for its main refinancing operations in euros ('reference rate'), plus three and a half points. The reference rate is the rate in force on the first day of the month in which the payment deadline expires, as published in the C series of the *Official Journal of the European Union*.

If the late-payment interest is lower than or equal to EUR 200, it will be paid to the coordinator only upon request submitted within two months of receiving the late payment.

Late-payment interest is not due if all beneficiaries are EU Member States (including regional and local government authorities or other public bodies acting on behalf of a Member State for the purpose of this Agreement).

Suspension of the payment deadline or payments (see Articles 47 and 48) will not be considered as late payment.

Late-payment interest covers the period running from the day following the due date for payment (see above), up to and including the date of payment.

Late-payment interest is not considered for the purposes of calculating the final grant amount.

21.11.2 If the coordinator breaches any of its obligations under this Article, the grant may be reduced (see Article 43) and the Agreement or the participation of the coordinator may be terminated (see Article 50).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 22 — CHECKS, REVIEWS, AUDITS AND INVESTIGATIONS — EXTENSION OF FINDINGS

22.1 Checks, reviews and audits by the Commission

22.1.1 Right to carry out checks

The Commission will — during the implementation of the action or afterwards — check the proper implementation of the action and compliance with the obligations under the Agreement, including assessing deliverables and reports.

For this purpose the Commission may be assisted by external persons or bodies.

The Commission may also request additional information in accordance with Article 17. The Commission may request beneficiaries to provide such information to it directly.

Information provided must be accurate, precise and complete and in the format requested, including electronic format.

22.1.2 Right to carry out reviews

The Commission may — during the implementation of the action or afterwards — carry out reviews on the proper implementation of the action (including assessment of deliverables and reports), compliance with the obligations under the Agreement and continued scientific or technological relevance of the action.

Reviews may be started up to two years after the payment of the balance. They will be formally notified to the coordinator or beneficiary concerned and will be considered to have started on the date of the formal notification.

If the review is carried out on a third party (see Articles 10 to 16), the beneficiary concerned must inform the third party.

The Commission may carry out reviews directly (using its own staff) or indirectly (using external persons or bodies appointed to do so). It will inform the coordinator or beneficiary concerned of the identity of the external persons or bodies. They have the right to object to the appointment on grounds of commercial confidentiality.

The coordinator or beneficiary concerned must provide — within the deadline requested — any information and data in addition to deliverables and reports already submitted (including information on the use of resources). The Commission may request beneficiaries to provide such information to it directly.

The coordinator or beneficiary concerned may be requested to participate in meetings, including with external experts.

For **on-the-spot** reviews, the beneficiaries must allow access to their sites and premises, including to external persons or bodies, and must ensure that information requested is readily available.

Information provided must be accurate, precise and complete and in the format requested, including electronic format.

On the basis of the review findings, a '**review report**' will be drawn up.

The Commission will formally notify the review report to the coordinator or beneficiary concerned, which has 30 days to formally notify observations ('**contradictory review procedure**').

Reviews (including review reports) are in the language of the Agreement.

22.1.3 Right to carry out audits

The Commission may — during the implementation of the action or afterwards — carry out audits on the proper implementation of the action and compliance with the obligations under the Agreement.

Audits may be started up to two years after the payment of the balance. They will be formally notified

to the coordinator or beneficiary concerned and will be considered to have started on the date of the formal notification.

If the audit is carried out on a third party (see Articles 10 to 16), the beneficiary concerned must inform the third party.

The Commission may carry out audits directly (using its own staff) or indirectly (using external persons or bodies appointed to do so). It will inform the coordinator or beneficiary concerned of the identity of the external persons or bodies. They have the right to object to the appointment on grounds of commercial confidentiality.

The coordinator or beneficiary concerned must provide — within the deadline requested — any information (including complete accounts, individual salary statements or other personal data) to verify compliance with the Agreement. The Commission may request beneficiaries to provide such information to it directly.

For **on-the-spot** audits, the beneficiaries must allow access to their sites and premises, including to external persons or bodies, and must ensure that information requested is readily available.

Information provided must be accurate, precise and complete and in the format requested, including electronic format.

On the basis of the audit findings, a ‘**draft audit report**’ will be drawn up.

The Commission will formally notify the draft audit report to the coordinator or beneficiary concerned, which has 30 days to formally notify observations (‘**contradictory audit procedure**’). This period may be extended by the Commission in justified cases.

The ‘**final audit report**’ will take into account observations by the coordinator or beneficiary concerned. The report will be formally notified to it.

Audits (including audit reports) are in the language of the Agreement.

The Commission may also access the beneficiaries’ statutory records for the periodical assessment of unit costs or flat-rate amounts.

22.2 Investigations by the European Anti-Fraud Office (OLAF)

Under Regulations No 883/2013¹³ and No 2185/96¹⁴ (and in accordance with their provisions and procedures), the European Anti-Fraud Office (OLAF) may — at any moment during implementation of the action or afterwards — carry out investigations, including on-the-spot checks and inspections, to establish whether there has been fraud, corruption or any other illegal activity affecting the financial interests of the EU.

¹³ Regulation (EU, Euratom) No 883/2013 of the European Parliament and of the Council of 11 September 2013 concerning investigations conducted by the European Anti-Fraud Office (OLAF) and repealing Regulation (EC) No 1073/1999 of the European Parliament and of the Council and Council Regulation (Euratom) No 1074/1999 (OJ L 248, 18.09.2013, p. 1).

¹⁴ Council Regulation (Euratom, EC) No 2185/1996 of 11 November 1996 concerning on-the-spot checks and inspections carried out by the Commission in order to protect the European Communities’ financial interests against fraud and other irregularities (OJ L 292, 15.11.1996, p. 2).

22.3 Checks and audits by the European Court of Auditors (ECA)

Under Article 287 of the Treaty on the Functioning of the European Union (TFEU) and Article 161 of the Financial Regulation No 966/2012¹⁵, the European Court of Auditors (ECA) may — at any moment during implementation of the action or afterwards — carry out audits.

The ECA has the right of access for the purpose of checks and audits.

22.4 Checks, reviews, audits and investigations for international organisations

Not applicable

22.5 Consequences of findings in checks, reviews, audits and investigations — Extension of findings

22.5.1 Findings in this grant

Findings in checks, reviews, audits or investigations carried out in the context of this grant may lead to the rejection of ineligible costs (see Article 42), reduction of the grant (see Article 43), recovery of undue amounts (see Article 44) or to any of the other measures described in Chapter 6.

Rejection of costs or reduction of the grant after the payment of the balance will lead to a revised final grant amount (see Article 5.4).

Findings in checks, reviews, audits or investigations may lead to a request for amendment for the modification of Annex 1 (see Article 55).

Checks, reviews, audits or investigations that find systemic or recurrent errors, irregularities, fraud or breach of obligations may also lead to consequences in other EU or Euratom grants awarded under similar conditions (**‘extension of findings from this grant to other grants’**).

Moreover, findings arising from an OLAF investigation may lead to criminal prosecution under national law.

22.5.2 Findings in other grants

The Commission may extend findings from other grants to this grant (**‘extension of findings from other grants to this grant’**), if:

- (a) the beneficiary concerned is found, in other EU or Euratom grants awarded under similar conditions, to have committed systemic or recurrent errors, irregularities, fraud or breach of obligations that have a material impact on this grant and
- (b) those findings are formally notified to the beneficiary concerned — together with the list of grants affected by the findings — no later than two years after the payment of the balance of this grant.

The extension of findings may lead to the rejection of costs (see Article 42), reduction of the grant

¹⁵ Regulation (EU, Euratom) No 966/2012 of the European Parliament and of the Council of 25 October 2012 on the financial rules applicable to the general budget of the Union and repealing Council Regulation (EC, Euratom) No 1605/2002 (OJ L 298, 26.10.2012, p. 1).

(see Article 43), recovery of undue amounts (see Article 44), suspension of payments (see Article 48), suspension of the action implementation (see Article 49) or termination (see Article 50).

22.5.3 Procedure

The Commission will formally notify the beneficiary concerned the systemic or recurrent errors and its intention to extend these audit findings, together with the list of grants affected.

22.5.3.1 If the findings concern **eligibility of costs**: the formal notification will include:

- (a) an invitation to submit observations on the list of grants affected by the findings;
- (b) the request to submit **revised financial statements** for all grants affected;
- (c) the **correction rate for extrapolation** established by the Commission on the basis of the systemic or recurrent errors, to calculate the amounts to be rejected if the beneficiary concerned:
 - (i) considers that the submission of revised financial statements is not possible or practicable or
 - (ii) does not submit revised financial statements.

The beneficiary concerned has 90 days from receiving notification to submit observations, revised financial statements or to propose a duly substantiated **alternative correction method**. This period may be extended by the Commission in justified cases.

The Commission may then start a rejection procedure in accordance with Article 42, on the basis of:

- the revised financial statements, if approved;
 - the proposed alternative correction method, if accepted
- or
- the initially notified correction rate for extrapolation, if it does not receive any observations or revised financial statements, does not accept the observations or the proposed alternative correction method or does not approve the revised financial statements.

22.5.3.2 If the findings concern **substantial errors, irregularities or fraud or serious breach of obligations**: the formal notification will include:

- (a) an invitation to submit observations on the list of grants affected by the findings and
- (b) the flat-rate the Commission intends to apply according to the principle of proportionality.

The beneficiary concerned has 90 days from receiving notification to submit observations or to propose a duly substantiated alternative flat-rate.

The Commission may then start a reduction procedure in accordance with Article 43, on the basis of:

- the proposed alternative flat-rate, if accepted
- or

- the initially notified flat-rate, if it does not receive any observations or does not accept the observations or the proposed alternative flat-rate.

22.6 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, any insufficiently substantiated costs will be ineligible (see Article 6) and will be rejected (see Article 42).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 23 — EVALUATION OF THE IMPACT OF THE ACTION

23.1 Right to evaluate the impact of the action

The Commission may carry out interim and final evaluations of the impact of the action measured against the objective of the EU programme.

Evaluations may be started during implementation of the action and up to five years after the payment of the balance. The evaluation is considered to start on the date of the formal notification to the coordinator or beneficiaries.

The Commission may make these evaluations directly (using its own staff) or indirectly (using external bodies or persons it has authorised to do so).

The coordinator or beneficiaries must provide any information relevant to evaluate the impact of the action, including information in electronic format.

23.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the Commission may apply the measures described in Chapter 6.

SECTION 3 RIGHTS AND OBLIGATIONS RELATED TO BACKGROUND AND RESULTS

SUBSECTION 1 GENERAL

ARTICLE 23a — MANAGEMENT OF INTELLECTUAL PROPERTY

23a.1 Obligation to take measures to implement the Commission Recommendation on the management of intellectual property in knowledge transfer activities

Beneficiaries that are universities or other public research organisations must take measures to implement the principles set out in Points 1 and 2 of the Code of Practice annexed to the Commission Recommendation on the management of intellectual property in knowledge transfer activities¹⁶.

¹⁶ Commission Recommendation C(2008) 1329 of 10.4.2008 on the management of intellectual property in knowledge transfer activities and the Code of Practice for universities and other public research institutions attached to this recommendation.

This does not change the obligations set out in Subsections 2 and 3 of this Section.

The beneficiaries must ensure that researchers and third parties involved in the action are aware of them.

23a.2 Consequences of non-compliance

If a beneficiary breaches its obligations under this Article, the Commission may apply any of the measures described in Chapter 6.

SUBSECTION 2 RIGHTS AND OBLIGATIONS RELATED TO BACKGROUND

ARTICLE 24 — AGREEMENT ON BACKGROUND

24.1 Agreement on background

The beneficiaries must identify and agree (in writing) on the background for the action (**‘agreement on background’**).

‘Background’ means any data, know-how or information — whatever its form or nature (tangible or intangible), including any rights such as intellectual property rights — that:

- (a) is held by the beneficiaries before they acceded to the Agreement, and
- (b) is needed to implement the action or exploit the results.

24.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 25 — ACCESS RIGHTS TO BACKGROUND

25.1 Exercise of access rights — Waiving of access rights — No sub-licensing

To exercise access rights, this must first be requested in writing (**‘request for access’**).

‘Access rights’ means rights to use results or background under the terms and conditions laid down in this Agreement.

Waivers of access rights are not valid unless in writing.

Unless agreed otherwise, access rights do not include the right to sub-license.

25.2 Access rights for other beneficiaries, for implementing their own tasks under the action

The beneficiaries must give each other access — on a royalty-free basis — to background needed to implement their own tasks under the action, unless the beneficiary that holds the background has — before acceding to the Agreement —:

- (a) informed the other beneficiaries that access to its background is subject to legal restrictions or limits, including those imposed by the rights of third parties (including personnel), or
- (b) agreed with the other beneficiaries that access would not be on a royalty-free basis.

25.3 Access rights for other beneficiaries, for exploiting their own results

The beneficiaries must give each other access — under fair and reasonable conditions — to background needed for exploiting their own results, unless the beneficiary that holds the background has — before acceding to the Agreement — informed the other beneficiaries that access to its background is subject to legal restrictions or limits, including those imposed by the rights of third parties (including personnel).

‘**Fair and reasonable conditions**’ means appropriate conditions, including possible financial terms or royalty-free conditions, taking into account the specific circumstances of the request for access, for example the actual or potential value of the results or background to which access is requested and/or the scope, duration or other characteristics of the exploitation envisaged.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

25.4 Access rights for affiliated entities

Unless otherwise agreed in the consortium agreement, access to background must also be given — under fair and reasonable conditions (see above; Article 25.3) and unless it is subject to legal restrictions or limits, including those imposed by the rights of third parties (including personnel) — to affiliated entities¹⁷ established in an EU Member State or ‘**associated country**’¹⁸, if this is needed to exploit the results generated by the beneficiaries to which they are affiliated.

Unless agreed otherwise (see above; Article 25.1), the affiliated entity concerned must make the request directly to the beneficiary that holds the background.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

25.5 Access rights for third parties

Not applicable

25.6 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

¹⁷ For the definition, see ‘affiliated entity’ footnote (Article 14.1).

¹⁸ For the definition, see Article 2.1(3) of the Rules for Participation Regulation No 1290/2013: ‘**associated country**’ means a third country which is party to an international agreement with the Union, as identified in Article 7 of Horizon 2020 Framework Programme Regulation No 1291/2013. Article 7 sets out the conditions for association of non-EU countries to Horizon 2020.

SUBSECTION 3 RIGHTS AND OBLIGATIONS RELATED TO RESULTS

ARTICLE 26 — OWNERSHIP OF RESULTS

26.1 Ownership by the beneficiary that generates the results

Results are owned by the beneficiary that generates them.

‘**Results**’ means any (tangible or intangible) output of the action such as data, knowledge or information — whatever its form or nature, whether it can be protected or not — that is generated in the action, as well as any rights attached to it, including intellectual property rights.

26.2 Joint ownership by several beneficiaries

Two or more beneficiaries own results jointly if:

- (a) they have jointly generated them and
- (b) it is not possible to:
 - (i) establish the respective contribution of each beneficiary, or
 - (ii) separate them for the purpose of applying for, obtaining or maintaining their protection (see Article 27).

The joint owners must agree (in writing) on the allocation and terms of exercise of their joint ownership (**‘joint ownership agreement’**), to ensure compliance with their obligations under this Agreement.

Unless otherwise agreed in the joint ownership agreement, each joint owner may grant non-exclusive licences to third parties to exploit jointly-owned results (without any right to sub-license), if the other joint owners are given:

- (a) at least 45 days advance notice and
- (b) fair and reasonable compensation.

Once the results have been generated, joint owners may agree (in writing) to apply another regime than joint ownership (such as, for instance, transfer to a single owner (see Article 30) with access rights for the others).

26.3 Rights of third parties (including personnel)

If third parties (including personnel) may claim rights to the results, the beneficiary concerned must ensure that it complies with its obligations under the Agreement.

If a third party generates results, the beneficiary concerned must obtain all necessary rights (transfer, licences or other) from the third party, in order to be able to respect its obligations as if those results were generated by the beneficiary itself.

If obtaining the rights is impossible, the beneficiary must refrain from using the third party to generate the results.

26.4 EU ownership, to protect results

26.4.1 The EU may — with the consent of the beneficiary concerned — assume ownership of results to protect them, if a beneficiary intends — up to four years after the period set out in Article 3 — to disseminate its results without protecting them, except in any of the following cases:

- (a) the lack of protection is because protecting the results is not possible, reasonable or justified (given the circumstances);
- (b) the lack of protection is because there is a lack of potential for commercial or industrial exploitation, or
- (c) the beneficiary intends to transfer the results to another beneficiary or third party established in an EU Member State or associated country, which will protect them.

Before the results are disseminated and unless any of the cases above under Points (a), (b) or (c) applies, the beneficiary must formally notify the Commission and at the same time inform it of any reasons for refusing consent. The beneficiary may refuse consent only if it can show that its legitimate interests would suffer significant harm.

If the Commission decides to assume ownership, it will formally notify the beneficiary concerned within 45 days of receiving notification.

No dissemination relating to these results may take place before the end of this period or, if the Commission takes a positive decision, until it has taken the necessary steps to protect the results.

26.4.2 The EU may — with the consent of the beneficiary concerned — assume ownership of results to protect them, if a beneficiary intends — up to four years after the period set out in Article 3 — to stop protecting them or not to seek an extension of protection, except in any of the following cases:

- (a) the protection is stopped because of a lack of potential for commercial or industrial exploitation;
- (b) an extension would not be justified given the circumstances.

A beneficiary that intends to stop protecting results or not seek an extension must — unless any of the cases above under Points (a) or (b) applies — formally notify the Commission at least 60 days before the protection lapses or its extension is no longer possible and at the same time inform it of any reasons for refusing consent. The beneficiary may refuse consent only if it can show that its legitimate interests would suffer significant harm.

If the Commission decides to assume ownership, it will formally notify the beneficiary concerned within 45 days of receiving notification.

26.5 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to the any of the other measures described in Chapter 6.

ARTICLE 27 — PROTECTION OF RESULTS — VISIBILITY OF EU FUNDING

27.1 Obligation to protect the results

Each beneficiary must examine the possibility of protecting its results and must adequately protect them — for an appropriate period and with appropriate territorial coverage — if:

- (a) the results can reasonably be expected to be commercially or industrially exploited and
- (b) protecting them is possible, reasonable and justified (given the circumstances).

When deciding on protection, the beneficiary must consider its own legitimate interests and the legitimate interests (especially commercial) of the other beneficiaries.

27.2 EU ownership, to protect the results

If a beneficiary intends not to protect its results, to stop protecting them or not seek an extension of protection, the EU may — under certain conditions (see Article 26.4) — assume ownership to ensure their (continued) protection.

27.3 Information on EU funding

Applications for protection of results (including patent applications) filed by or on behalf of a beneficiary must — unless the Commission requests or agrees otherwise or unless it is impossible — include the following:

“The project leading to this application has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 847593”.

27.4 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such a breach may also lead to any of the other measures described in Chapter 6.

ARTICLE 28 — EXPLOITATION OF RESULTS

28.1 Obligation to exploit the results

Each beneficiary must — up to four years after the period set out in Article 3 — take measures aiming to ensure ‘**exploitation**’ of its results (either directly or indirectly, in particular through transfer or licensing; see Article 30) by:

- (a) using them in further research activities (outside the action);
- (b) developing, creating or marketing a product or process;
- (c) creating and providing a service, or
- (d) using them in standardisation activities.

This does not change the security obligations in Article 37, which still apply.

28.2 Results that could contribute to European or international standards — Information on EU funding

If results are incorporated in a standard, the beneficiary concerned must — unless the Commission requests or agrees otherwise or unless it is impossible — ask the standardisation body to include the following statement in (information related to) the standard:

“Results incorporated in this standard received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 847593”.

28.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced in accordance with Article 43.

Such a breach may also lead to any of the other measures described in Chapter 6.

ARTICLE 29 — DISSEMINATION OF RESULTS — OPEN ACCESS — VISIBILITY OF EU FUNDING

29.1 Obligation to disseminate results

Unless it goes against their legitimate interests, each beneficiary must — as soon as possible — ‘**disseminate**’ its results by disclosing them to the public by appropriate means (other than those resulting from protecting or exploiting the results), including in scientific publications (in any medium).

This does not change the obligation to protect results in Article 27, the confidentiality obligations in Article 36, the security obligations in Article 37 or the obligations to protect personal data in Article 39, all of which still apply.

A beneficiary that intends to disseminate its results must give advance notice to the other beneficiaries of — unless agreed otherwise — at least 45 days, together with sufficient information on the results it will disseminate.

Any other beneficiary may object within — unless agreed otherwise — 30 days of receiving notification, if it can show that its legitimate interests in relation to the results or background would be significantly harmed. In such cases, the dissemination may not take place unless appropriate steps are taken to safeguard these legitimate interests.

If a beneficiary intends not to protect its results, it may — under certain conditions (see Article 26.4.1) — need to formally notify the Commission before dissemination takes place.

29.2 Open access to scientific publications

Each beneficiary must ensure open access (free of charge online access for any user) to all peer-reviewed scientific publications relating to its results.

In particular, it must:

- (a) as soon as possible and at the latest on publication, deposit a machine-readable electronic

copy of the published version or final peer-reviewed manuscript accepted for publication in a repository for scientific publications;

Moreover, the beneficiary must aim to deposit at the same time the research data needed to validate the results presented in the deposited scientific publications.

- (b) ensure open access to the deposited publication — via the repository — at the latest:
 - (i) on publication, if an electronic version is available for free via the publisher, or
 - (ii) within six months of publication (twelve months for publications in the social sciences and humanities) in any other case.
- (c) ensure open access — via the repository — to the bibliographic metadata that identify the deposited publication.

The bibliographic metadata must be in a standard format and must include all of the following:

- the terms “European Union (EU)” and “Horizon 2020”;
- the name of the action, acronym and grant number;
- the publication date, and length of embargo period if applicable, and
- a persistent identifier.

29.3 Open access to research data

Regarding the digital research data generated in the action (**‘data’**), the beneficiaries must:

- (a) deposit in a research data repository and take measures to make it possible for third parties to access, mine, exploit, reproduce and disseminate — free of charge for any user — the following:
 - (i) the data, including associated metadata, needed to validate the results presented in scientific publications, as soon as possible;
 - (ii) other data, including associated metadata, as specified and within the deadlines laid down in the ‘data management plan’ (see Annex 1);
- (b) provide information — via the repository — about tools and instruments at the disposal of the beneficiaries and necessary for validating the results (and — where possible — provide the tools and instruments themselves).

This does not change the obligation to protect results in Article 27, the confidentiality obligations in Article 36, the security obligations in Article 37 or the obligations to protect personal data in Article 39, all of which still apply.

As an exception, the beneficiaries do not have to ensure open access to specific parts of their research data under Point (a)(i) and (iii), if the achievement of the action's main objective (as described in Annex 1) would be jeopardised by making those specific parts of the research data openly accessible. In this case, the data management plan must contain the reasons for not giving access.

29.4 Information on EU funding — Obligation and right to use the EU emblem

Unless the Commission requests or agrees otherwise or unless it is impossible, any dissemination of results (in any form, including electronic) must:

(a) display the EU emblem and

(b) include the following text:

“This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 847593”.

When displayed together with another logo, the EU emblem must have appropriate prominence.

For the purposes of their obligations under this Article, the beneficiaries may use the EU emblem without first obtaining approval from the Commission.

This does not however give them the right to exclusive use.

Moreover, they may not appropriate the EU emblem or any similar trademark or logo, either by registration or by any other means.

29.5 Disclaimer excluding Commission responsibility

Any dissemination of results must indicate that it reflects only the author's view and that the Commission is not responsible for any use that may be made of the information it contains.

29.6 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such a breach may also lead to any of the other measures described in Chapter 6.

ARTICLE 30 — TRANSFER AND LICENSING OF RESULTS

30.1 Transfer of ownership

Each beneficiary may transfer ownership of its results.

It must however ensure that its obligations under Articles 26.2, 26.4, 27, 28, 29, 30 and 31 also apply to the new owner and that this owner has the obligation to pass them on in any subsequent transfer.

This does not change the security obligations in Article 37, which still apply.

Unless agreed otherwise (in writing) for specifically-identified third parties or unless impossible under applicable EU and national laws on mergers and acquisitions, a beneficiary that intends to transfer ownership of results must give at least 45 days advance notice (or less if agreed in writing) to the other beneficiaries that still have (or still may request) access rights to the results. This notification must include sufficient information on the new owner to enable any beneficiary concerned to assess the effects on its access rights.

Unless agreed otherwise (in writing) for specifically-identified third parties, any other beneficiary may object within 30 days of receiving notification (or less if agreed in writing), if it can show that

the transfer would adversely affect its access rights. In this case, the transfer may not take place until agreement has been reached between the beneficiaries concerned.

30.2 Granting licenses

Each beneficiary may grant licences to its results (or otherwise give the right to exploit them), if:

- (a) this does not impede the access rights under Article 31 and
- (b) not applicable.

In addition to Points (a) and (b), exclusive licences for results may be granted only if all the other beneficiaries concerned have waived their access rights (see Article 31.1).

This does not change the dissemination obligations in Article 29 or security obligations in Article 37, which still apply.

30.3 Commission right to object to transfers or licensing

Not applicable

30.4 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such a breach may also lead to any of the other measures described in Chapter 6.

ARTICLE 31 — ACCESS RIGHTS TO RESULTS

31.1 Exercise of access rights — Waiving of access rights — No sub-licensing

The conditions set out in Article 25.1 apply.

The obligations set out in this Article do not change the security obligations in Article 37, which still apply.

31.2 Access rights for other beneficiaries, for implementing their own tasks under the action

The beneficiaries must give each other access — on a royalty-free basis — to results needed for implementing their own tasks under the action.

31.3 Access rights for other beneficiaries, for exploiting their own results

The beneficiaries must give each other — under fair and reasonable conditions (see Article 25.3) — access to results needed for exploiting their own results.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

31.4 Access rights of affiliated entities

Unless agreed otherwise in the consortium agreement, access to results must also be given — under fair and reasonable conditions (Article 25.3) — to affiliated entities established in an EU Member State or associated country, if this is needed for those entities to exploit the results generated by the beneficiaries to which they are affiliated.

Unless agreed otherwise (see above; Article 31.1), the affiliated entity concerned must make any such request directly to the beneficiary that owns the results.

Requests for access may be made — unless agreed otherwise — up to one year after the period set out in Article 3.

31.5 Access rights for the EU institutions, bodies, offices or agencies and EU Member States

The beneficiaries must give access to their results — on a royalty-free basis — to EU institutions, bodies, offices or agencies, for developing, implementing or monitoring EU policies or programmes.

Such access rights are limited to non-commercial and non-competitive use.

This does not change the right to use any material, document or information received from the beneficiaries for communication and publicising activities (see Article 38.2).

31.6 Access rights for third parties

Not applicable

31.7 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

SECTION 4 OTHER RIGHTS AND OBLIGATIONS

ARTICLE 32 — RECRUITMENT AND WORKING CONDITIONS FOR RESEARCHERS

32.1 Obligation to take measures to implement the European Charter for Researchers and Code of Conduct for the Recruitment of Researchers

The beneficiaries must take all measures to implement the principles set out in the Commission Recommendation on the European Charter for Researchers and the Code of Conduct for the Recruitment of Researchers²⁰, in particular regarding:

- working conditions;
- transparent recruitment processes based on merit, and
- career development.

²⁰ Commission Recommendation 2005/251/EC of 11 March 2005 on the European Charter for Researchers and on a Code of Conduct for the Recruitment of Researchers (OJ L 75, 22.3.2005, p. 67).

The beneficiaries must ensure that researchers and third parties involved in the action are aware of them.

32.2 Consequences of non-compliance

If a beneficiary breaches its obligations under this Article, the Commission may apply any of the measures described in Chapter 6.

ARTICLE 33 — GENDER EQUALITY

33.1 Obligation to aim for gender equality

The beneficiaries must take all measures to promote equal opportunities between men and women in the implementation of the action. They must aim, to the extent possible, for a gender balance at all levels of personnel assigned to the action, including at supervisory and managerial level.

33.2 Consequences of non-compliance

If a beneficiary breaches its obligations under this Article, the Commission may apply any of the measures described in Chapter 6.

ARTICLE 34 — ETHICS AND RESEARCH INTEGRITY

34.1 Obligation to comply with ethical and research integrity principles

The beneficiaries must carry out the action in compliance with:

- (a) ethical principles (including the highest standards of research integrity)

and

- (b) applicable international, EU and national law.

Funding will not be granted for activities carried out outside the EU if they are prohibited in all Member States or for activities which destroy human embryos (for example, for obtaining stem cells).

The beneficiaries must ensure that the activities under the action have an exclusive focus on civil applications.

The beneficiaries must ensure that the activities under the action do not:

- (a) aim at human cloning for reproductive purposes;
- (b) intend to modify the genetic heritage of human beings which could make such changes heritable (with the exception of research relating to cancer treatment of the gonads, which may be financed), or
- (c) intend to create human embryos solely for the purpose of research or for the purpose of stem cell procurement, including by means of somatic cell nuclear transfer.

In addition, the beneficiaries must respect the fundamental principle of research integrity — as set out, for instance, in the European Code of Conduct for Research Integrity²¹.

This implies compliance with the following fundamental principles:

- **reliability** in ensuring the quality of research reflected in the design, the methodology, the analysis and the use of resources;
- **honesty** in developing, undertaking, reviewing, reporting and communicating research in a transparent, fair and unbiased way;
- **respect** for colleagues, research participants, society, ecosystems, cultural heritage and the environment;
- **accountability** for the research from idea to publication, for its management and organisation, for training, supervision and mentoring, and for its wider impacts

and means that beneficiaries must ensure that persons carrying out research tasks follow the good research practices and refrain from the research integrity violations described in this Code.

This does not change the other obligations under this Agreement or obligations under applicable international, EU or national law, all of which still apply.

34.2 Activities raising ethical issues

Activities raising ethical issues must comply with the ‘**ethics requirements**’ set out as deliverables in Annex 1.

Before the beginning of an activity raising an ethical issue, each beneficiary must have obtained:

- (a) any ethics committee opinion required under national law and
- (b) any notification or authorisation for activities raising ethical issues required under national and/or European law

needed for implementing the action tasks in question.

The documents must be kept on file and be submitted upon request by the coordinator to the Commission (see Article 52). If they are not in English, they must be submitted together with an English summary, which shows that the action tasks in question are covered and includes the conclusions of the committee or authority concerned (if available).

34.3 Activities involving human embryos or human embryonic stem cells

Activities involving research on human embryos or human embryonic stem cells may be carried out, in addition to Article 34.1, only if:

- they are set out in Annex 1 or

²¹ European Code of Conduct for Research Integrity of ALLEA (All European Academies)
http://ec.europa.eu/research/participants/data/ref/h2020/other/hi/h2020-ethics_code-of-conduct_en.pdf

- the coordinator has obtained explicit approval (in writing) from the Commission (see Article 52).

34.4 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43) and the Agreement or participation of the beneficiary may be terminated (see Article 50).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 35 — CONFLICT OF INTERESTS

35.1 Obligation to avoid a conflict of interests

The beneficiaries must take all measures to prevent any situation where the impartial and objective implementation of the action is compromised for reasons involving economic interest, political or national affinity, family or emotional ties or any other shared interest (**‘conflict of interests’**).

They must formally notify to the Commission without delay any situation constituting or likely to lead to a conflict of interests and immediately take all the necessary steps to rectify this situation.

The Commission may verify that the measures taken are appropriate and may require additional measures to be taken by a specified deadline.

35.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43) and the Agreement or participation of the beneficiary may be terminated (see Article 50).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 36 — CONFIDENTIALITY

36.1 General obligation to maintain confidentiality

During implementation of the action and for four years after the period set out in Article 3, the parties must keep confidential any data, documents or other material (in any form) that is identified as confidential at the time it is disclosed (**‘confidential information’**).

If a beneficiary requests, the Commission may agree to keep such information confidential for an additional period beyond the initial four years.

If information has been identified as confidential only orally, it will be considered to be confidential only if this is confirmed in writing within 15 days of the oral disclosure.

Unless otherwise agreed between the parties, they may use confidential information only to implement the Agreement.

The beneficiaries may disclose confidential information to their personnel or third parties involved in the action only if they:

- (a) need to know to implement the Agreement and

(b) are bound by an obligation of confidentiality.

This does not change the security obligations in Article 37, which still apply.

The Commission may disclose confidential information to its staff, other EU institutions and bodies. It may disclose confidential information to third parties, if:

- (a) this is necessary to implement the Agreement or safeguard the EU's financial interests and
- (b) the recipients of the information are bound by an obligation of confidentiality.

Under the conditions set out in Article 4 of the Rules for Participation Regulation No 1290/2013²², the Commission must moreover make available information on the results to other EU institutions, bodies, offices or agencies as well as Member States or associated countries.

The confidentiality obligations no longer apply if:

- (a) the disclosing party agrees to release the other party;
- (b) the information was already known by the recipient or is given to him without obligation of confidentiality by a third party that was not bound by any obligation of confidentiality;
- (c) the recipient proves that the information was developed without the use of confidential information;
- (d) the information becomes generally and publicly available, without breaching any confidentiality obligation, or
- (e) the disclosure of the information is required by EU or national law.

36.2 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 37 — SECURITY-RELATED OBLIGATIONS

37.1 Results with a security recommendation

Not applicable

37.2 Classified information

Not applicable

37.3 Activities involving dual-use goods or dangerous materials and substances

²² Regulation (EU) No 1290/2013 of the European Parliament and of the Council of 11 December 2013 laying down the rules for participation and dissemination in "Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020)" (OJ L 347, 20.12.2013 p.81).

Not applicable

37.4 Consequences of non-compliance

Not applicable

ARTICLE 38 — PROMOTING THE ACTION — VISIBILITY OF EU FUNDING

38.1 Communication activities by beneficiaries

38.1.1 Obligation to promote the action and its results

The beneficiaries must promote the action and its results, by providing targeted information to multiple audiences (including the media and the public) in a strategic and effective manner.

This does not change the dissemination obligations in Article 29, the confidentiality obligations in Article 36 or the security obligations in Article 37, all of which still apply.

Before engaging in a communication activity expected to have a major media impact, the beneficiaries must inform the Commission (see Article 52).

38.1.2 Information on EU funding — Obligation and right to use the EU emblem

Unless the Commission requests or agrees otherwise or unless it is impossible, any communication activity related to the action (including in electronic form, via social media, etc.) and any infrastructure, equipment and major results funded by the grant must:

(a) display the EU emblem and

(b) include the following text:

For communication activities:

“This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 847593”.

For infrastructure, equipment and major results:

“This *[infrastructure]/[equipment]/[insert type of result]* is part of a project that has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 847593”.

When displayed together with another logo, the EU emblem must have appropriate prominence.

For the purposes of their obligations under this Article, the beneficiaries may use the EU emblem without first obtaining approval from the Commission.

This does not, however, give them the right to exclusive use.

Moreover, they may not appropriate the EU emblem or any similar trademark or logo, either by registration or by any other means.

38.1.3 Disclaimer excluding Commission responsibility

Any communication activity related to the action must indicate that it reflects only the author's view and that the Commission is not responsible for any use that may be made of the information it contains.

38.2 Communication activities by the Commission

38.2.1 Right to use beneficiaries' materials, documents or information

The Commission may use, for its communication and publicising activities, information relating to the action, documents notably summaries for publication and public deliverables as well as any other material, such as pictures or audio-visual material received from any beneficiary (including in electronic form).

This does not change the confidentiality obligations in Article 36 and the security obligations in Article 37, all of which still apply.

If the Commission's use of these materials, documents or information would risk compromising legitimate interests, the beneficiary concerned may request the Commission not to use it (see Article 52).

The right to use a beneficiary's materials, documents and information includes:

- (a) **use for its own purposes** (in particular, making them available to persons working for the Commission or any other EU institution, body, office or agency or body or institutions in EU Member States; and copying or reproducing them in whole or in part, in unlimited numbers);
- (b) **distribution to the public** (in particular, publication as hard copies and in electronic or digital format, publication on the internet, as a downloadable or non-downloadable file, broadcasting by any channel, public display or presentation, communicating through press information services, or inclusion in widely accessible databases or indexes);
- (c) **editing or redrafting** for communication and publicising activities (including shortening, summarising, inserting other elements (such as meta-data, legends, other graphic, visual, audio or text elements), extracting parts (e.g. audio or video files), dividing into parts, use in a compilation);
- (d) translation;
- (e) giving **access in response to individual requests** under Regulation No 1049/2001²⁴, without the right to reproduce or exploit;
- (f) **storage** in paper, electronic or other form;
- (g) **archiving**, in line with applicable document-management rules, and
- (h) the right to authorise **third parties** to act on its behalf or sub-license the modes of use set out in Points (b), (c), (d) and (f) to third parties if needed for the communication and publicising activities of the Commission.

If the right of use is subject to rights of a third party (including personnel of the beneficiary), the

²⁴ Regulation (EC) No 1049/2001 of the European Parliament and of the Council of 30 May 2001 regarding public access to European Parliament, Council and Commission documents, OJ L 145, 31.5.2001, p. 43.

beneficiary must ensure that it complies with its obligations under this Agreement (in particular, by obtaining the necessary approval from the third parties concerned).

Where applicable (and if provided by the beneficiaries), the Commission will insert the following information:

“© – [year] – [name of the copyright owner]. All rights reserved. Licensed to the European Union (EU) under conditions.”

38.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under this Article, the grant may be reduced (see Article 43).

Such breaches may also lead to any of the other measures described in Chapter 6.

ARTICLE 39 — PROCESSING OF PERSONAL DATA

39.1 Processing of personal data by the Commission

Any personal data under the Agreement will be processed by the Commission under Regulation No 45/2001²⁵ and according to the ‘notifications of the processing operations’ to the Data Protection Officer (DPO) of the Commission (publicly accessible in the DPO register).

Such data will be processed by the ‘**data controller**’ of the Commission for the purposes of implementing, managing and monitoring the Agreement or protecting the financial interests of the EU or Euratom (including checks, reviews, audits and investigations; see Article 22).

The persons whose personal data are processed have the right to access and correct their own personal data. For this purpose, they must send any queries about the processing of their personal data to the data controller, via the contact point indicated in the privacy statement(s) that are published on the Commission websites.

They also have the right to have recourse at any time to the European Data Protection Supervisor (EDPS).

39.2 Processing of personal data by the beneficiaries

The beneficiaries must process personal data under the Agreement in compliance with applicable EU and national law on data protection (including authorisations or notification requirements).

The beneficiaries may grant their personnel access only to data that is strictly necessary for implementing, managing and monitoring the Agreement.

The beneficiaries must inform the personnel whose personal data are collected and processed by the Commission. For this purpose, they must provide them with the privacy statement(s) (see above), before transmitting their data to the Commission.

²⁵ Regulation (EC) No 45/2001 of the European Parliament and of the Council of 18 December 2000 on the protection of individuals with regard to the processing of personal data by the Community institutions and bodies and on the free movement of such data (OJ L 8, 12.01.2001, p. 1).

39.3 Consequences of non-compliance

If a beneficiary breaches any of its obligations under Article 39.2, the Commission may apply any of the measures described in Chapter 6.

ARTICLE 40 — ASSIGNMENTS OF CLAIMS FOR PAYMENT AGAINST THE COMMISSION

The beneficiaries may not assign any of their claims for payment against the Commission to any third party, except if approved by the Commission on the basis of a reasoned, written request by the coordinator (on behalf of the beneficiary concerned).

If the Commission has not accepted the assignment or the terms of it are not observed, the assignment will have no effect on it.

In no circumstances will an assignment release the beneficiaries from their obligations towards the Commission.

CHAPTER 5 DIVISION OF BENEFICIARIES' ROLES AND RESPONSIBILITIES — RELATIONSHIP WITH COMPLEMENTARY BENEFICIARIES — RELATIONSHIP WITH PARTNERS OF A JOINT ACTION

ARTICLE 41 — DIVISION OF BENEFICIARIES' ROLES AND RESPONSIBILITIES — RELATIONSHIP WITH COMPLEMENTARY BENEFICIARIES — RELATIONSHIP WITH PARTNERS OF A JOINT ACTION

41.1 Roles and responsibility towards the Commission

The beneficiaries have full responsibility for implementing the action and complying with the Agreement.

The beneficiaries are jointly and severally liable for the **technical implementation** of the action as described in Annex 1. If a beneficiary fails to implement its part of the action, the other beneficiaries become responsible for implementing this part (without being entitled to any additional EU funding for doing so), unless the Commission expressly relieves them of this obligation.

The **financial responsibility** of each beneficiary is governed by Article 44.

41.2 Internal division of roles and responsibilities

The internal roles and responsibilities of the beneficiaries are divided as follows:

(a) Each **beneficiary** must:

- (i) keep information stored in the Participant Portal Beneficiary Register (via the electronic exchange system) up to date (see Article 17);
- (ii) inform the coordinator immediately of any events or circumstances likely to affect significantly or delay the implementation of the action (see Article 17);

(iii) submit to the coordinator in good time:

- individual financial statements for itself and its linked third parties and, if required, certificates on the financial statements (see Article 20);
- the data needed to draw up the technical reports (see Article 20);
- ethics committee opinions and notifications or authorisations for activities raising ethical issues (see Article 34);
- any other documents or information required by the Commission under the Agreement, unless the Agreement requires the beneficiary to submit this information directly to the Commission.

(b) The **coordinator** must:

- (i) monitor that the action is implemented properly (see Article 7);
- (ii) act as the intermediary for all communications between the beneficiaries and the Commission (in particular, providing the Commission with the information described in Article 17), unless the Agreement specifies otherwise;
- (iii) request and review any documents or information required by the Commission and verify their completeness and correctness before passing them on to the Commission;
- (iv) submit the deliverables and reports to the Commission (see Articles 19 and 20);
- (v) ensure that all payments are made to the other beneficiaries without unjustified delay (see Article 21);
- (vi) inform the Commission of the amounts paid to each beneficiary, when required under the Agreement (see Articles 44 and 50) or requested by the Commission.

The coordinator may not delegate or subcontract the above-mentioned tasks to any other beneficiary or third party (including linked third parties).

41.3 Internal arrangements between beneficiaries — Consortium agreement

The beneficiaries must have internal arrangements regarding their operation and co-ordination to ensure that the action is implemented properly. These internal arrangements must be set out in a written ‘**consortium agreement**’ between the beneficiaries, which may cover:

- internal organisation of the consortium;
- management of access to the electronic exchange system;
- distribution of EU funding;
- additional rules on rights and obligations related to background and results (including whether access rights remain or not, if a beneficiary is in breach of its obligations) (see Section 3 of Chapter 4);

- settlement of internal disputes;
- liability, indemnification and confidentiality arrangements between the beneficiaries.

The consortium agreement must not contain any provision contrary to the Agreement.

41.4 Relationship with complementary beneficiaries — Collaboration agreement

Not applicable

41.5 Relationship with partners of a joint action — Coordination agreement

Not applicable

CHAPTER 6 REJECTION OF COSTS — REDUCTION OF THE GRANT — RECOVERY — SANCTIONS — DAMAGES — SUSPENSION — TERMINATION — FORCE MAJEURE

SECTION 1 REJECTION OF COSTS — REDUCTION OF THE GRANT — RECOVERY — SANCTIONS

ARTICLE 42 — REJECTION OF INELIGIBLE COSTS

42.1 Conditions

The Commission will — after **termination of the participation of a beneficiary**, at the time of an **interim payment, at the payment of the balance or afterwards** — reject any costs which are ineligible (see Article 6), in particular following checks, reviews, audits or investigations (see Article 22).

The rejection may also be based on the **extension of findings from other grants to this grant** (see Article 22.5.2).

42.2 Ineligible costs to be rejected — Calculation — Procedure

Ineligible costs will be rejected in full.

If the rejection of costs does not lead to a recovery (see Article 44), the Commission will formally notify the coordinator or beneficiary concerned of the rejection of costs, the amounts and the reasons why (if applicable, together with the notification of amounts due; see Article 21.5). The coordinator or beneficiary concerned may — within 30 days of receiving notification — formally notify the Commission of its disagreement and the reasons why.

If the rejection of costs leads to a recovery, the Commission will follow the contradictory procedure with pre-information letter set out in Article 44.

42.3 Effects

If the Commission rejects costs at the time of an **interim payment or the payment of the balance**, it will deduct them from the total eligible costs declared, for the action, in the periodic or final summary

financial statement (see Articles 20.3 and 20.4). It will then calculate the interim payment or payment of the balance as set out in Articles 21.3 or 21.4.

If the Commission rejects costs **after termination of the participation of a beneficiary**, it will deduct them from the costs declared by the beneficiary in the termination report and include the rejection in the calculation after termination (see Article 50.2 and 50.3).

If the Commission — **after an interim payment but before the payment of the balance** — rejects costs declared in a periodic summary financial statement, it will deduct them from the total eligible costs declared, for the action, in the next periodic summary financial statement or in the final summary financial statement. It will then calculate the interim payment or payment of the balance as set out in Articles 21.3 or 21.4.

If the Commission rejects costs **after the payment of the balance**, it will deduct the amount rejected from the total eligible costs declared, by the beneficiary, in the final summary financial statement. It will then calculate the revised final grant amount as set out in Article 5.4.

ARTICLE 43 — REDUCTION OF THE GRANT

43.1 Conditions

The Commission may — **after termination of the participation of a beneficiary, at the payment of the balance or afterwards** — reduce the grant, if :

- (a) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has committed:
 - (i) substantial errors, irregularities or fraud or
 - (ii) serious breach of obligations under the Agreement or during the award procedure (including improper implementation of the action, submission of false information, failure to provide requested information, breach of ethical principles) or
- (b) a beneficiary (or a natural person who has the power to represent or take decision on its behalf) has committed — in other EU or Euratom grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant (**extension of findings from other grants to this grant**; see Article 22.5.2).

43.2 Amount to be reduced — Calculation — Procedure

The amount of the reduction will be proportionate to the seriousness of the errors, irregularities or fraud or breach of obligations.

Before reduction of the grant, the Commission will formally notify a ‘**pre-information letter**’ to the coordinator or beneficiary concerned:

- informing it of its intention to reduce the grant, the amount it intends to reduce and the reasons why and
- inviting it to submit observations within 30 days of receiving notification

If the Commission does not receive any observations or decides to pursue reduction despite the observations it has received, it will formally notify **confirmation** of the reduction (if applicable, together with the notification of amounts due; see Article 21).

43.3 Effects

If the Commission reduces the grant **after termination of the participation of a beneficiary**, it will calculate the reduced grant amount for that beneficiary and then determine the amount due to that beneficiary (see Article 50.2 and 50.3).

If the Commission reduces the grant **at the time of the payment of the balance**, it will calculate the reduced grant amount for the action and then determine the amount due as payment of the balance (see Articles 5.3.4 and 21.4).

If the Commission reduces the grant **after the payment of the balance**, it will calculate the revised final grant amount for the beneficiary concerned (see Article 5.4). If the revised final grant amount for the beneficiary concerned is lower than its share of the final grant amount, the Commission will recover the difference (see Article 44).

ARTICLE 44 — RECOVERY OF UNDUE AMOUNTS

44.1 Amount to be recovered — Calculation — Procedure

The Commission will — after **termination of the participation of a beneficiary, at the payment of the balance or afterwards** — claim back any amount that was paid, but is not due under the Agreement.

Each beneficiary's financial responsibility in case of recovery is limited to its own debt (including undue amounts paid by the Commission for costs declared by its linked third parties), except for the amount retained for the Guarantee Fund (see Article 21.4).

44.1.1 Recovery after termination of a beneficiary's participation

If recovery takes place after termination of a beneficiary's participation (including the coordinator), the Commission will claim back the undue amount from the beneficiary concerned, by formally notifying it a debit note (see Article 50.2 and 50.3). This note will specify the amount to be recovered, the terms and the date for payment.

If payment is not made by the date specified in the debit note, the Commission will **recover** the amount:

- (a) by '**offsetting**' it — without the beneficiary's consent — against any amounts owed to the beneficiary concerned by the Commission or an executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU's financial interests, the Commission may offset before the payment date specified in the debit note;

- (b) not applicable;

- (c) by **taking legal action** (see Article 57) or by **adopting an enforceable decision** under

Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial regulation No 966/2012.

If payment is not made by the date specified in the debit note, the amount to be recovered (see above) will be increased by **late-payment interest** at the rate set out in Article 21.11, from the day following the payment date in the debit note, up to and including the date the Commission receives full payment of the amount.

Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2007/64/EC²⁶ applies.

44.1.2 Recovery at payment of the balance

If the payment of the balance takes the form of a recovery (see Article 21.4), the Commission will formally notify a ‘**pre-information letter**’ to the coordinator:

- informing it of its intention to recover, the amount due as the balance and the reasons why;
- specifying that it intends to deduct the amount to be recovered from the amount retained for the Guarantee Fund;
- requesting the coordinator to submit a report on the distribution of payments to the beneficiaries within 30 days of receiving notification, and
- inviting the coordinator to submit observations within 30 days of receiving notification.

If no observations are submitted or the Commission decides to pursue recovery despite the observations it has received, it will **confirm recovery** (together with the notification of amounts due; see Article 21.5) and:

- pay the difference between the amount to be recovered and the amount retained for the Guarantee Fund, **if the difference is positive** or
- formally notify to the coordinator a **debit note** for the difference between the amount to be recovered and the amount retained for the Guarantee Fund, **if the difference is negative**. This note will also specify the terms and the date for payment.

If the coordinator does not repay the Commission by the date in the debit note and has not submitted the report on the distribution of payments: the Commission will **recover** the amount set out in the debit note from the coordinator (see below).

If the coordinator does not repay the Commission by the date in the debit note, but has submitted the report on the distribution of payments: the Commission will:

- (a) identify the beneficiaries for which the amount calculated as follows is negative:

²⁶ Directive 2007/64/EC of the European Parliament and of the Council of 13 November 2007 on payment services in the internal market amending Directives 97/7/EC, 2002/65/EC, 2005/60/EC and 2006/48/EC and repealing Directive 97/5/EC (OJ L 319, 05.12.2007, p. 1).

{ { { {beneficiary's costs declared in the final summary financial statement and approved by the Commission multiplied by the reimbursement rate set out in Article 5.2 for the beneficiary concerned
plus

its linked third parties' costs declared in the final summary financial statement and approved by the Commission multiplied by the reimbursement rate set out in Article 5.2 for each linked third party concerned}

divided by

the EU contribution for the action calculated according to Article 5.3.1}

multiplied by

the final grant amount (see Article 5.3)},

minus

{pre-financing and interim payments received by the beneficiary}}.

- (b) formally notify to each beneficiary identified according to point (a) a **debit note** specifying the terms and date for payment. The amount of the debit note is calculated as follows:

{ {amount calculated according to point (a) for the beneficiary concerned

divided by

the sum of the amounts calculated according to point (a) for all the beneficiaries identified according to point (a)}

multiplied by

the amount set out in the debit note formally notified to the coordinator}.

If payment is not made by the date specified in the debit note, the Commission will **recover** the amount:

- (a) by **offsetting** it — without the beneficiary's consent — against any amounts owed to the beneficiary concerned by the Commission or an executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU's financial interests, the Commission may offset before the payment date specified in the debit note;

- (b) by **drawing on the Guarantee Fund**. The Commission will formally notify the beneficiary concerned the debit note on behalf of the Guarantee Fund and recover the amount:

- (i) not applicable;

- (ii) by **taking legal action** (see Article 57) or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial Regulation No 966/2012.

If payment is not made by the date in the debit note, the amount to be recovered (see above) will be increased by **late-payment interest** at the rate set out in Article 21.11, from the day following the

payment date in the debit note, up to and including the date the Commission receives full payment of the amount.

Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2007/64/EC applies.

44.1.3 Recovery of amounts after payment of the balance

If, for a beneficiary, the revised final grant amount (see Article 5.4) is lower than its share of the final grant amount, it must repay the difference to the Commission.

The beneficiary's share of the final grant amount is calculated as follows:

$$\left\{ \left\{ \begin{array}{l} \text{beneficiary's costs declared in the final summary financial statement and approved by the Commission} \\ \text{multiplied by the reimbursement rate set out in Article 5.2 for the beneficiary concerned} \end{array} \right\} \right.$$

plus

$$\left\{ \begin{array}{l} \text{its linked third parties' costs declared in the final summary financial statement and approved by the Commission} \\ \text{multiplied by the reimbursement rate set out in Article 5.2 for each linked third party concerned} \end{array} \right\}$$

divided by

$$\left\{ \begin{array}{l} \text{the EU contribution for the action calculated according to Article 5.3.1} \end{array} \right\}$$

multiplied by

$$\left\{ \begin{array}{l} \text{the final grant amount (see Article 5.3)} \end{array} \right\}.$$

If the coordinator has not distributed amounts received (see Article 21.7), the Commission will also recover these amounts.

The Commission will formally notify a **pre-information letter** to the beneficiary concerned:

- informing it of its intention to recover, the due amount and the reasons why and
- inviting it to submit observations within 30 days of receiving notification.

If no observations are submitted or the Commission decides to pursue recovery despite the observations it has received, it will **confirm** the amount to be recovered and formally notify to the beneficiary concerned a **debit note**. This note will also specify the terms and the date for payment.

If payment is not made by the date specified in the debit note, the Commission will **recover** the amount:

- (a) by **offsetting** it — without the beneficiary's consent — against any amounts owed to the beneficiary concerned by the Commission or an executive agency (from the EU or Euratom budget).

In exceptional circumstances, to safeguard the EU's financial interests, the Commission may offset before the payment date specified in the debit note;

(b) by **drawing on the Guarantee Fund**. The Commission will formally notify the beneficiary concerned the debit note on behalf of the Guarantee Fund and recover the amount:

- (i) not applicable;
- (ii) by **taking legal action** (see Article 57) or by **adopting an enforceable decision** under Article 299 of the Treaty on the Functioning of the EU (TFEU) and Article 79(2) of the Financial Regulation No 966/2012.

If payment is not made by the date in the debit note, the amount to be recovered (see above) will be increased by **late-payment interest** at the rate set out in Article 21.11, from the day following the date for payment in the debit note, up to and including the date the Commission receives full payment of the amount.

Partial payments will be first credited against expenses, charges and late-payment interest and then against the principal.

Bank charges incurred in the recovery process will be borne by the beneficiary, unless Directive 2007/64/EC applies.

ARTICLE 45 — ADMINISTRATIVE SANCTIONS

In addition to contractual measures, the Commission may also adopt administrative sanctions under Articles 106 and 131(4) of the Financial Regulation No 966/2012 (i.e. exclusion from future procurement contracts, grants, prizes and expert contracts and/or financial penalties).

SECTION 2 LIABILITY FOR DAMAGES

ARTICLE 46 — LIABILITY FOR DAMAGES

46.1 Liability of the Commission

The Commission cannot be held liable for any damage caused to the beneficiaries or to third parties as a consequence of implementing the Agreement, including for gross negligence.

The Commission cannot be held liable for any damage caused by any of the beneficiaries or third parties involved in the action, as a consequence of implementing the Agreement.

46.2 Liability of the beneficiaries

Except in case of force majeure (see Article 51), the beneficiaries must compensate the Commission for any damage it sustains as a result of the implementation of the action or because the action was not implemented in full compliance with the Agreement.

SECTION 3 SUSPENSION AND TERMINATION

ARTICLE 47 — SUSPENSION OF PAYMENT DEADLINE

47.1 Conditions

The Commission may — at any moment — suspend the payment deadline (see Article 21.2 to 21.4) if a request for payment (see Article 20) cannot be approved because:

- (a) it does not comply with the provisions of the Agreement (see Article 20);
- (b) the technical or financial reports have not been submitted or are not complete or additional information is needed, or
- (c) there is doubt about the eligibility of the costs declared in the financial statements and additional checks, reviews, audits or investigations are necessary.

47.2 Procedure

The Commission will formally notify the coordinator of the suspension and the reasons why.

The suspension will **take effect** the day notification is sent by the Commission (see Article 52).

If the conditions for suspending the payment deadline are no longer met, the suspension will be **lifted** — and the remaining period will resume.

If the suspension exceeds two months, the coordinator may request the Commission if the suspension will continue.

If the payment deadline has been suspended due to the non-compliance of the technical or financial reports (see Article 20) and the revised report or statement is not submitted or was submitted but is also rejected, the Commission may also terminate the Agreement or the participation of the beneficiary (see Article 50.3.1(l)).

ARTICLE 48 — SUSPENSION OF PAYMENTS

48.1 Conditions

The Commission may — at any moment — suspend payments, in whole or in part and interim payments or the payment of the balance for one or more beneficiaries, if:

- (a) a beneficiary (or a natural person who has the power to represent or take decision on its behalf) has committed or is suspected of having committed:
 - (i) substantial errors, irregularities or fraud or
 - (ii) serious breach of obligations under the Agreement or during the award procedure (including improper implementation of the action, submission of false information, failure to provide required information, breach of ethical principles) or
- (b) a beneficiary (or a natural person who has the power to represent or take decision on its behalf) has committed — in other EU or Euratom grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant (**extension of findings from other grants to this grant**; see Article 22.5.2).

If payments are suspended for one or more beneficiaries, the Commission will make partial payment(s) for the part(s) not suspended. If suspension concerns the payment of the balance, — once suspension

is lifted — the payment or the recovery of the amount(s) concerned will be considered the payment of the balance that closes the action.

48.2 Procedure

Before suspending payments, the Commission will formally notify the coordinator or beneficiary concerned:

- informing it of its intention to suspend payments and the reasons why and
- inviting it to submit observations within 30 days of receiving notification.

If the Commission does not receive observations or decides to pursue the procedure despite the observations it has received, it will formally notify **confirmation** of the suspension. Otherwise, it will formally notify that the suspension procedure is not continued.

The suspension will **take effect** the day the confirmation notification is sent by the Commission.

If the conditions for resuming payments are met, the suspension will be **lifted**. The Commission will formally notify the coordinator or beneficiary concerned.

During the suspension, the periodic report(s) for all reporting periods except the last one (see Article 20.3), must not contain any individual financial statements from the beneficiary concerned and its linked third parties. The coordinator must include them in the next periodic report after the suspension is lifted or — if suspension is not lifted before the end of the action — in the last periodic report.

The beneficiaries may suspend implementation of the action (see Article 49.1) or terminate the Agreement or the participation of the beneficiary concerned (see Article 50.1 and 50.2).

ARTICLE 49 — SUSPENSION OF THE ACTION IMPLEMENTATION

49.1 Suspension of the action implementation, by the beneficiaries

49.1.1 Conditions

The beneficiaries may suspend implementation of the action or any part of it, if exceptional circumstances — in particular *force majeure* (see Article 51) — make implementation impossible or excessively difficult.

49.1.2 Procedure

The coordinator must immediately formally notify to the Commission the suspension (see Article 52), stating:

- the reasons why and
- the expected date of resumption.

The suspension will **take effect** the day this notification is received by the Commission.

Once circumstances allow for implementation to resume, the coordinator must immediately formally

notify the Commission and request an **amendment** of the Agreement to set the date on which the action will be resumed, extend the duration of the action and make other changes necessary to adapt the action to the new situation (see Article 55) — unless the Agreement or the participation of a beneficiary has been terminated (see Article 50).

The suspension will be **lifted** with effect from the resumption date set out in the amendment. This date may be before the date on which the amendment enters into force.

Costs incurred during suspension of the action implementation are not eligible (see Article 6).

49.2 Suspension of the action implementation, by the Commission

49.2.1 Conditions

The Commission may suspend implementation of the action or any part of it, if:

- (a) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has committed or is suspected of having committed:
 - (i) substantial errors, irregularities or fraud or
 - (ii) serious breach of obligations under the Agreement or during the award procedure (including improper implementation of the action, submission of false information, failure to provide required information, breach of ethical principles);
- (b) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has committed — in other EU or Euratom grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant (**extension of findings from other grants to this grant**; see Article 22.5.2), or
- (c) the action is suspected of having lost its scientific or technological relevance.

49.2.2 Procedure

Before suspending implementation of the action, the Commission will formally notify the coordinator or beneficiary concerned:

- informing it of its intention to suspend the implementation and the reasons why and
- inviting it to submit observations within 30 days of receiving notification.

If the Commission does not receive observations or decides to pursue the procedure despite the observations it has received, it will formally notify **confirmation** of the suspension. Otherwise, it will formally notify that the procedure is not continued.

The suspension will **take effect** five days after confirmation notification is received (or on a later date specified in the notification).

It will be **lifted** if the conditions for resuming implementation of the action are met.

The coordinator or beneficiary concerned will be formally notified of the lifting and the Agreement will be **amended** to set the date on which the action will be resumed, extend the duration of the action

and make other changes necessary to adapt the action to the new situation (see Article 55) — unless the Agreement has already been terminated (see Article 50).

The suspension will be lifted with effect from the resumption date set out in the amendment. This date may be before the date on which the amendment enters into force.

Costs incurred during suspension are not eligible (see Article 6).

The beneficiaries may not claim damages due to suspension by the Commission (see Article 46).

Suspension of the action implementation does not affect the Commission's right to terminate the Agreement or participation of a beneficiary (see Article 50), reduce the grant or recover amounts unduly paid (see Articles 43 and 44).

ARTICLE 50 — TERMINATION OF THE AGREEMENT OR OF THE PARTICIPATION OF ONE OR MORE BENEFICIARIES

50.1 Termination of the Agreement, by the beneficiaries

50.1.1 Conditions and procedure

The beneficiaries may terminate the Agreement.

The coordinator must formally notify termination to the Commission (see Article 52), stating:

- the reasons why and
- the date the termination will take effect. This date must be after the notification.

If no reasons are given or if the Commission considers the reasons do not justify termination, the Agreement will be considered to have been '**terminated improperly**'.

The termination will **take effect** on the day specified in the notification.

50.1.2 Effects

The coordinator must — within 60 days from when termination takes effect — submit:

- (i) a periodic report (for the open reporting period until termination; see Article 20.3) and
- (ii) the final report (see Article 20.4).

If the Commission does not receive the reports within the deadline (see above), only costs which are included in an approved periodic report will be taken into account.

The Commission will **calculate** the final grant amount (see Article 5.3) and the balance (see Article 21.4) on the basis of the reports submitted. Only costs incurred until termination are eligible (see Article 6). Costs relating to contracts due for execution only after termination are not eligible.

Improper termination may lead to a reduction of the grant (see Article 43).

After termination, the beneficiaries' obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38, 40, 42, 43 and 44) continue to apply.

50.2 Termination of the participation of one or more beneficiaries, by the beneficiaries

50.2.1 Conditions and procedure

The participation of one or more beneficiaries may be terminated by the coordinator, on request of the beneficiary concerned or on behalf of the other beneficiaries.

The coordinator must formally notify termination to the Commission (see Article 52) and inform the beneficiary concerned.

If the coordinator's participation is terminated without its agreement, the formal notification must be done by another beneficiary (acting on behalf of the other beneficiaries).

The notification must include:

- the reasons why;
- the opinion of the beneficiary concerned (or proof that this opinion has been requested in writing);
- the date the termination takes effect. This date must be after the notification, and
- a request for amendment (see Article 55), with a proposal for reallocation of the tasks and the estimated budget of the beneficiary concerned (see Annexes 1 and 2) and, if necessary, the addition of one or more new beneficiaries (see Article 56). If termination takes effect after the period set out in Article 3, no request for amendment must be included unless the beneficiary concerned is the coordinator. In this case, the request for amendment must propose a new coordinator.

If this information is not given or if the Commission considers that the reasons do not justify termination, the participation will be considered to have been **terminated improperly**.

The termination will **take effect** on the day specified in the notification.

50.2.2 Effects

The coordinator must — within 30 days from when termination takes effect — submit:

- (i) a report on the distribution of payments to the beneficiary concerned and
- (ii) if termination takes effect during the period set out in Article 3, a '**termination report**' from the beneficiary concerned, for the open reporting period until termination, containing an overview of the progress of the work, an overview of the use of resources, the individual financial statement and, if applicable, the certificate on the financial statement (see Articles 20.3 and 20.4).

The information in the termination report must also be included in the periodic report for the next reporting period (see Article 20.3).

If the request for amendment is rejected by the Commission (because it calls into question the decision awarding the grant or breaches the principle of equal treatment of applicants), the Agreement may be terminated according to Article 50.3.1(c).

If the request for amendment is accepted by the Commission, the Agreement is **amended** to introduce the necessary changes (see Article 55).

The Commission will — on the basis of the periodic reports, the termination report and the report on the distribution of payments — **calculate** the amount which is due to the beneficiary and if the (pre-financing and interim) payments received by the beneficiary exceed this amount.

The **amount which is due** is calculated in the following steps:

Step 1 — Application of the reimbursement rate to the eligible costs

The grant amount for the beneficiary is calculated by applying the reimbursement rate(s) to the total eligible costs declared by the beneficiary and its linked third parties in the termination report and approved by the Commission.

Only costs incurred by the beneficiary concerned until termination takes effect are eligible (see Article 6). Costs relating to contracts due for execution only after termination are not eligible.

Step 2 — Reduction due to substantial errors, irregularities or fraud or serious breach of obligations

In case of a reduction (see Article 43), the Commission will calculate the reduced grant amount for the beneficiary by deducting the amount of the reduction (calculated in proportion to the seriousness of the errors, irregularities or fraud or breach of obligations, in accordance with Article 43.2) from the grant amount for the beneficiary.

If the payments received **exceed the amounts due**:

- if termination takes effect during the period set out in Article 3 and the request for amendment is accepted, the beneficiary concerned must repay to the coordinator the amount unduly received. The Commission will formally notify the amount unduly received and request the beneficiary concerned to repay it to the coordinator within 30 days of receiving notification. If it does not repay the coordinator, the Commission will draw upon the Guarantee Fund to pay the coordinator and then notify a **debit note** on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);
- in all other cases, in particular if termination takes effect after the period set out in Article 3, the Commission will formally notify a **debit note** to the beneficiary concerned. If payment is not made by the date in the debit note, the Guarantee Fund will pay to the Commission the amount due and the Commission will notify a debit note on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);
- if the beneficiary concerned is the former coordinator, it must repay the new coordinator according to the procedure above, unless:
 - termination takes effect after an interim payment and
 - the former coordinator has not distributed amounts received as pre-financing or interim payments (see Article 21.7).

In this case, the Commission will formally notify a **debit note** to the former coordinator. If payment is not made by the date in the debit note, the Guarantee Fund will pay to the Commission the amount due. The Commission will then pay the new coordinator and notify a debit note on behalf of the Guarantee Fund to the former coordinator (see Article 44).

If the payments received **do not exceed the amounts due**: amounts owed to the beneficiary concerned will be included in the next interim or final payment.

If the Commission does not receive the termination report within the deadline (see above), only costs included in an approved periodic report will be taken into account.

If the Commission does not receive the report on the distribution of payments within the deadline (see above), it will consider that:

- the coordinator did not distribute any payment to the beneficiary concerned and that
- the beneficiary concerned must not repay any amount to the coordinator.

Improper termination may lead to a reduction of the grant (see Article 43) or termination of the Agreement (see Article 50).

After termination, the concerned beneficiary's obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38, 40, 42, 43 and 44) continue to apply.

50.3 Termination of the Agreement or the participation of one or more beneficiaries, by the Commission

50.3.1 Conditions

The Commission may terminate the Agreement or the participation of one or more beneficiaries, if:

- (a) one or more beneficiaries do not accede to the Agreement (see Article 56);
- (b) a change to their legal, financial, technical, organisational or ownership situation (or those of its linked third parties) is likely to substantially affect or delay the implementation of the action or calls into question the decision to award the grant;
- (c) following termination of participation for one or more beneficiaries (see above), the necessary changes to the Agreement would call into question the decision awarding the grant or breach the principle of equal treatment of applicants (see Article 55);
- (d) implementation of the action is prevented by force majeure (see Article 51) or suspended by the coordinator (see Article 49.1) and either:
 - (i) resumption is impossible, or
 - (ii) the necessary changes to the Agreement would call into question the decision awarding the grant or breach the principle of equal treatment of applicants;
- (e) a beneficiary is declared bankrupt, being wound up, having its affairs administered by the courts, has entered into an arrangement with creditors, has suspended business activities, or is subject to any other similar proceedings or procedures under national law;

- (f) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has been found guilty of professional misconduct, proven by any means;
- (g) a beneficiary does not comply with the applicable national law on taxes and social security;
- (h) the action has lost scientific or technological relevance;
- (i) not applicable;
- (j) not applicable;
- (k) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has committed fraud, corruption, or is involved in a criminal organisation, money laundering or any other illegal activity;
- (l) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has committed:
 - (i) substantial errors, irregularities or fraud or
 - (ii) serious breach of obligations under the Agreement or during the award procedure (including improper implementation of the action, submission of false information, failure to provide required information, breach of ethical principles);
- (m) a beneficiary (or a natural person who has the power to represent or take decisions on its behalf) has committed — in other EU or Euratom grants awarded to it under similar conditions — systemic or recurrent errors, irregularities, fraud or serious breach of obligations that have a material impact on this grant (**extension of findings from other grants to this grant**; see Article 22.5.2);
- (n) despite a specific request by the Commission, a beneficiary does not request — through the coordinator — an amendment to the Agreement to end the participation of one of its linked third parties or international partners that is in one of the situations under points (e), (f), (g), (k), (l) or (m) and to reallocate its tasks.

50.3.2 Procedure

Before terminating the Agreement or participation of one or more beneficiaries, the Commission will formally notify the coordinator or beneficiary concerned:

- informing it of its intention to terminate and the reasons why and
- inviting it, within 30 days of receiving notification, to submit observations and — in case of Point (l.ii) above — to inform the Commission of the measures to ensure compliance with the obligations under the Agreement.

If the Commission does not receive observations or decides to pursue the procedure despite the observations it has received, it will formally notify to the coordinator or beneficiary concerned **confirmation** of the termination and the date it will take effect. Otherwise, it will formally notify that the procedure is not continued.

The termination will **take effect**:

- for terminations under Points (b), (c), (e), (g), (h), (j), (l.ii) and (n) above: on the day specified in the notification of the confirmation (see above);
- for terminations under Points (a), (d), (f), (i), (k), (l.i) and (m) above: on the day after the notification of the confirmation is received.

50.3.3 Effects

(a) for **termination of the Agreement**:

The coordinator must — within 60 days from when termination takes effect — submit:

- (i) a periodic report (for the last open reporting period until termination; see Article 20.3) and
- (ii) a final report (see Article 20.4).

If the Agreement is terminated for breach of the obligation to submit reports (see Articles 20.8 and 50.3.1(l)), the coordinator may not submit any reports after termination.

If the Commission does not receive the reports within the deadline (see above), only costs which are included in an approved periodic report will be taken into account.

The Commission will **calculate** the final grant amount (see Article 5.3) and the balance (see Article 21.4) on the basis of the reports submitted. Only costs incurred until termination takes effect are eligible (see Article 6). Costs relating to contracts due for execution only after termination are not eligible.

This does not affect the Commission's right to reduce the grant (see Article 43) or to impose administrative sanctions (Article 45).

The beneficiaries may not claim damages due to termination by the Commission (see Article 46).

After termination, the beneficiaries' obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38, 40, 42, 43 and 44) continue to apply.

(b) for **termination of the participation of one or more beneficiaries**:

The coordinator must — within 60 days from when termination takes effect — submit:

- (i) a report on the distribution of payments to the beneficiary concerned;
- (ii) a request for amendment (see Article 55), with a proposal for reallocation of the tasks and estimated budget of the beneficiary concerned (see Annexes 1 and 2) and, if necessary, the addition of one or more new beneficiaries (see Article 56). If termination is notified after the period set out in Article 3, no request for amendment must be submitted unless the beneficiary concerned is the coordinator. In this case the request for amendment must propose a new coordinator, and
- (iii) if termination takes effect during the period set out in Article 3, a **termination report** from the beneficiary concerned, for the open reporting period until termination, containing an overview of the progress of the work, an overview of the use of resources,

the individual financial statement and, if applicable, the certificate on the financial statement (see Article 20).

The information in the termination report must also be included in the periodic report for the next reporting period (see Article 20.3).

If the request for amendment is rejected by the Commission (because it calls into question the decision awarding the grant or breaches the principle of equal treatment of applicants), the Agreement may be terminated according to Article 50.3.1(c).

If the request for amendment is accepted by the Commission, the Agreement is **amended** to introduce the necessary changes (see Article 55).

The Commission will — on the basis of the periodic reports, the termination report and the report on the distribution of payments — **calculate** the amount which is due to the beneficiary and if the (pre-financing and interim) payments received by the beneficiary exceed this amount.

The **amount which is due** is calculated in the following steps:

Step 1 — Application of the reimbursement rate to the eligible costs

The grant amount for the beneficiary is calculated by applying the reimbursement rate(s) to the total eligible costs declared by the beneficiary and its linked third parties in the termination report and approved by the Commission.

Only costs incurred by the beneficiary concerned until termination takes effect are eligible (see Article 6). Costs relating to contracts due for execution only after termination are not eligible.

Step 2 — Reduction due to substantial errors, irregularities or fraud or serious breach of obligations

In case of a reduction (see Article 43), the Commission will calculate the reduced grant amount for the beneficiary by deducting the amount of the reduction (calculated in proportion to the seriousness of the errors, irregularities or fraud or breach of obligations, in accordance with Article 43.2) from the grant amount for the beneficiary.

If the payments received **exceed the amounts due**:

- if termination takes effect during the period set out in Article 3 and the request for amendment is accepted, the beneficiary concerned must repay to the coordinator the amount unduly received. The Commission will formally notify the amount unduly received and request the beneficiary concerned to repay it to the coordinator within 30 days of receiving notification. If it does not repay the coordinator, the Commission will draw upon the Guarantee Fund to pay the coordinator and then notify a **debit note** on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);
- in all other cases, in particular if termination takes effect after the period set out in Article 3, the Commission will formally notify a **debit note** to the beneficiary concerned. If payment is not made by the date in the debit note, the Guarantee Fund

will pay to the Commission the amount due and the Commission will notify a debit note on behalf of the Guarantee Fund to the beneficiary concerned (see Article 44);

- if the beneficiary concerned is the former coordinator, it must repay the new coordinator according to the procedure above, unless:
 - termination takes effect after an interim payment and
 - the former coordinator has not distributed amounts received as pre-financing or interim payments (see Article 21.7).

In this case, the Commission will formally notify a **debit note** to the former coordinator. If payment is not made by the date in the debit note, the Guarantee Fund will pay to the Commission the amount due. The Commission will then pay the new coordinator and notify a debit note on behalf of the Guarantee Fund to the former coordinator (see Article 44).

If the payments received **do not exceed the amounts due**: amounts owed to the beneficiary concerned will be included in the next interim or final payment.

If the Commission does not receive the termination report within the deadline (see above), only costs included in an approved periodic report will be taken into account.

If the Commission does not receive the report on the distribution of payments within the deadline (see above), it will consider that:

- the coordinator did not distribute any payment to the beneficiary concerned and that
- the beneficiary concerned must not repay any amount to the coordinator.

After termination, the concerned beneficiary's obligations (in particular Articles 20, 22, 23, Section 3 of Chapter 4, 36, 37, 38, 40, 42, 43 and 44) continue to apply.

SECTION 4 FORCE MAJEURE

ARTICLE 51 — FORCE MAJEURE

‘Force majeure’ means any situation or event that:

- prevents either party from fulfilling their obligations under the Agreement,
- was unforeseeable, exceptional situation and beyond the parties' control,
- was not due to error or negligence on their part (or on the part of third parties involved in the action), and
- proves to be inevitable in spite of exercising all due diligence.

The following cannot be invoked as force majeure:

- any default of a service, defect in equipment or material or delays in making them available, unless they stem directly from a relevant case of force majeure,

- labour disputes or strikes, or
- financial difficulties.

Any situation constituting force majeure must be formally notified to the other party without delay, stating the nature, likely duration and foreseeable effects.

The parties must immediately take all the necessary steps to limit any damage due to force majeure and do their best to resume implementation of the action as soon as possible.

The party prevented by force majeure from fulfilling its obligations under the Agreement cannot be considered in breach of them.

CHAPTER 7 FINAL PROVISIONS

ARTICLE 52 — COMMUNICATION BETWEEN THE PARTIES

52.1 Form and means of communication

Communication under the Agreement (information, requests, submissions, ‘formal notifications’, etc.) must:

- be made in writing and
- bear the number of the Agreement.

All communication must be made through the Participant Portal **electronic** exchange system and using the forms and templates provided there.

If — after the payment of the balance — the Commission finds that a formal notification was not accessed, a second formal notification will be made by registered post with proof of delivery (‘formal notification on **paper**’). Deadlines will be calculated from the moment of the second notification.

Communications in the electronic exchange system must be made by persons authorised according to the Participant Portal Terms & Conditions. For naming the authorised persons, each beneficiary must have designated — before the signature of this Agreement — a ‘legal entity appointed representative (LEAR)’. The role and tasks of the LEAR are stipulated in his/her appointment letter (see Participant Portal Terms & Conditions).

If the electronic exchange system is temporarily unavailable, instructions will be given on the Commission website.

52.2 Date of communication

Communications are considered to have been made when they are sent by the sending party (i.e. on the date and time they are sent through the electronic exchange system).

Formal notifications through the **electronic** exchange system are considered to have been made when they are received by the receiving party (i.e. on the date and time of acceptance by the receiving party, as indicated by the time stamp). A formal notification that has not been accepted within 10 days after sending is considered to have been accepted.

Formal notifications **on paper** sent by **registered post** with proof of delivery (only after the payment of the balance) are considered to have been made on either:

- the delivery date registered by the postal service or
- the deadline for collection at the post office.

If the electronic exchange system is temporarily unavailable, the sending party cannot be considered in breach of its obligation to send a communication within a specified deadline.

52.3 Addresses for communication

The **electronic** exchange system must be accessed via the following URL:

<https://ec.europa.eu/research/participants/portal/desktop/en/projects/>

The Commission will formally notify the coordinator and beneficiaries in advance any changes to this URL.

Formal notifications on paper (only after the payment of the balance) addressed **to the Commission** must be sent to the official mailing address indicated on the Commission's website.

Formal notifications on paper (only after the payment of the balance) addressed **to the beneficiaries** must be sent to their legal address as specified in the Participant Portal Beneficiary Register.

ARTICLE 53 — INTERPRETATION OF THE AGREEMENT

53.1 Precedence of the Terms and Conditions over the Annexes

The provisions in the Terms and Conditions of the Agreement take precedence over its Annexes.

Annex 2 takes precedence over Annex 1.

53.2 Privileges and immunities

Not applicable

ARTICLE 54 — CALCULATION OF PERIODS, DATES AND DEADLINES

In accordance with Regulation No 1182/71²⁷, periods expressed in days, months or years are calculated from the moment the triggering event occurs.

The day during which that event occurs is not considered as falling within the period.

ARTICLE 55 — AMENDMENTS TO THE AGREEMENT

55.1 Conditions

The Agreement may be amended, unless the amendment entails changes to the Agreement which

²⁷ Regulation (EEC, Euratom) No 1182/71 of the Council of 3 June 1971 determining the rules applicable to periods, dates and time-limits (OJ L 124, 8.6.1971, p. 1).

would call into question the decision awarding the grant or breach the principle of equal treatment of applicants.

Amendments may be requested by any of the parties.

55.2 Procedure

The party requesting an amendment must submit a request for amendment signed in the electronic exchange system (see Article 52).

The coordinator submits and receives requests for amendment on behalf of the beneficiaries (see Annex 3).

If a change of coordinator is requested without its agreement, the submission must be done by another beneficiary (acting on behalf of the other beneficiaries).

The request for amendment must include:

- the reasons why;
- the appropriate supporting documents, and
- for a change of coordinator without its agreement: the opinion of the coordinator (or proof that this opinion has been requested in writing).

The Commission may request additional information.

If the party receiving the request agrees, it must sign the amendment in the electronic exchange system within 45 days of receiving notification (or any additional information the Commission has requested). If it does not agree, it must formally notify its disagreement within the same deadline. The deadline may be extended, if necessary for the assessment of the request. If no notification is received within the deadline, the request is considered to have been rejected

An amendment **enters into force** on the day of the signature of the receiving party.

An amendment **takes effect** on the date agreed by the parties or, in the absence of such an agreement, on the date on which the amendment enters into force.

ARTICLE 56 — ACCESSION TO THE AGREEMENT

56.1 Accession of the beneficiaries mentioned in the Preamble

The other beneficiaries must accede to the Agreement by signing the Accession Form (see Annex 3) in the electronic exchange system (see Article 52) within 30 days after its entry into force (see Article 58).

They will assume the rights and obligations under the Agreement with effect from the date of its entry into force (see Article 58).

If a beneficiary does not accede to the Agreement within the above deadline, the coordinator must — within 30 days — request an amendment to make any changes necessary to ensure proper implementation of the action. This does not affect the Commission's right to terminate the Agreement (see Article 50).

56.2 Addition of new beneficiaries

In justified cases, the beneficiaries may request the addition of a new beneficiary.

For this purpose, the coordinator must submit a request for amendment in accordance with Article 55. It must include an Accession Form (see Annex 3) signed by the new beneficiary in the electronic exchange system (see Article 52).

New beneficiaries must assume the rights and obligations under the Agreement with effect from the date of their accession specified in the Accession Form (see Annex 3).

ARTICLE 57 — APPLICABLE LAW AND SETTLEMENT OF DISPUTES

57.1 Applicable law

The Agreement is governed by the applicable EU law, supplemented if necessary by the law of Belgium.

57.2 Dispute settlement

If a dispute concerning the interpretation, application or validity of the Agreement cannot be settled amicably, the General Court — or, on appeal, the Court of Justice of the European Union — has sole jurisdiction. Such actions must be brought under Article 272 of the Treaty on the Functioning of the EU (TFEU).

As an exception, if such a dispute is between the Commission and PUBLIC UNION CHORNOBYL RESEARCH AND DEVELOPMENT INSTITUTE, NATIONALE GENOSSENSCHAFT FUER DIE LAGERUNG RADIOAKTIVER ABFAELLE, PAUL SCHERRER INSTITUT, STATE ENTERPRISE STATE SCIENTIFIC AND TECHNICAL CENTER FOR NUCLEAR AND RADIATION SAFETY, the competent Belgian courts have sole jurisdiction.

If a dispute concerns administrative sanctions, offsetting or an enforceable decision under Article 299 TFEU (see Articles 44, 45 and 46), the beneficiaries must bring action before the General Court — or, on appeal, the Court of Justice of the European Union — under Article 263 TFEU.

ARTICLE 58 — ENTRY INTO FORCE OF THE AGREEMENT

The Agreement will enter into force on the day of signature by the Commission or the coordinator, depending on which is later.

SIGNATURES

For the coordinator

Pierre-Marie ABADIE with ECAS id nabadipi signed in the Participant Portal on 24/05/2019 at 14:07:14 (transaction id SigId-39241-7zzT2OKG5ztxEnVDXnbldyDRyss21ONauH0TzRvpv0AMY3XNzcvBEHzWUoJDqnml83ePjdTsz1J3qnYLoXpzZ2p-jpJZscgsw0Kv1vxGC5zvJV-62L0MAGec4HRNx0QdAF6rVJgT9HGTmsazRech234Zay). Timestamp by third party at Fri May 24 15:07:23 CEST 2019

For the Commission

Signed by Milagros BAS SANCHEZ with ECAS id bassami as an authorised representative on 24-05-2019 17:26:43 (transaction id SigId-42152-j791yADHSOU2PuAHtY9ZoGibhVNzPpAVAE04295iE2frbKmNZJgdxg0l0tiEwUsxknQMC8uXndqst3PYFr2zzGG-jpJZscgsw0Kv1vxGC5zvJV-UpR63lMNYUg5v89VmNPe1b8wgqBPbzcMjfgkEuezwNlm). Timestamp by third party at Fri May 24 17:26:47 CEST 2019



EUROPEAN COMMISSION
Directorate-General for Research and Innovation
Fission Energy



ANNEX 1 (part A)

COFUND (European Joint Programme)

NUMBER — 847593 — EURAD

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1.1. The project summary

Project Number ¹	847593	Project Acronym ²	EURAD

One form per project

General information

Project title ³	European Joint Programme on Radioactive Waste Management
Starting date ⁴	The first day of the month after the signature by the Commission
Duration in months ⁵	60
Call (part) identifier ⁶	NFRP-2018
Topic	NFRP-2018-6 European Joint Research Programme in the management and disposal of radioactive waste
Fixed EC Keywords	Nuclear
Free keywords	Radioactive Waste Management; Disposal Solutions; Geological Disposal; Science and Technology ; Safety

Abstract ⁷

Following decades of RD&D in support of the safe management and disposal of radioactive waste, and building on the preparatory work of the recent EC JOPRAD project, a European Joint Programme on Radioactive Waste Management (EURAD) is now proposed to coordinate activities on agreed priorities of common interest between European Waste Management Organisations (WMOs), Technical Support Organisations (TSOs) and Research Entities (REs).

Such Joint Programming will complement National RD&D Programmes, by jointly establishing and carrying out activities jointly where there is added value at the European level. It is the logical next step in deepening collaboration between European actors in the field of radioactive waste management (RWM). It builds on existing and emerging networks of European actors (IGD-TP, SITEX and REs network), preceding coordination and support actions (in particular, SecIGD2, SITEX-II project and JOPRAD).

The Joint Programme will generate and manage knowledge to support EU Member States with their implementation of the Directive 2011/70/Euratom (Waste Directive), taking into account the different magnitudes and stages of advancement of Member State National Programmes. This will encompass:

- Supporting Member-States in developing and implementing their national RD&D programmes for the safe long-term management of their full range of different types of radioactive waste through participation in the RWM Joint Programme; in particular:
- Consolidating existing knowledge for the safe start of operation of the first geological disposal facilities for spent fuel, high-level waste, and other long-lived radioactive waste, and supporting optimization linked with the stepwise implementation of geological disposal; and
- Enhancing knowledge management and transfer between organisations, Member-States and generations.

1.2. List of Beneficiaries

Project Number ¹	847593	Project Acronym ²	EURAD

List of Beneficiaries

No	Name	Short name	Country	Project entry month ⁸	Project exit month
1	AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS	ANDRA	France	1	60
2	ARAO-AGENCIJA ZA RADIOAKTIVNE ODPADKE LJUBLJANA ZAVOD	ARAO	Slovenia	1	60
3	BEL V	BEL V	Belgium	1	60
4	BUNDES-GESELLSCHAFT FUR ENDLAGERUNGMBH (BGE)	BGE	Germany	1	60
5	COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	CEA	France	1	60
6	CENTRO DE INVESTIGACIONES ENERGETICAS, MEDIOAMBIENTALES Y TECNOLOGICAS-CIEMAT	CIEMAT	Spain	1	60
7	PUBLIC UNION CHORNOBYL RESEARCH AND DEVELOPMENT INSTITUTE	ChRDI	Ukraine	1	60
8	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	CNRS	France	1	60
9	CENTRALE ORGANISATIE VOOR RADIOACTIEF AFVAL NV	COVRA	Netherlands	1	60
10	VALSTYBINIS MOKSLINIU TYRIMU INSTITUTAS FIZINIU IR TECHNOLOGIJOS MOKSLU CENTRAS	FTMC	Lithuania	1	60
11	CENTRUM VYZKUMU REZ S.R.O.	CV REZ	Czech Republic	1	60
12	DANSK DEKOMMISSIONERING	Dekom	Denmark	1	60
13	ELLINIKI EPITROPI ATOMIKIS ENERGEIAS	EEAE	Greece	1	60
14	EMPRESA NACIONAL DE RESIDUOS RADIATIVOS S.A.	ENRESA	Spain	1	60
15	FORSCHUNGSZENTRUM JULICH GMBH	JUELICH	Germany	1	60
16	GESELLSCHAFT FUR ANLAGEN UND REAKTORSICHERHEIT (GRS) gGmbH	GRS	Germany	1	60
17	VALSTYBES IMONE IGNALINOS ATOMINE ELEKTRINE	IAE	Lithuania	1	60
18	INSTYTUT CHEMII I TECHNIKI JADROWEJ	INCT	Poland	1	60
19	INSTITUT DE RADIOPROTECTION ET DE SURETE NUCLEAIRE	IRSN	France	1	60
20	INSTITUTO SUPERIOR TECNICO	IST	Portugal	1	60

1.2. List of Beneficiaries

No	Name	Short name	Country	Project entry month ⁸	Project exit month
21	ASSOCIACAO DO INSTITUTO SUPERIOR TECNICO PARA A INVESTIGACAO E DESENVOLVIMENTO	IST ID	Portugal	1	60
22	INSTITUT JOZEF STEFAN	JSI	Slovenia	1	60
23	JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION	JRC	Belgium	1	60
24	KARLSRUHER INSTITUT FUER TECHNOLOGIE	KIT	Germany	1	60
25	LIETUVOS ENERGETIKOS INSTITUTAS	LEI	Lithuania	1	60
26	MAGYAR TUDOMANYOS AKADEMIA ENERGIATUDOMANYI KUTATOKOZPONT	MTA EK	Hungary	1	60
27	NATIONALE GENOSSENSCHAFT FUER DIE LAGERUNG RADIOAKTIVER ABFAELLE	NAGRA	Switzerland	1	60
28	NATIONAL CENTER FOR SCIENTIFIC RESEARCH "DEMOKRITOS"	NCSR	Greece	1	60
29	NUCLEAR ENGINEERING SEIBERSDORF GMBH	NES	Austria	1	60
30	NARODNY JADROVY FOND	NJF	Slovakia	1	60
31	NUCLEAR RESEARCH AND CONSULTANCY GROUP	NRG	Netherlands	1	60
32	NATIONALE INSTELLING VOOR RADIOACTIEF AFVAL EN VERRIJKTE SPLIJSTOFFEN	ONDRAF/NIRAS	Belgium	1	60
33	POSIVA OY	POSIVA	Finland	1	60
34	PAUL SCHERRER INSTITUT	PSI	Switzerland	1	60
35	RADIOAKTIV HULLADEKOKAT KEZELO KOZHASZNU NONPROFIT KORLATOLT FELELOSSEGU TARSASAG	PURAM	Hungary	1	60
36	REGIA AUTONOMA TEHNOLOGII PENTRU ENERGIA NUCLEARA - RATEN	RATEN	Romania	1	60
37	RADIOACTIVE WASTE MANAGEMENT LIMITED	RWM	United Kingdom	1	60
38	STUDIECENTRUM VOOR KERNENERGIE / CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE	SCK•CEN	Belgium	1	60
39	SVENSK KARNBRANSLEHANTERING AKTIEBOLAG	SKB	Sweden	1	60
40	STATE ENTERPRISE STATE SCIENTIFIC AND TECHNICAL CENTER FOR NUCLEAR AND RADIATION SAFETY	SSTC NRS	Ukraine	1	60

1.2. List of Beneficiaries

No	Name	Short name	Country	Project entry month ⁸	Project exit month
41	SLOVENSKA TECHNICKA UNIVERZITA V BRATISLAVE	STUBA	Slovakia	1	60
42	Radioactive Waste Repository Authority	SÚRAO	Czech Republic	1	60
43	STATNI USTAV RADIACNI OCHRANY v.v.i.	SURO	Czech Republic	1	60
44	NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO	TNO	Netherlands	1	60
45	TS ENERCON MERNOKIRODA KFT	TS Enercon	Hungary	1	60
46	TECHNICAL UNIVERSITY OF SOFIA	TUS	Bulgaria	1	60
47	UNIVERSITY OF CYPRUS	UCyprus	Cyprus	1	60
48	HELSINGIN YLIOPISTO	UHelsinki	Finland	1	60
49	UNITED KINGDOM RESEARCH AND INNOVATION	UKRI	United Kingdom	1	60
50	Teknologian tutkimuskeskus VTT Oy	VTT	Finland	1	60
51	VUJE AS	VUJE	Slovakia	1	60

1.3. Workplan Tables - Detailed Implementation

Associated with document Ref. Ares(2019)3258794 - 17/05/2019

1.3.1. WT1 List of work packages

WP Number ⁹	WP Title	Lead beneficiary ¹⁰	Person-months ¹¹	Start month ¹²	End month ¹³
WP1	Programme Management Office	1 - ANDRA	150.00	1	60
WP2	Assessment of Chemical Evolution of ILW and HLW Disposal Cells (ACED)	38 - SCK•CEN	516.20	1	48
WP3	Cement-Organic-Radionuclide-Interactions (CORI)	24 - KIT	534.20	1	48
WP4	Development and Improvement Of NUMerical methods and Tools for modelling coupled processes (DONUT)	1 - ANDRA	519.10	1	48
WP5	Fundamental understanding of radionuclide retention (FUTuRE)	15 - JUELICH	595.10	1	48
WP6	Mechanistic understanding of gas transport in clay materials (GAS)	32 - ONDRAF/NIRAS	681.70	1	60
WP7	Influence of temperature on clay-based material behaviour (HITEC)	50 - VTT	700.70	1	48
WP8	Spent Fuel Characterization and Evolution Until Disposal (SFC)	39 - SKB	653.65	1	48
WP9	Waste management routes in Europe from cradle to grave (ROUTES)	19 - IRSN	147.30	1	60
WP10	Uncertainty Management multi-Actor Network (UMAN)	3 - BEL V	134.00	1	48
WP11	State-of-Knowledge	4 - BGE	74.75	1	60
WP12	Guidance	42 - SÚRAO	64.30	1	60
WP13	Training & Mobility	38 - SCK•CEN	58.75	1	60
WP14	Ethics requirements	1 - ANDRA	N/A	1	60
Total			4,829.75		

1.3.2. WT2 list of deliverables

Deliverable Number ¹⁴	Deliverable Title	WP number ⁹	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D1.1	2nd Annual Work Plan	WP1	1 - ANDRA	Report	Confidential, only for members of the consortium (including the Commission Services)	9
D1.2	3rd Annual Work Plan	WP1	1 - ANDRA	Report	Confidential, only for members of the consortium (including the Commission Services)	21
D1.3	4th Annual Work Plan	WP1	1 - ANDRA	Report	Confidential, only for members of the consortium (including the Commission Services)	33
D1.4	5th Annual Work Plan	WP1	1 - ANDRA	Report	Confidential, only for members of the consortium (including the Commission Services)	45
D1.5	PMO - EURAD Quality Management Plan	WP1	1 - ANDRA	Report	Public	3
D1.6	EURAD Data Management Plan	WP1	1 - ANDRA	ORDP: Open Research Data Pilot	Confidential, only for members of the consortium (including the Commission Services)	12
D1.7	EURAD Roadmap, extended with Competence Matrix	WP1	1 - ANDRA	Report	Public	12
D1.8	'Soft' update of the EURAD SRA/ Roadmap	WP1	1 - ANDRA	Report	Public	12
D1.9	'Extensive' update of the SRA/Roadmap	WP1	1 - ANDRA	Report	Public	44
D1.10	- Identification of Subject Matter/Theme Experts from EURAD Colleges	WP1	1 - ANDRA	Report	Public	12
D1.11	EURAD Dissemination strategy	WP1	1 - ANDRA	Report	Public	3

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
D1.12	EURAD website	WP1	1 - ANDRA	Websites, patents filling, etc.	Public	3
D1.13	List of members of the CS group	WP1	19 - IRSN	Report	Public	6
D1.14	Mid-term evaluation of the ICS activities and experimental model of interaction between EURAD participants and Civil Society	WP1	19 - IRSN	Report	Public	30
D1.15	Integrated review of the ICS activities in EURAD	WP1	19 - IRSN	Report	Public	58
D1.16	Evaluation of experimental model of interaction between EURAD participants and Civil Society	WP1	19 - IRSN	Report	Public	58
D1.17	Evaluation of the impacts of EURAD first implementation phase	WP1	1 - ANDRA	Report	Public	60
D2.1	ACED - State-of-the-art report	WP2	9 - COVRA	Report	Public	6
D2.2	ACED - Updated State-of-the-art report & Summary of major conclusions from the work package	WP2	9 - COVRA	Report	Public	48
D2.3	ACED - Training materials	WP2	38 - SCK•CEN	Report	Public	36
D2.4	ACED - Treatment of chemical evolution in national programmes	WP2	9 - COVRA	Report	Public	5
D2.5	ACED - Experiments and numerical model studies on interfaces	WP2	15 - JUELICH	Report	Public	5
D2.6	ACED Task 2.1 - Technical report on the modelling approach proposed	WP2	42 - SÚRAO	Report	Public	15
D2.7	ACED Task 2.1 - Final technical report on the steel/cement material interactions	WP2	19 - IRSN	Report	Public	46

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
D2.8	ACED Task 2.2 - Technical report on the modelling approach proposed	WP2	31 - NRG	Report	Public	15
D2.9	ACED Task 2.2 - Final technical report on the steel/clay material interactions	WP2	19 - IRSN	Report	Public	46
D2.10	ACED Task 3.1 - HLW: Report describing the selected experiments and the existing/ expected experimental results	WP2	26 - MTA EK	Report	Public	7
D2.11	ACED Task 3.1 - ILW: Report describing the selected experiments and the existing/ expected experimental results	WP2	22 - JSI	Report	Public	7
D2.12	ACED Task 3.1 - HLW: Report describing the results of characterization performed during the project	WP2	5 - CEA	Report	Public	31
D2.13	ACED Task 3.1 - ILW: Report describing the results of characterization performed during the project	WP2	22 - JSI	Report	Public	31
D2.14	ACED Task 3.2 - Report describing the results of modelling, and the recommendations for future experimental and numerical work	WP2	38 - SCK•CEN	Report	Public	46
D2.15	ACED Task 3.3 - Report describing the results of modelling, and the recommendations for future experimental and numerical work	WP2	1 - ANDRA	Report	Public	46
D2.16	ACED Task 4.1 - Report on the conceptual model formulation for a	WP2	14 - ENRESA	Report	Public	12

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
	mechanistic based model on implementing the initial SOTA knowledge on models and parameters in existing numerical tools					
D2.17	ACED Task 4.1 - Report on the integrated model for assessing the chemical evolution in a disposal cell on the simulations with a reactive transport model of the chemical evolution at the disposal cell scale	WP2	19 - IRSN	Report	Public	30
D2.18	ACED Task 4.2 - Report on the conceptualization of upscaling including upscaling & model abstraction methods for the integration of process-level knowledge to disposal cell scale knowledge	WP2	38 - SCK•CEN	Report	Public	24
D2.19	ACED Task 4.2 - Report on comparison of model abstraction results	WP2	15 - JUELICH	Report	Public	45
D2.20	ACED Task 4.3 - Integration report of the work on disposal cell scale chemical evolution	WP2	14 - ENRESA	Report	Public	45
D3.1	CORI - SOTA on cement-organic-radionuclide-interactions in the content of L/ILW disposal	WP3	24 - KIT	Report	Public	6
D3.2	CORI - SOTA UPDATE on cement-organic-radionuclide-interactions in the content of L/ILW disposal	WP3	24 - KIT	Report	Public	48
D3.3	CORI - Training Materials	WP3	24 - KIT	Report	Public	8

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
D3.4	CORI - Training Materials UPDATE	WP3	24 - KIT	Report	Public	48
D3.5	CORI - Final Report integrating the RD&D performed in CORI, including application to the Safety Case	WP3	24 - KIT	Report	Public	48
D3.6	CORI - Final Report on results generated in Task 2 of CORI	WP3	8 - CNRS	Report	Public	44
D3.7	CORI - Final Report on organic retention in cementitious systems	WP3	1 - ANDRA	Report	Public	44
D3.8	CORI - Final Report on radionuclide mobility in cementitious materials in the presence of organics	WP3	5 - CEA	Report	Public	46
D4.1	DONUT - State-of-the-art in the fields of numerical analysis and scientific computing	WP4	1 - ANDRA	Report	Public	6
D4.2	DONUT - Updated State-of-the-art in the fields of numerical analysis and scientific computing	WP4	1 - ANDRA	Report	Public	48
D4.3	DONUT - Training materials	WP4	1 - ANDRA	Report	Public	36
D4.4	DONUT - Report describing the benchmarks to be carried out during the WP	WP4	1 - ANDRA	Report	Public	24
D4.5	DONUT - Technical report describing numerical method improvement and their transferability in numerical tools as well as benchmarks realization	WP4	8 - CNRS	Report	Public	46
D4.6	DONUT - Final report describing improvement and implementation of scale transition methods	WP4	1 - ANDRA	Report	Public	46

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
	to model coupled processes					
D4.7	DONUT - Report describing numerical improvement and developments and their application to treat uncertainty when dealing with coupled processes	WP4	1 - ANDRA	Report	Public	46
D4.8	DONUT - Final report describing benchmark realisations and (i) influence of the development carried out in other tasks on the quantification of improvement (ii) comparison, when possible, of tools on which numerical methods have been implemented	WP4	1 - ANDRA	Report	Public	46
D5.1	FUTuRE - Initial State-of-the-art report on the understanding of radionuclide retention in clay and crystalline rocks	WP5	38 - SCK•CEN	Report	Public	6
D5.2	FUTuRE - Updated State-of-the-art on the understanding of radionuclide retention in clay and crystalline rocks	WP5	38 - SCK•CEN	Report	Public	48
D5.3	FUTuRE - Related deliverable: D5.4 Training materials	WP5	15 - JUELICH	Report	Public	36
D5.4	FUTuRE - Final technical report on radionuclide mobility in compacted clay systems	WP5	34 - PSI	Report	Public	48
D5.5	FUTuRE - Final technical report on radionuclide mobility in crystalline systems	WP5	15 - JUELICH	Report	Public	48
D5.6	FUTuRE - Final report on reversibility of sorption	WP5	34 - PSI	Report	Public	48

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
D5.7	FUTuRE - Final technical report on redox reactivity of radionuclides on mineral surfaces	WP5	1 - ANDRA	Report	Public	48
D6.1	GAS - Initial State-of-the-art (SOTA) report on gas transport through clay materials	WP6	32 - ONDRAF/NIRAS	Report	Public	18
D6.2	GAS - Updated State-of-the-art (SOTA) report on gas transport through clay materials	WP6	32 - ONDRAF/NIRAS	Report	Public	60
D6.3	GAS - Training materials of the 1st GAS/HITEC Joint training course (copy of the presentations of each doctoral school organised during the course of the project)	WP6	32 - ONDRAF/NIRAS	Report	Public	3
D6.4	GAS - Training materials of the 2nd GAS/HITEC Joint training course (copy of the presentations of each doctoral school organised during the course of the project)	WP6	32 - ONDRAF/NIRAS	Report	Public	48
D6.5	GAS - Book of proceedings of the final GAS workshop	WP6	32 - ONDRAF/NIRAS	Report	Public	60
D6.6	GAS - Technical report of the GAS WP	WP6	32 - ONDRAF/NIRAS	Report	Public	60
D6.7	GAS - Technical report Gas Transport Mechanisms including diffusion, retention and advective processes in clay	WP6	49 - UKRI	Report	Public	57
D6.8	GAS - Technical report on barrier integrity	WP6	27 - NAGRA	Report	Public	57
D6.9	GAS - Technical report on conceptualisation and evaluation at the repository scale	WP6	1 - ANDRA	Report	Public	57
D7.1	HITEC - Initial State-of-the-art on THM	WP7	6 - CIEMAT	Report	Public	6

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
	behaviour of i) buffer clay materials and of ii) host clay materials					
D7.2	HITEC -Updated State-of-the-art on THM behaviour of i) buffer clay materials and of ii) host clay materials	WP7	6 - CIEMAT	Report	Public	48
D7.3	HITEC -Final technical report on thermal effects on near field properties	WP7	8 - CNRS	Report	Public	46
D7.4	HITEC -Specific GAS/HITEC technical report on self-sealing processes	WP7	1 - ANDRA	Report	Public	46
D7.5	HITEC -Final technical report on effect of temperature on far field properties	WP7	8 - CNRS	Report	Public	46
D7.6	HITEC - Final modelling report on effect of temperature on near field properties	WP7	8 - CNRS	Report	Public	46
D7.7	HITEC - technical report on Material characterisation – Task 3.1 final results	WP7	39 - SKB	Report	Public	46
D7.8	HITEC - HITEC technical report on test at high temperature – Task 3.2 final results	WP7	49 - UKRI	Report	Public	46
D7.9	HITEC - Experimental works (small and mid-scale laboratory experiments) – final report (Results of the experimental works of T3.3)	WP7	6 - CIEMAT	Report	Public	46
D7.10	HITEC - Modelling – final report (Results of all modelling task carried in T3.3 in cooperation with DONUT	WP7	6 - CIEMAT	Report	Public	46
D7.11	HITEC - Guidance for safety case	WP7	27 - NAGRA	Report	Public	46

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
	development and repository optimization					
D7.12	HITEC - Final report on Influence of temperature on clay-based material behaviour	WP7	50 - VTT	Report	Public	48
D8.1	SFC - State-of-the-art report	WP8	27 - NAGRA	Report	Public	6
D8.2	SFC - Updated State-of-the-art report	WP8	27 - NAGRA	Report	Public	48
D8.3	SFC - Summary of training materials produced during the SFC WP	WP8	6 - CIEMAT	Report	Public	48
D8.4	SFC - principles and performance of NDA systems and innovative detection techniques used for the characterisation of SNF samples and assemblies	WP8	23 - JRC	Report	Public	36
D8.5	SFC - results of the characterisation of SNF samples by NDA and radiochemical analysis: results from subtasks 2.2 and 2.3	WP8	38 - SCK•CEN	Report	Public	48
D8.6	SFC - performance of “sophisticated” and “best-practice industry” codes based on SKB-50 data and data produced in subtask 2.2 and 2.3	WP8	34 - PSI	Report	Public	48
D8.7	SFC - recommended procedures to determine the SNF source terms	WP8	39 - SKB	Report	Public	48
D8.8	SFC - Thermo-mechanical-chemical properties of unirradiated and irradiated samples of spent nuclear fuel rod segments and cladding	WP8	24 - KIT	Report	Public	48
D8.9	SFC - Influence of oxygen and fission products on microstructure of UO ₂	WP8	15 - JUELICH	Report	Public	48

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
	fuel and He within the UO2 matrix					
D8.10	SFC - Chemical and structural / crystallographic properties of simulated fuel pellets and irradiated fuel pellets at the cladding/fuel interface	WP8	24 - KIT	Report	Public	48
D8.11	SFC - Identification and analysis of potential accident scenarios for fuel assembly damage and fuel material release during fuel handling in an interim storage and/or packaging facility	WP8	27 - NAGRA	Report	Public	36
D8.12	SFC - Assessment of fuel performances for a postulated accident scenario under storage conditions: re-criticality, integrity under mechanical loads and container degradation studies	WP8	6 - CIEMAT	Report	Public	48
D8.13	SFC - Analysis of the dynamics of the state-of-emergency radioactive waste packages from the Chernobyl catastrophe	WP8	7 - ChRDI	Report	Public	36
D9.1	ROUTES - Training materials	WP9	19 - IRSN	Report	Public	60
D9.2	ROUTES - Recommendations for future RD&D, strategic study and KM activities for the 2nd wave of EURAD-1	WP9	19 - IRSN	Report	Public	18
D9.3	ROUTES - Recommendations for future RD&D, strategic study and KM activities for future European collaboration	WP9	19 - IRSN	Report	Public	58
D9.4	ROUTES - Overview of existing work	WP9	1 - ANDRA	Report	Public	10

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
	on categorization/ classification of RWs in participating states					
D9.5	ROUTES - Overview of issues related to challenging wastes	WP9	1 - ANDRA	Report	Public	24
D9.6	ROUTES - Common understanding of the practical issues on waste management routes	WP9	1 - ANDRA	Report	Public	48
D9.7	ROUTES - Review of radioanalytical characterisation of selected radioactive wastes and wastes with complex chemical and toxic properties	WP9	15 - JUELICH	Report	Public	24
D9.8	ROUTES - Review of characterization of legacy and historical wastes	WP9	15 - JUELICH	Report	Public	33
D9.9	ROUTES - Report suggestions for the management of challenging wastes while maintaining compatibility with the option(s) for disposal	WP9	50 - VTT	Report	Public	40
D9.10	ROUTES - Report about the knowledge for existing and potential disposal options for SIMS	WP9	28 - NCSR	Report	Public	24
D9.11	ROUTES - Report presenting the results of the workshop dealing with possible conditioning routes for SIMS	WP9	29 - NES	Report	Public	36
D9.12	ROUTES - Studies and plans for developing shared solutions for radioactive waste management in Europe	WP9	9 - COVRA	Report	Public	12
D9.13	ROUTES - Case studies of shared development and use of technologies and facilities	WP9	5 - CEA	Report	Public	24

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
D9.14	ROUTES - Report on the feasibility of developing further European shared solutions for waste management from cradle to grave	WP9	9 - COVRA	Report	Public	42
D9.15	Scoping of ROUTES, initial CS input and ICS action plan (task 7.1)	WP9	22 - JSI	Report	Public	11
D9.16	Implementation of the ROUTES ICS action plan first phase - CS discussion and input focused on the first topic identified in the ICS action plan (task 7.2)	WP9	19 - IRSN	Report	Public	23
D9.17	Implementation of the ROUTES ICS action plan second phase - CS discussion and input focused on the second topic identified in the ICS action plan (task 7.2)	WP9	19 - IRSN	Report	Public	35
D9.18	Implementation of the ROUTES ICS action plan third phase - CS discussion and input focused on the third topic identified in the ICS action plan (task 7.2)	WP9	19 - IRSN	Report	Public	47
D9.19	Final synthesis ROUTES report of the work and results of task 7 including the documentation of the interaction framework developed, including recommendations for future CS interaction	WP9	22 - JSI	Report	Public	60
D9.20	Contribution to ROUTES factsheet presenting the results and outcomes of ROUTES and in a larger context	WP9	19 - IRSN	Report	Public	60

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
D10.1	UMAN - Training materials	WP10	3 - BEL V	Report	Public	48
D10.2	UMAN - Strategies for managing uncertainties	WP10	50 - VTT	Report	Public	36
D10.3	UMAN - Uncertainty identification, classification and quantification	WP10	15 - JUELICH	Report	Public	36
D10.4	UMAN - Methodological approaches to uncertainty and sensitivity analysis	WP10	24 - KIT	Report	Public	48
D10.5	UMAN - Uncertainties relevant to the safety case	WP10	8 - CNRS	Report	Public	36
D10.6	UMAN - Views of the different actors on the identification, characterization and potential significance of uncertainties on waste inventory and on the impact of predisposal steps	WP10	38 - SCK•CEN	Report	Public	36
D10.7	UMAN - Views of the different actors on the identification, characterization and potential significance of uncertainties on site and geosphere	WP10	36 - RATEN	Report	Public	36
D10.8	UMAN - Views of the different actors on the identification, characterization and potential significance of uncertainties on human aspects	WP10	1 - ANDRA	Report	Public	36
D10.9	UMAN - Views of the different actors on the identification, characterization and potential significance of uncertainties associated with spent fuel	WP10	6 - CIEMAT	Report	Public	48
D10.10	UMAN - Analysis and description of groups of different actors	WP10	4 - BGE	Report	Public	12

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
D10.11	UMAN - Study on management options for different types of uncertainties and programme phases	WP10	27 - NAGRA	Report	Public	42
D10.12	UMAN - Identification, analysis and description of preferences of different actors on uncertainty management options	WP10	31 - NRG	Report	Public	48
D10.13	UMAN - Understanding of uncertainty management by the various stakeholders	WP10	24 - KIT	Report	Public	40
D10.14	UMAN - Pluralistic analysis of uncertainty pictures	WP10	19 - IRSN	Report	Public	40
D10.15	UMAN - Pluralistic analysis of uncertainty management options and preferences of stakeholders vis-à-vis uncertainty management	WP10	1 - ANDRA	Report	Public	48
D10.16	UMAN - Methods for a pluralistic assessment of uncertainties and their management along the disposal programme	WP10	19 - IRSN	Report	Public	48
D10.17	UMAN - Synthetic mapping of the stakes related to WP UMAN outcomes from a civil society point of view	WP10	19 - IRSN	Report	Public	48
D11.1	Screening and review of existing/ available knowledge management approaches and/or tools	WP11	15 - JUELICH	Report	Public	13
D11.2	List of selected demonstration cases, criteria for final selection, proposal and estimation of effort and resources	WP11	4 - BGE	Report	Public	9
D11.3	Outcomes of the demonstration cases	WP11	4 - BGE	Report	Public	22

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
D11.4	Procedures to Involve Knowledge providers	WP11	4 - BGE	Report	Public	13
D11.5	QA procedures for the generation of SoK demonstration cases	WP11	40 - SSTC NRS	Report	Public	4
D11.6	revised QA procedures	WP11	40 - SSTC NRS	Report	Public	19
D11.7	Results summary of WP11 during Year 1 and 2 and proposal for the for broad SoK implementation in the following years	WP11	4 - BGE	Report	Public	24
D12.1	KM Guidance - PLANMAN Guide - Updated version of the PLANDIS Guide consistent with the EJP Roadmap and including perspectives of the TSOs needs (PLANMAN Guide)	WP12	42 - SÚRAO	Report	Public	12
D12.2	KM Guidance - Quality management procedure for PLANMAN development (incl. review and approval procedure)	WP12	42 - SÚRAO	Report	Public	12
D12.3	KM Guidance - Approved schedule for delineation of the PLANMAN Guide in-line with the PMO-developed competence matrix and approved Editorial Plan for Year 1	WP12	42 - SÚRAO	Report	Public	10
D12.4	KM Guidance - Quality management procedure and methodology for developing the detailed delineation guidance of PLANMAN	WP12	42 - SÚRAO	Report	Public	12
D12.5	KM Guidance - Delineated version of the PLANMAN Guide after Year 1	WP12	42 - SÚRAO	Report	Public	24
D12.6	KM Guidance - Final report on the PLANMAN Guide	WP12	42 - SÚRAO	Report	Public	60

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
	and the subsequent detailed Guidance, overall conclusions and recommendations					
D13.1	KM Training - List of training needs from the RD&D and SS WPs	WP13	38 - SCK•CEN	Report	Public	3
D13.2	KM Training - Mapping of available course material	WP13	38 - SCK•CEN	Report	Public	8
D13.3	KM Training - Alignment of the available course material with the Roadmap	WP13	38 - SCK•CEN	Report	Public	12
D13.4	KM Training - Priority list and schedule for training/mobility	WP13	38 - SCK•CEN	Report	Public	12
D13.5	KM Training - Quality criteria and training specification as a reference guide of requirements and expectations of the training courses to be developed	WP13	38 - SCK•CEN	Report	Public	9
D13.6	KM Training - Implementation of first training courses developed and implemented depending on the priorities identified and approved within the EJP	WP13	38 - SCK•CEN	Report	Public	13
D13.7	KM Training - Specification document of the content, material, and learning outcomes of mobility training e.g. in relation with a curricular of S/T knowledge acquisition targets	WP13	43 - SURO	Report	Public	12
D13.8	KM Training - Development of mobility programme	WP13	43 - SURO	Report	Public	13
D14.1	EPQ - Requirement No. 1	WP14	1 - ANDRA	Ethics	Confidential, only for members	12

Deliverable Number¹⁴	Deliverable Title	WP number⁹	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
					of the consortium (including the Commission Services)	
D14.2	EPQ - Requirement No. 2	WP14	1 - ANDRA	Ethics	Confidential, only for members of the consortium (including the Commission Services)	12
D14.3	EPQ - Requirement No. 3	WP14	1 - ANDRA	Ethics	Confidential, only for members of the consortium (including the Commission Services)	12

1.3.3. WT3 Work package descriptions

Work package number ⁹	WP1	Lead beneficiary ¹⁰	1 - ANDRA
Work package title	Programme Management Office		
Start month	1	End month	60

Objectives

The 'Programme Management Office' (PMO) has a strategic role in ensuring the overall coordination of the deployment of EURAD. More specifically, the PMO ensures:

- Day-to-day management of the administrative, legal and financial aspects;
- Internal communication between EURAD Beneficiaries (Mandated Actors);
- Reporting to and interfaces with EC;
- Overall scientific and technical coordination/ integration/ evaluation of impacts (RD&D, Strategic Studies and KM, interaction with Civil Society)
- Interfaces with third parties;
- Dissemination of EURAD progress and overall results (of RD&D WPs, Strategic Studies WPs and KM WPs) and outreach activities.

Description of work and role of partners

WP1 - Programme Management Office [Months: 1-60]

ANDRA, CNRS, IRSN, JSI, JRC, RWM

Description of work

Task 1 - Management and coordination of the administrative, legal and financial aspects

Start Date: Month 1 – End Date: Month 60

Task Leader: [Andra]

The PMO is in charge of the day-to-day management of the administrative, legal and financial aspects of EURAD. This includes:

- Developing a Quality Management Plan (D1.5) that will describe all the procedures for a smooth coordination and fulfilment of obligations as stated in the Grant Agreement and the Consortium Agreement (this includes procedures for assuring reporting standards, check of industrial or intellectual property rights, risk management, respect of ethical EU standards etc.)
- Managing any update of the Consortium Agreement and Grant Agreement;
- Coordinating the preparation and submission to EC of the Annual Periodic Reports (administrative and financial aspects);
- Coordinating the preparation and submission to EC of the Annual Work Plans (D1.1, D1.2, D1.3 and D1.4);
- Monitoring of the budget, ensure that the overall budget is in line with the commitment and in case of significant changes propose to the General Assembly adequate amendments.
- Assistance to the Consortium for administrative and financial aspects;
- Intellectual Property Rights rules establishment and follow-up, development of the EURAD Data Management Plan (D1.6)

Task 2 – Overall scientific and technical coordination/integration/evaluation of impacts (RD&D, Strategic Studies and KM)

Start Date: Month 1 – End Date: Month 60

Task contributors [CNRS] [RWM] and [IRSN] from Month 1 to Month 30 and [JRC] [Andra]

At WP level, it is reminded that the scientific and technical coordination of a WP is done by the WP Board. At EURAD level, and as a permanent mission, the PMO shall ensure appropriate coordination and integration of the overall programme of activities (RD&D, Strategic Studies and Knowledge Management) for an effective deployment of the objectives, in line with EURAD SRA and Roadmap.

The PMO shall :

- Establish monitoring and evaluation criteria to assess EURAD outputs, early affects and long-term impacts constructed (this will be integrated in the Quality Management Plan). This will serve as the basis for the development of a set of key performance indicators (KPI) and shall be in alignment with the Strategic Research Agenda and the Roadmap in order to analyse the impacts of EURAD work on strategies for RWM. Such KPIs shall help measuring outcomes and impacts towards the phases of the Roadmap and in terms which can also be assessed by decision makers (EC,

Programme Owners). The list of KPIs will be annually assessed and revised and sent for review to EC in the framework of EC annual reviews of the EJP. As part of this task, and towards the end of the action the PMO shall prepare a tool (e.g. questionnaire aligned to the Waste Directive) for getting the views from national programme owners on EURAD impacts during phase 1.

- In addition to KPIs, the PMO will actively maintain and monitor a Risk Register to document those risks identified within each Work Package that may impact the overall performance of the EJP. With respect to the DONUT Work Package (and other WPs that require significant coordination and strategic oversight to ensure consistency and continued support by each College), it is anticipated that a key risk will be raised that relates to meeting the needs of safety assessment end-users with a focus on generic methodologies (exact wording to be agreed). This risk will be managed through identified mitigation measures to be developed and continuously monitored together with the WP Leader, Key WP Contributors from each College, and the PMO.

- Propose and ensure the implementation of a set of criteria for monitoring the performance of each Work Package and regularly update the report on the evolution of the implementation;

- Ensure, in liaison with the WP Leaders that quality control and quality assurance practice is applied.

- Ensure that the quality of the scientific/technical reporting from each WP is adequate and that uniform standards are applied;

- Coordinate the preparation of the scientific/technical aspects of the Annual Reports based on the inputs provided by the WP Boards;

- Coordinate the preparation of the Annual Work Plans (scientific/technical aspects) based on the inputs provided by the WP Boards;

- Ensure and enhance that activities at interfaces among WPs are properly implemented and developed by the WP Boards (e.g. joint workshops between WPs, identification of clear experimental boundary conditions, which allow better exchange between model and experimental teams, development of KPI to monitor the performance of these exchanges);

- Ensure effective internal scientific/technical communication and transfer of results from WPs to WPs, and effective coordination of the communities of practice.

Task 3 – Support the Bureau/General Assembly in the extension/update of the SRA and the Roadmap

Start Date: Month 1 – End Date: Month 60

Task contributors [CNRS] [RWM] and [IRSN] from Month 1 to Month 30 and [JRC] [Andra]

The SRA and the Roadmap form the backbone for handling and visualizing the overall situation with respect to the scientific-technical state-of-the-art, the state of knowledge, research needs, needs for and access to guidance, competence needs and tools for knowledge transfer, along with the different phases of a RWM programme. The SRA/Roadmap is also an important input for identifying future work programme priorities (RD&D, Strategic Studies and KM) and up-dating the work programme. It is also the tool for identifying and structuring expert support and the activities of Communities of Practice for different field (see WP1-Task 4). Finally, the SRA/Roadmap is a valuable tool for visualizing EURAD progress, i.e. fields where needs are met and the overall RWM situation thus has improved.

The PMO shall support the Bureau/General Assembly in the exercise that consists of extending/updating the SRA and the Roadmap. During EURAD-1, the following exercises are anticipated:

- [Year 1] Roadmap Extension - Complete EURAD Roadmap with a Competency Matrix, to identify competencies for different Actors (WMOs, TSOs and REs) and to map existing/available SoK, Guidance and Training material (open access) against Themes of EURAD SRA for different phases of implementation of a RWM programme. This shall support identification of the key need-gaps, which will then be used to prioritise the scope of each of the main KM WPs. This task will be undertaken by the PMO, with inputs from participants of the KM WPs and with oversight and guidance by the appointed Joint Programme Fellows/Experts (Deliverable 1.7)

- [Year 2] ‘Soft’ update of the SRA/Roadmap in view of the preparation of the 2nd wave of RD&D and Strategic Studies WPs where it is anticipated that minor edits and additions should be made, e.g. assessing the level of common interest of topics that emerged lately in the process of developing the SRA; identification of emerging RD&D needs and assess level of common interest. (Deliverable 1.8)

- [Year 4-5] ‘Extensive’ update of the SRA/Roadmap (exact timing to be adjusted in order to be in line with Euratom work programme) to coincide with preparation and prioritisation of the scope of the potential EURAD2. During this extensive update, it is anticipated that significant changes may result to take account of learning from EURAD-1 and align the Vision, SRA, Roadmap and RD&D, Strategic Studies and KM Work Packages scope and methodologies with how things evolve, particularly with respect to the JP governance scheme and how the criteria used to identify needs of the WMOs, TSOs and REs. (Deliverable 1.9)

Task 4 –Identification of Subject Matter/Theme Experts from EURAD Colleges

Start Date: Month 1 – End Date: Month 60

Task contributors [CNRS] [RWM] and [IRSN] from Month 1 to Month 30 and [JRC] [Andra]

Recognising that good Knowledge Management is as much about people, as it is about documentation, the PMO at initiation will issue invitations to WMO, TSO and RE Colleges to identify subject matter experts against each of the Roadmap Sub-themes/topics (Deliverable 1.9) as well as experts having a broad overview of a RWM programme. Those identified experts will be able to provide adhoc technical support for a set term (possibly be reviewed/updated annually). The approach is that we utilise those identified to guide Roadmap updates and Joint Programme Knowledge Management Activities, to oversee and direct (with limited effort) SoK (WP11), Guidance (WP12) and Training (WP13) efforts in collaboration with the KM Work Package Leaders. Our ambition is that by identifying experts upfront, we have a clear and transparent framework while reducing the administrative efforts for the PMO and Colleges for technical review and the oversight activities.

Candidates would be colleagues that those working in the RWM community can turn to for their insights and experience and with a set allocation of volunteered hours dedicated to providing input and advice. Committed to passing on their knowledge, appointed experts would focus purely on the science of developing documents or organisation of the State of Knowledge for their given field, and only at the request of the KM WPs.

Task 5 – Internal communication and meetings of the Consortium

Task contributors [CNRS] [RWM] and [IRSN] from Month 1 to Month 30 and [JRC] [Andra]

Start Date: Month 1 – End Date: Month 60

The PMO shall coordinate the organisation of EURAD Consortium meetings, as described in the Governance section (section 3.5.1), Kick-off meeting, General Assemblies, EURAD Annual Meetings, Bureau meetings and PMO/WP Boards meetings.

In addition to these regular meetings, the PMO shall ensure the internal communication through:

- Management of a private Intranet section only accessible by EURAD Participants (Beneficiaries and Linked Third Parties) in order to facilitate exchanges between them. Specific access rights will be provided individually depending on the role of each contributor;
- Regularly updated distribution/contact lists;
- Regular transfer of information about EURAD implementation

Task 6 – Dissemination

Task contributors [CNRS] [RWM] and [IRSN] from Month 1 to Month 30 and [JRC] [Andra]

Start Date: Month 1 – End Date: Month 60

Subtask 6.1 - Dissemination Strategy

Given the wide scope and objectives of EURAD, it will be of high value to come up with a cohesive, consistent and concise dissemination strategy that highlights both methodological and technical/scientific achievements made within EURAD. More specifically, a Dissemination Strategy (D1.11) will be developed at the PMO level to identify the key messages to be delivered, the target audiences to be addressed, the method/channels to address them, and the timing and process of dissemination.

A first version of this strategy shall be available in its first version at month 3. It will be then updated periodically after each annual periodic report (at month 14, 26, 38, 50 and 60+2) and validated by the GA.

Subtask 6.2 - Tools to deploy the Dissemination Strategy

Dissemination tools will be developed which help in the raising of awareness concerning the Joint Programme goals and results/achievements. These tools will include a website, annual EURAD meetings, newsletters, etc.

a) Development, update and maintenance of a website

As a communication tool with the broader community, a public website (D1.12) will be developed and maintained for disseminating the Joint Programme objectives, main results and achievements, as well as main open events and workshops.

b) Newsletters

EURAD newsletters will be issued on a quarterly basis in order to keep all interested parties informed on EURAD activities. This newsletter will be sent by email to all interested parties, and will also be made available on EURAD website.

c) Briefs and news papers

EURAD will be a step change in the visibility of European research on RWM. The voice of EURAD shall therefore be solicited on key research findings for example for press statements, newspaper articles, public hearings etc.

d) EURAD Annual Meetings

EURAD Meetings will be organised on an annual basis with the main objectives to i) disseminate EURAD on-going activities, results and achievements to the large RWM community ii) explore new ideas that may be developed in the framework of EURAD-1 (2nd wave of RD&D/Strategic Studies, annual work programme of the KM activities) iii) organise sessions in the framework the Interactions with Civil Society activities; iv) initiate or deepen collaborations with organisations such as IAEA, NEA, NUGENIA, ENEN, etc.

e) Presentation of EURAD in international/European/national events/forums.

Personal contacts and presentations through attendance at relevant workshops, conferences, and events are important channels for the dissemination of EURAD results. Networking remains a crucial way to exchange, give information about EURAD, and keep informed about the latest developments and outcomes. Non-exhaustive list of external events related to RWM: IGD-TP events, SITEX events, IAEA events, NEA events, NUGENIA events, ENEF Forum, EURADWASTE, Clay Conference, Annual Waste Management Conference, national and local events, etc.

Task 7 - EURAD in the international arena

Task Leader: [Andra]

Start Date: Month 1 – End Date: Month 60

The size and the inclusiveness of EURAD consortium as well as its large generic RD&D/Strategic Studies programme and KM activities will make it a key player in European and worldwide RWM. Exchange with other international actors is essential for increasing the impact of EURAD in the international landscape. EURAD will as well be solicited by various partner organisations and programme owners in their National Programme dissemination. The PMO will ensure interfaces and interactions at EURAD level with IGD-TP, SITEX, EuradSciences, IAEA, NEA, third country organisations (DOE...) and any other relevant organisations. This can include the formulation of MoU or any other joint agreements, to be validated at the GA and in agreement with EC rules.

Task 8 - Coordination, organisation and reporting on Interactions with CS Task 8 –

Start Date: Month 1 – End Date: Month 60

Task [IRSN (MUTADIS)]

This task is dedicated to the coordination of CS interactions within EURAD. It is organizing the attendance of the CS members of the CS group to EURAD workshops and will ensure the integration of the results of the participants of the CS teams involved in the different scientific/technical WPs, as well as methodological support for interactions between CS and stakeholders.

Finalizing the composition of the CS group

The composition of the CS group will be finalised during the inception phase of the JP according to a selection procedure open to Civil Society applicants from the EU (D1.13). The CS group includes several categories of participants such as representatives of European or national Civil Society Organisations, members of local communities having interest in RWM, be they representatives of local groups such as local association, local Committee of Information, local partnership (or having participated to such groups) .

A call for expression of interest will be sent to identify potential members in the first quarter of the first year of EURAD-1 with the perspective to finalize the CS group by the end of the first semester of the project. In order to select the members of the CS group, a list of criteria will be established and after receiving all the applications, they will be assessed through this list of criteria. According to the evaluation, the applicants will receive a formal confirmation of their participation or a formal answer explaining why they do not fulfil the criteria of the CS group. It will be still possible to enter the CS group after and the applicants will be assessed on the same basis.

Organizing yearly a workshop (as part of EURAD Annual Meeting) involving the participants of the CS group, the CS Experts together with a panel of WMOs, TSOS and REs participants in EURAD

Task 8 will organize each year a workshop that will be divided in one general session on the overall progress of EURAD scientific and technical activities and topical sessions (for the 1st wave: ROUTES & UMAN WPs), this includes elaboration of material, methodologies, processes and sessions to prepare EURAD participants and CS representatives in order facilitate fruitful interactions. The topical sessions will each be prepared and animated by the dedicated CS experts team involved in ROUTES and UMAN WPs. Each CS Experts team will gather CS views on the activities of their WP. In order to organize the general session of its annual workshop in the frame of the EURAD Annual meetings, Task 8 will collect results from the work of the different scientific/technical WPs, ensure the translation of results to the CS group during the session and gather CS advices and comments on the activities of the scientific and technical WPs. A small team of CS experts will be dedicated to this task and will work together with representatives from WMOs, TSOs and REs from the different WPs.

Assessment of the experimental model of Interaction between EURAD participants and Civil Society.

Evaluation of the experimental model of Interaction between EURAD participants and Civil Society will be carried out at mid-term (Month 30) and at the end of EURAD-1 (Month 60) under the supervision of the PMO. It will be performed by integrating the views of EURAD consortium (through the 3 colleges WMOs, TSOs and REs), CS Experts and CS group. It shall make sure the scheme for interactions is evolving positively, and if felt necessary as a conclusion of the evaluation, adapt and revise it in order to improve it. (D1.14, D1.15 and D1.16).

Partner number and short name	WP1 effort
1 - ANDRA	100.00
8 - CNRS	7.50
19 - IRSN	3.00
MUTADIS	4.10
NTW	10.70
22 - JSI	0.00
EIMV	2.20
23 - JRC	15.00
37 - RWM	7.50
Total	150.00

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D1.1	2nd Annual Work Plan	1 - ANDRA	Report	Confidential, only for members of the consortium (including the Commission Services)	9
D1.2	3rd Annual Work Plan	1 - ANDRA	Report	Confidential, only for members of the consortium (including the Commission Services)	21
D1.3	4th Annual Work Plan	1 - ANDRA	Report	Confidential, only for members of the consortium (including the Commission Services)	33
D1.4	5th Annual Work Plan	1 - ANDRA	Report	Confidential, only for members of the consortium (including the Commission Services)	45
D1.5	PMO - EURAD Quality Management Plan	1 - ANDRA	Report	Public	3
D1.6	EURAD Data Management Plan	1 - ANDRA	ORDP: Open Research Data Pilot	Confidential, only for members of the consortium (including the Commission Services)	12

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D1.7	EURAD Roadmap, extended with Competence Matrix	1 - ANDRA	Report	Public	12
D1.8	'Soft' update of the EURAD SRA/Roadmap	1 - ANDRA	Report	Public	12
D1.9	'Extensive' update of the SRA/Roadmap	1 - ANDRA	Report	Public	44
D1.10	- Identification of Subject Matter/Theme Experts from EURAD Colleges	1 - ANDRA	Report	Public	12
D1.11	EURAD Dissemination strategy	1 - ANDRA	Report	Public	3
D1.12	EURAD website	1 - ANDRA	Websites, patents filling, etc.	Public	3
D1.13	List of members of the CS group	19 - IRSN	Report	Public	6
D1.14	Mid-term evaluation of the ICS activities and experimental model of interaction between EURAD participants and Civil Society	19 - IRSN	Report	Public	30
D1.15	Integrated review of the ICS activities in EURAD	19 - IRSN	Report	Public	58
D1.16	Evaluation of experimental model of interaction between EURAD participants and Civil Society	19 - IRSN	Report	Public	58
D1.17	Evaluation of the impacts of EURAD first implementation phase	1 - ANDRA	Report	Public	60

Description of deliverables

- D1.1 – Second Annual Work Plan [Month 9] – Lead: [Andra]
- D1.2 – Third Annual Work Plan [Month 21] – Lead: [Andra]
- D1.3 – Fourth Annual Work Plan [Month 33] – Lead: [Andra]
- D1.4 – Fifth Annual Work Plan [Month 45] – Lead: [Andra]
- D1.5 – EURAD Quality Management Plan [Month 3] + its annual update - Lead: [Andra]
- D1.6 – EURAD Data Management Plan [Month 12] – Lead: [Andra]
- D1.7 - EURAD Roadmap, extended with Competence Matrix and mapping exercise on related SoK, Guidance, and Training/Mobility Resource input from D1.9 [Month 12] - Lead: [Andra]
- D1.8 - 'Soft' update of the EURAD SRA/Roadmap – [Month 12] - Lead: [Andra]
- D1.9 - 'Extensive' update of the EURAD SRA/Roadmap – [Month 44] - Lead: [Andra]

- D1.10 - Identification of Subject Matter/Theme Experts from EURAD Colleges [Month 12] + its update - Lead: [Andra]
- D1.11 - EURAD Dissemination strategy [Month 3] + annual update - Lead: [Andra]
- D1.12- EURAD website [Month 3] - Lead: [Andra]
- D1.13 List of members of the CS group [Month 6] + its annual update Lead [IRSN (Mutadis)]
- D1.14- Mid-term evaluation of the ICS activities and experimental model of interaction between EURAD participants and Civil Society [Month 30] Lead [IRSN (Mutadis)]
- D1.15 - Integrated review of the ICS activities in EURAD [Month 58] Lead [IRSN (Mutadis)]
- D1.16 - Evaluation of experimental model of interaction between EURAD participants and Civil Society [Month 58] Lead [IRSN (Mutadis)]
- D1.17 – Evaluation of the impacts of EURAD first implementation phase [Month 60] – Lead: [Andra]

D1.1 : 2nd Annual Work Plan [9]

2nd Annual Work Plan

D1.2 : 3rd Annual Work Plan [21]

3rd Annual Work Plan

D1.3 : 4th Annual Work Plan [33]

3rd Annual Work Plan

D1.4 : 5th Annual Work Plan [45]

5th Annual Work Plan

D1.5 : PMO - EURAD Quality Management Plan [3]

EURAD Quality Management Plan

D1.6 : EURAD Data Management Plan [12]

EURAD DMP specifies how research data will be handled both during and after EURAD projects. It identifies key actions and strategies to ensure that research data are of a high quality, safe, sustainable and – where possible – accessible and reusable.

D1.7 : EURAD Roadmap, extended with Competence Matrix [12]

EURAD Roadmap, extended with Competence Matrix and mapping exercise on related SoK, Guidance, and Training/ Mobility Resource input from D1.9

D1.8 : ‘Soft’ update of the EURAD SRA/Roadmap [12]

‘Soft’ update of the SRA/Roadmap in view of the preparation of the 2nd wave of RD&D and Strategic Studies WPs where it is anticipated that minor edits and additions should be made, e.g. assessing the level of common interest of topics that emerged lately in the process of developing the SRA; identification of emerging RD&D needs and assess level of common interest.

D1.9 : ‘Extensive’ update of the SRA/Roadmap [44]

‘Extensive’ update of the SRA/Roadmap (exact timing to be adjusted in order to be in line with Euratom work programme) to coincide with preparation and prioritisation of the scope of the potential EURAD2. During this extensive update, it is anticipated that significant changes may result to take account of learning from EURAD-1 and align the Vision, SRA, Roadmap and RD&D, Strategic Studies and KM Work Packages scope and methodologies with how things evolve, particularly with respect to the JP governance scheme and how the criteria used to identify needs of the WMOs, TSOs and REs

D1.10 : - Identification of Subject Matter/Theme Experts from EURAD Colleges [12]

identification of subject matter experts against each of the Roadmap Sub-themes/topics as well as experts having a broad overview of a RWM programme who experts will be able to provide adhoc technical support for a set term (possibly be reviewed/updated annually) in order to guide Roadmap updates and Joint Programme Knowledge Management Activities

D1.11 : EURAD Dissemination strategy [3]

a Dissemination Strategy will be developed to identify the key messages to be delivered, the target audiences to be addressed, the method/channels to address them, and the timing and process of dissemination.

D1.12 : EURAD website [3]

EURAD website

D1.13 : List of members of the CS group [6]

List of members of the CS group

D1.14 : Mid-term evaluation of the ICS activities and experimental model of interaction between EURAD participants and Civil Society [30]

Mid-term evaluation of the ICS activities and experimental model of interaction between EURAD participants and Civil Society

D1.15 : Integrated review of the ICS activities in EURAD [58]

Integrated review of the ICS activities in EURAD

D1.16 : Evaluation of experimental model of interaction between EURAD participants and Civil Society [58]

Evaluation of experimental model of interaction between EURAD participants and Civil Society

D1.17 : Evaluation of the impacts of EURAD first implementation phase [60]

Evaluation of the impacts of EURAD first implementation phase

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	EURAD Kick-off meeting (General Assembly n°1)	1 - ANDRA	1	EURAD Kick-off meeting (General Assembly n°1)
MS12	EURAD EJP Newsletters	1 - ANDRA	3	EURAD EJP Newsletters (Due date : M3 and then every quarter)
MS30	EURAD General Assembly n°2	1 - ANDRA	7	EURAD General Assembly n°2
MS42	EURAD Annual Work Plan 2	1 - ANDRA	9	EURAD Annual Work Plan 2
MS71	Methodology for ICS activities assessment	19 - IRSN	12	Methodology for ICS activities assessment
MS81	EURAD General Assembly n°3 + EURAD Annual Meeting 1	1 - ANDRA	13	EURAD General Assembly n°3 + EURAD Annual Meeting 1
MS82	ICS Workshop 1	19 - IRSN	13	ICS Workshop 1
MS85	EURAD Periodic Report 1	1 - ANDRA	14	EURAD Periodic Report 1
MS103	EURAD General Assembly n°4	1 - ANDRA	19	EURAD General Assembly n°4
MS112	EURAD Annual Work Plan 3	1 - ANDRA	21	EURAD Annual Work Plan 3
MS136	EURAD General Assembly n°5 + EURAD Annual Meeting 2	1 - ANDRA	25	EURAD General Assembly n°5 + EURAD Annual Meeting 2
MS137	ICS Workshop 2	19 - IRSN	25	ICS Workshop 2
MS140	EURAD Periodic Report 2	1 - ANDRA	26	EURAD Periodic Report 2
MS153	EURAD General Assembly n°6	1 - ANDRA	31	EURAD General Assembly n°6
MS162	EURAD Annual Work Plan 4	1 - ANDRA	33	EURAD Annual Work Plan 4

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS185	EURAD General Assembly n°7 + EURAD Annual Meeting 3	1 - ANDRA	37	EURAD General Assembly n°7 + EURAD Annual Meeting 3
MS186	ICS Workshop 3	19 - IRSN	37	ICS Workshop 3
MS189	EURAD Periodic Report 3	1 - ANDRA	38	EURAD Periodic Report 3
MS199	EURAD General Assembly n°8	1 - ANDRA	43	EURAD General Assembly n°8
MS206	EURAD Annual Work Plan 5	1 - ANDRA	45	EURAD Annual Work Plan 5
MS222	EURAD General Assembly n°9 + EURAD Annual Meeting 4	1 - ANDRA	49	EURAD General Assembly n°9 + EURAD Annual Meeting 4
MS223	ICS Workshop 4	19 - IRSN	49	ICS Workshop 4
MS224	EURAD Periodic Report 4	1 - ANDRA	50	EURAD Periodic Report 4
MS234	EURAD General Assembly n°10	1 - ANDRA	55	EURAD General Assembly n°10
MS235	ICS Workshop 5	19 - IRSN	55	ICS Workshop 5
MS240	EURAD General Assembly n°11 + EURAD Annual Meeting 5	1 - ANDRA	60	EURAD General Assembly n°11 + EURAD Annual Meeting 5
MS241	EURAD Periodic Report 5	1 - ANDRA	60	EURAD Periodic Report 5 (Due date: 60+2)

Work package number ⁹	WP2	Lead beneficiary ¹⁰	38 - SCK•CEN
Work package title	Assessment of Chemical Evolution of ILW and HLW Disposal Cells (ACED)		
Start month	1	End month	48

Objectives

Objectives

The broader scope of this work package is the assessment of the chemical evolution at the disposal cell scale involving interacting components/materials and thermal, hydraulic and/or chemical gradients by considering ILW and HLW disposal concepts representative for different concepts throughout Europe. To increase the attention towards relevant materials and processes, the work package addresses ILW and HLW components up to the disposal cell scale. The study of the disposal cell in this WP ranges from microscale processes at interfaces between different materials up to interactions of waste packages with their immediate surrounding near field environment and the host rock.

The main objective is to improve methodologies to obtain multi-scale quantitative models for the chemical model at cell disposal scale based on existing and new experimental data and process knowledge and to improve the description of the most relevant processes driving the chemical evolution into robust mathematical frameworks. This is done for four selected representative disposal cell designs by analysing and combining information from available experimental studies, new targeted experimental studies developed within this WP and modelling exercises at both process and system levels. Applications will lead to integrated process understanding at larger temporal and spatial scales compared to individual process scale studies. The outcomes will impact the safety case in different ways such as with respect to material specifications and establishment of requirements for deposition scenarios. The representative designs are set for ILW and HLW in both crystalline and sedimentary rock types, representing prevailing designs of the WMOs as end-users.

More specifically, the WP seeks to:

- Compile and integrate the process level knowledge and description of reactivity at the interfaces between materials relevant for ILW and HLW disposal cells
- Develop and evaluate methodologies to integrate available process-level knowledge and processes into a multi-process and multi-scale modelling framework for assessing chemical evolution at the disposal cell level
- Propose and apply a step-wise scale-up process-based approach to identify (i) processes and features which control the chemical evolution for representative HLW and ILW disposal cells and (ii) to which detail and complexity these processes should be incorporated in models for different type of safety and performance related studies. The information gained through study of the more generic but European representative HLW and ILW disposal cells can later be used and adapted for more specific, national disposal cell designs.

Expected impacts

Regarding RWM implementation needs

The WP evaluates how process level knowledge can be incorporated in models describing chemical evolution between the waste form (glass, cemented waste) and the near field materials to assess the evolution of the buffer, container and waste matrix accounting for transport of reactive species and/or other drivers for geochemical alterations. The methodologies are important to obtain a holistic view of the effect of interacting processes on the geochemical evolution at relevant spatial and temporal scales, which help in understanding the evolution of such systems. For example, a number of chemical perturbations by considering different materials (glass, steel, clay, cement, granite) under relevant hydraulic and thermal gradients are integrated at relevant spatial and temporal scales. The interaction of metallic and cement materials with each other is studied with experimental characterization and through modelling at different scales. The performance of the improved models is evaluated using experimental data. Such integrated models can then be used in process and parameter sensitivity studies to identify key features, processes and parameters to describe the chemical evolution at the relevant space and timescales.

A good understanding and assessment of the geochemical evolution forms also the basis for other aspects. The WP studies degradation/corrosion of different waste immobilisation matrices (vitrified waste, cemented waste) and metallic wastes as function of the evolving conditions imposed by different materials and geometrical features. The experimental and modelling studies concerning waste form alteration considered in this WP provide essential information on geochemical boundary conditions affecting the mechanisms and kinetics of radionuclide release. The impact of geochemical transformations at the interfaces will induce an evolution of porosity (including clogging phenomena) which is a critical parameter as porosity represents the primary affected physical variable determining radionuclide migration and fluid flow.

The process of model simplification at the system level basis, allows for the identification of the most relevant processes, features and parameters determining the chemical evolution at the cell disposal scale. This will provide inputs to how chemical evolution should be handled in a safety case for the repository level.

Building model capacity for assessing chemical evolution with benchmarked simplified models at the system level allows for model calculations for program-specific disposal cell geometries and analyses for optimization, sensitivity and uncertainties. The systematic approach for model abstraction developed in the work package will increase the confidence in the different models with different model complexity.

Assessment of the chemical evolution at the cell disposal scale will give input to identify critical features in the design of a disposal cell. The model capacity and benchmarked simplified models will help in the engineering and design of immediate surroundings of waste packages.

Regarding safety

The methodological developments and applications for assessing the chemical evolution at a cell disposal scale will allow for better representation of interactive and complex processes, with emphasis on chemical processes, within ILW or HLW disposal cell systems. The chemical evolution forms the basis for the evolution and the assessment of many safety- and performance-related aspects such as waste form degradation, material alteration, source term (radionuclide release), and radionuclide speciation, fate and transport. This better representation of expected evolutions will help:

- To assess and quantify the generic safety functions isolation of waste and immobility of the waste. The chemical conditions induce geochemical alteration of different barriers. These alterations may lead to change in lifetime of a barrier, including the waste package container (isolation), and change in mobility of radionuclides, including both solubility and sorption. The methodologies developed and evaluated in this work package contributes to the assessment of these generic safety functions as they will describe the change in chemical conditions over time when different materials, waste packages and disposal cells interact with each other.
- To further reduce conservatism and uncertainty, and to quantify the safety margin.
- To define the requirements on materials, including the robustness of allowable tolerances. The specifications, including dimensioning, of the packages and disposal cell(s) can be influenced based on the WP outcomes. Acceptance criteria for varying wastes and stabilization materials can also be influenced by the WP achievements towards understanding material evolution and impact sensitivity.

Both methodological routes can be applied in different steps in a safety case. A good approach for the integration of process knowledge helps to build scientific-based models for understanding system behaviour and evolution and for identifying key processes determining chemical evolution. The abstraction methodology provides guidelines about how to assess which level of process or system representation is needed to assess the chemical evolution in an acceptable way, or to quantify the level of conservatism when a specific simplification is used. Although the methodological routes are applied in this work package for the assessment of the chemical evolution, information and recommendations will also be relevant for other processes to be considered within a safety case such as those studied in some of the other work packages in this project.

Relevance for European National Programmes

As mentioned above, both ILW and HLW disposal cells will be studied. On one side, there are a number of elements, especially at the interface scale, which are common for both disposal cell types. On the other hand, the disposal cells for ILW and HLW also have specific elements only relevant for either one of the two such as involved processes, features, etc. Therefore, having both the ILW and HLW as separate study objects in the evaluation of the methodologies for process integration and model abstraction will allow for a much broader application of the outcomes of this work package for the different national programs. ILW and HLW studies are included in the waste package (Task 3) and disposal cell scale (Task 4). For the interface scale (task 2), the studies on the steel-clay interface are relevant for the HLW disposal cell in many European national programs, whereas the steel-cement interface, beside in HLW disposal cell in a limited number of European national programs, is present in many, if not all, waste packages in ILW disposal cells. The weight between the amount of effort devoted specifically to ILW compared to HLW studies has been partially influenced by the needs and associated co-funding.

Description of work and role of partners

WP2 - Assessment of Chemical Evolution of ILW and HLW Disposal Cells (ACED) [Months: 1-48]

SCK•CEN, ANDRA, BEL V, CEA, CIEMAT, CNRS, COVRA, ENRESA, JUELICH, IRSN, JSI, LEI, MTA EK, NAGRA, NRG, PSI, SÚRAO, VTT

Task 1 – S/T coordination, State-of-the-art and training material

Start: Month 1 – End: Month 48 - Task Leader: [SCK•CEN] Co-Task Leaders [COVRA] [JUELICH]

Task contributors: [Andra] [CIEMAT] [COVRA] [ENRESA] [JUELICH] [LEI] [SÚRAO] [SCK•CEN] [VTT]

Total PM: 32,5

Task Objectives:

- S/T coordination of the WP
- Developing/updating State-of-the-art
- Developing training materials as an input to KM
- In-depth analysis of the current handling of the chemical evolution in Europe
- Building blocks (experimental studies, conceptual and mathematical models, parameters, etc.) for Task 2, 3, and 4

Subtask 1.1 – S/T coordination Start: Month 1 – End: Month 48 – Subtask Leader: [SCK•CEN]

Total PM: 2

The scientific and technical coordination of ACED will be performed by the WP Leader [SCK•CEN]. The WP Leader will be supported by the Task leaders and co-leaders: [IRSN] [PSI] [Andra] [VTT] [COVRA] [JUELICH] [SÚRAO (UJV)] which together with [SCK•CEN] constitute the WP Board of ACED. The WP Leader will make sure that EURAD rule are followed by all partners, that the scientific milestones and deliverables are reached timely, and that the results are disseminated efficiently inside and outside the project. It includes also participation to PMO meetings twice a year. Subtask 1.1 consists of ensuring information transfer between different (sub)tasks. This is accomplished by a number of WP meetings, workshops and general milestones.

The following WP meetings (WPM) are planned :

- Kick-off meeting (WPM1) at the start of the WP including a discussion on the specifications of the representative systems and discussion between experimentalists and modellers on requirements for modelling approaches and expected experimental input (input to MS8) (Month 1)
- WPM 2 - including task meetings and a first workshop (Month 7)
- WPM 3 - including task meetings (Month 19)
- WPM 4 - including task meetings and MS155 (Month 31)
- WPM 5 - including task meetings and workshop 6 (Month 43)
- Closure meeting (WPM 6) at the end of the WP (Month 48)

Following workshops (WS) or interaction meetings are planned :

- WS1 (Month 7) (adjacent to work package meeting) – workshop on data, model concepts, and parameters based on expected experimental results for interface and waste package scales (input from D2.1, MS16, D2.10), on coordination of information exchange between experiments and models within and between scales and on scale transitions of data, model approaches and model results (leading to MS31, MS43 and D2.18)
- WS2 (Month 13-18) – Joint workshop with GAS and DONUT on (i) possible benchmark studies for DONUT (input from D2.14, D2.15 and D2.16), (ii) numerical challenges, and (iii) abstraction methodologies.
- WS3 (Month 31) (adjacent to WP meeting) – workshop on status of experiments and models for the different scales and information exchange of preliminary data between experiments and models within scales and update of model concepts and parameters based on these preliminary data towards information exchange between scales and upscaling (Milestone 1.1.4).
- WS4 (Month 30-37) – Joint workshop with GAS and DONUT on intermediate results of (i) benchmark studies, (ii) numerical developments, and (iii) application of abstraction methodologies.
- WS5: (Month 37) (adjacent to project meeting) – workshop on information exchange of data between experiments and models within scale and information exchange towards upscaling with update of model concepts and parameters (MS180)
- WS6: (Month 43) (adjacent to WP meeting) – workshop on how to use the different methodologies applied and evaluated in the work package in safety assessment methodologies for geological disposal of radioactive waste (as input to D2.2)

Subtask 1.2 – State-of-the-art Start: Month 1 – End: Month 48 – Subtask Leader: [COVRA]

Sub-Task Contributors: [SCK•CEN] [JUELICH] [COVRA]

Total PM: 6

This sub-task compiles and evaluates the state-of-the-art regarding relevant processes that influence the long-term chemical evolution in disposal cells for vitrified HLW and for cemented ILW (D2.1). Besides information from integrated experiments, other alternative routes to study the long-term chemical evolution are included as well such as evidence from natural or archaeological analogues. Also, current practices of integration are reviewed. These desktop studies will provide:

- Description of relevant processes and transients that influence the chemical evolution in the disposal cells (e.g. with respect to pH, redox, temperature, chemistry of near field water, etc.) and at the following six interfaces glass-steel, cement/mortar granite, cement/concrete-clay, steel/iron bentonite, steel/iron-cement/concrete and steel/iron-granite (e.g. formation of new phases, porosity/permeability changes influencing fluid/gas transport, etc.)

- Overview about which conceptual and mathematical models have been and are used to describe these processes and the chemical evolution; how are these models parameterized (e.g. sources of data to parameterize long-term processes, e.g. application of data/insight from experiments, natural/archaeological analogues, etc.)

Integration of the results of WP tasks 2 to 4 by updating the state-of-the-art pertaining to chemical evolution process understanding and model capacity. It furthermore addresses questions related to methodological aspects of integration of knowledge and addressing complexity of chemical evolution in a disposal cell taking into account interaction between components and processes. (D2.2)

Subtask 1.3 – Training materials Start: Month 24 – End: Month 48 – Subtask Leader: [SCK•CEN]

Total PM: 2

Experience on methodological and practical aspects for developing, implementing and interpreting models for the assessment of the chemical evolution at the disposal cell scale will be obtained in this WP. Based on the expertise gained during the first two years of the project, different tools for learning material will be developed in close cooperation with the training/mobility KM WP. The tools envisaged are theoretical lectures/tutors, demonstration of simulation tools used within this WP, tutorials and practical exercises for some example simulation tools. The practical exercises will be based on the simulations performed in the tasks 2 – 4 and will cover the three scales envisaged in this WP. Possible topics includes principle and approaches in reactive transport modelling at different scales and model abstraction, sensitivity and uncertainty analysis. A training workshop (level doctoral school) is organised during the third year on one of these topics. Collaboration with other WPs, especially DONUT, in development of the training materials will be investigated. [SCK•CEN] will coordinate and assemble training material for the work package on the assessment of the chemical evolution at cell disposal scale. (D2.3)

Subtask 1.4 – Current handling of the chemical evolution

Start: Month 1 – End: Month 5 – Subtask Leader: [COVRA]

Subtask Contributors: [SCK•CEN] [JUELICH] [Andra] [VTT] [SÚRAO] [ENRESA] [LEI] [COVRA]

Total PM: 11

There may be current European practices why the chemical evolutions for disposal are included and how the chemical evolution at the disposal cell scale has been treated e.g. in safety cases. The conceptualisations of the chemical evolutions and which parts have been modelled in Europe will be collected. For countries not participating in Task 1, teleconferences with authors of safety cases will be held to get the conceptualisations, model descriptions and sources of data at a sufficient detail from the other National Programmes. (D2.4)

Subtask 1.5 – Analysis of experiments and numerical model studies on interfaces

Start: Month 1 – End: Month 4 – Subtask Leader: [JUELICH]

Subtask Contributors: [SCK•CEN] [Andra] [VTT] [SÚRAO] [COVRA] [CIEMAT] [JUELICH]

Total PM: 11,5

In a pre-project phase, the existing/running and proposed experiments have been reviewed with the 5 selection criteria to have experiments for task 2: chemical evidence for model validation, solid-solid interfaces, not a clay-cement interface due to the running EU project Cebama, preference for running experiments and more than one country should have interest in the specific interface. The following interfaces with steel were selected for task 2 after application of these selection criteria: steel-bentonite, steel-concrete, steel-granite. The benefit of these steel interfaces is that they all three contain another distinctly different parameter value i.e. (initial) pH of pore water and process i.e. transport of degraded corrosion products. This set is therefore expected to provide process understanding of the chemical evolution at these interfaces. Within task 3 and 4 also additional interfaces not included in the experimental work in task 2 will be relevant, such as glass-steel, concrete-clay, and concrete-granite. Therefore, desk-based studies will be performed to provide a structured overview of existing (experimental) data on relevant processes occurring at the following six interfaces: glass-steel, cement/mortar-granite, cement/concrete-clay, steel/iron-bentonite, steel/iron-cement/concrete and steel/iron-granite. The overviews includes also natural/ archaeological analogues that may provide insight/data for long-term processes relevant to the chemical evolution of the disposal cells not accessible in short-term (laboratory) experiments. In addition, the desk-based studies will also provide an overview on the conceptual models used to describe the processes at the interface. This overview forms the basis for conceptualisation of the chemical evolution at these interfaces in the other tasks and will be used to support model validation and parametrization of models (D2.5)

Task 2 - Interface scale: Reactivity of Steel/Material Interfaces

Start: Month 1 – End: Month 48 - Task Leader: [IRSN] - Co-Leader: [SÚRAO (UJV)]

Task contributors: [BEL V] [CIEMAT (UAM)] [CNRS-SUBATECH (IMT Atlantique)] [ENRESA] [IRSN (Mines ParisTech)] [JSI [ZAG]] [MTA EK] [NAGRA (UBERN)] [NRG] [PSI] [SÚRAO (UJV)] [VTT]

Total PM: 259

Task objectives:

The general task objective is to provide geochemical and coupled reactive transport models for assessing the geochemical evolution at steel/clay material and steel/cement material interfaces in terms of corrosion rates, geochemical alterations and physical alterations. These models will provide the bases of the up-scaling to waste package (Task 3) and disposal cell (Task 4) modelling.

More specifically, the combined modeling-experimental approach will result in an increased confidence and decreased uncertainty of model simulations of:

- the corrosion rates of steel in contact with clay or cement materials under different environmental conditions as temperature, redox conditions, chemistry of solutions or quality of the interface;
- the fate of corrosion products (Fe(II)) in the cement or clay material;
- the physical-chemical evolution at the interface;
- the evolution of transport properties.

The experimental studies ultimately lead to a consistent input and validation data set for geochemical and reactive transport modelling of the interface evolution by obtaining information on:

- the geochemical reactions and transport properties controlling the corrosion and the interaction of corrosion products with bentonite and cement materials;
- the corrosion type and the corrosion rate in function to the environmental variables;
- specifically for the steel/clay material interface, the diffusivity of Fe(II) in bentonite;
- specifically for the steel/cement material interface, effects of temperature and alkalinity of the environment, of chemistry of relevant waters (granite groundwater or clayey pore waters), and of the presence of heterogeneities at the interface.

The model studies will:

- use this data to validate modelling approaches including geochemical models for corrosion products, corrosion rates, corrosion type, redox processes, fate of Fe, and evolution of the materials in contact with steel;
- analyze the effect of different environmental conditions on the chemical evolution at the steel-clay and steel-cement interface;
- provide the base for up-scale to waste package (Task 3) and disposal cell (Task 4) scale by a significant reduction in the uncertainties of reactive transport models.

To ensure interactions between modelling and experimental work, a workshop will be organized by each subtask leader each year (to define, adapt and synthesize the modelling approach (interaction modelling teams) and to optimize experiments and characterization for model validation (interaction modelling and experimental teams). This results in following work plan for each subtask:

- Workshop 1 (Month 3)
- Milestone MS16 (M6) – A note on the specific experimental conditions at the steel/clay or steel/cement material interface and parameters and the modelling approaches with detailed information on set-ups and work flow, variables to measure and a dismantling and characterization plan. It will also define the link between the experiments and the model approaches (also input to general workshop 1, and M1.1.2).
- Workshop 2 (Month 19)
- Workshop 3 (Month 31)
- Workshop 4 (Month 43)

Subtask 2.1 – Steel/clay material interface reactivity

Start: Month 1 – End: Month 48 – Subtask Leader: [SÚRAO (UJV)]

Subtask Contributors: [SÚRAO (UJV)] [CIEMAT (UAM)] [ENRESA] [NAGRA (UBERN)] [IRSN (Mines Paris Tech)] [MTA EK] [NRG] [CNRS-SUBATECH (IMT Atlantique)]

Total PM: 169,5 PM

Interactions between a modeling and an experimental group will identify the critical elements to improve the conceptual description of steel/clay material interactions in reactive transport models and the crucial variables to measure for model validation and predictions of corrosion rates and clay alterations. Corrosion rates, physico-chemical evolution, mineralogical evolution at the interface or porosity evolution, amongst others, are measured on existing and two new experimental set-ups for a range of environmental conditions as redox state, aggressive anions (chloride concentration from few mg/L to 35 g/L), temperature (from 20°C to 80°C), close to neutral pH.

The experimental group [SÚRAO (UJV)] [NAGRA (UBERN)] [CNRS-SUBATECH (IMT Atlantique)] [CIEMAT (UAM)] [MTA EK] designs, manages and characterizes a number of experiments that forms the basis for the modelling group (Figure 19). The experimental programme combines two approaches: i/ two existing experiments with a steel (or iron)/clay material interface during a few months (EE2-1/2) [SÚRAO (UJV)] to several years (EE2-1/1) [CIEMAT (UAM)] and [NAGRA (UBERN)] ii/ two new experiments, a first one to understand the FeII reactivity with bentonite in a simplified approach (porous iron steel/smectite interface) (NE2-1/1) [U. Bern] and second one to understand the

evolution of a steel/clayey material interface [MTA EK] at different temperature (NE2-1/2). Several partners [CNRS-SUBATECH (IMT Atlantique)] [CIEMAT(UAM)] contribute to the characterization of the interface experiments. The modelling group [ENRESA] [NAGRA (UBERN)] [IRSN (Mines Paris Tech)] [NRG] and [SÚRAO (UJV)] will perform geochemical and coupled reactive transport calculations on the selected experiments with these modelling features:

- New experiment that studies the impact of FeII release on smectite (NE2-1/1). [NAGRA –UBERN] and [IRSN (Mines Paris Tech)] collaborate to improve the modeling of the iron reactivity in smectite. This model will provide input to long-term model and for models at waste package and disposal cell scale.
- The experiments EE2-1/1 and NE2-1/2. [NRG] implements a kinetic steel corrosion model into a reactive transport model to model the existing (EE2-1/1) and new experiments (NE2-1/2).
- The short term existing experiment (EE2-1/2). [SÚRAO (UJV)] will simulate the main reactive pathways with geochemical modeling to describe the experiment.
- The long term experiments (EE2-1/1). [NAGRA (UBERN)] and [ENRESA] collaborate to improve the comprehensiveness of the reactive transport modelling to reproduce the physico-chemical evolution (e.g. saturated and unsaturated conditions) of the steel/bentonite interfaces and the extension of the perturbations.

Related deliverables are D2.6 and D2.7.

Subtask 2.2 – Steel/cement material interface reactivity

Start: Month 1 – End: Month 48 – Subtask Leader: [IRSN]

Subtask Contributors: [BEL V] [IRSN (Mines ParisTech)] [MTA EK] [NRG] [PSI] [CNRS-SUBATECH (IMT Atlantique)] [VTT] [JSI (ZAG)]

Total PM: 89,5

As for the subtask 2-1, interactions between a modeling and an experimental group will identify the critical elements to improve the conceptual description of steel/cement material interactions in reactive transport models and the crucial variables to measure for model validation and predictions of corrosion rates and cement alteration products (e.g. physico-chemical evolution, mineralogical and porosity evolution of the interface). These parameters, amongst others, are measured on two existing and two new experimental set-ups for a range of environmental conditions as redox state (essentially in anoxic conditions), aggressive anions with chloride concentration from few mg/L to 35 g/L (e.g. clayey solution in EE2-2/1 and NE2-2/1 to sea water in NE2-2/2), temperature from ambient conditions (EE2-2/1, EE2-2/2) to 80°C (NE2-2/1, NE2-2/2), high pH range starting from neutral (EE2-2/2) to high pH (EE2-2/1, EE2-2/2, NE2-2/1, NE2-2/2) (see Fig. 2).

The experimental work [IRSN] [VTT] [BELV] [CNRS-SUBATECH (IMT Atlantique)] [MTA EK] [JSI (ZAG)] is starting with characterizations of existing experiments (EE2-2/1, EE2-2/2) [IRSN] [VTT] along the needs for model validation and continue with a number of new dedicated experiments (NE2-2/1, NE2-2/2), identified as critical for process understanding and model validation [IRSN] [MTA EK]. Mainly in situ experiments are planned to be characterized or started [IRSN, VTT]. Existing experiments with Portland cement or grout cement (low alkaline cement) in contact with steel in saturated conditions in ambient temperature will be characterized by several organizations [IRSN] [CNRS (SUBATECH)] [VTT]. The new experiments in situ [IRSN] and in laboratory [MTA EK] will be focused on the interface reactivity at 80°C (NE2-2/1, NE2-2/2). The role of heterogeneities (e.g. non-perfect interface or presence of voids) at the interface will be also treated to identify a potential local influence on the corrosion type and rate.

The modelling group [IRSN (Mines ParisTech)] [PSI] and [NRG] reformulate an existing solid/solution model for C-S-H, AFm and AFt phases to describe Fe uptake in the cementitious material exposed to steel corrosion [PSI]. Reactive transport models will then be evaluated to describe the ageing of the steel/cement interface for different conditions (low or high temperature, in contact with low or high alkaline cement/concrete) [IRSN (Mines Paris Tech)] [NRG]. And if successful also incorporate the solid/solution approach [PSI].

Related deliverables are D2.8 and D2.9.

Task 3 - Waste package scale (conditioned waste, disposal container, overpack)

Start: Month 1 – End: Month 48 - Task Leader: [PSI] - Co-Leader: [Andra]

Task contributors: [Andra (BRGM)] [CEA (EDF)] [CNRS-SUBATECH (IMT Atlantique) (ULorraine)] [COVRA] [JUELICH] [JSI (ZAG)] [MTA EK] [NRG] [PSI] [SCK•CEN]

Total PM: 174,6

Task Objectives:

This subtask concerns the first upscaling step from the relatively isolated processes at interfaces (studied in Task 2) to repository sub-systems, representative for HL/IL waste packages, where chemical and physical processes might be closely intertwined. As the long term evolution of such systems by laboratory experiments is not easily available, or cannot be obtained within the timeframe of this project, the investigations will be based largely on (i) existing

datasets, or on (ii) using some 'running' datasets complemented by limited additional measurements, or on (iii) new measurements on 'analogues' (existing waste packages, existing infrastructure), or on (iv) a limited and targeted set of new experiment(s) to provide data which could be analysed during this WP.

Numerical modelling of the coupling between chemistry, transport processes and material alterations will be a major effort in this task. The modelling work will concentrate on describing the evolution of important chemical properties (redox pH, ionic strength) and other (geochemical) variables (e.g., mineralogy, porosity). This includes the evaluation and comparison of different conceptual and modelling approaches. The goal will be to investigate to what extent abstraction in terms of process de-coupling or scale separations (spatial and temporal) are possible and appropriate: this analysis will be shared with Task 4. For models that describe complex interactions between materials and processes it is absolutely necessary to evaluate not only single process couplings with experimental data but also to compare with experiments with more complex interactions of materials and processes, preferably, if possible, at relevant space and time scales.

This main objectives of this task are:

- To evaluate how adequate available phenomenological concepts and models describe the chemical evolution of typical materials at an intermediate scale – i.e., parts of a repository composed of several materials in a fixed geometry (representative for ILW or HLW waste packages) well below the disposal cell scale.
- To identify critical processes and features driving and controlling the chemical evolution at the waste package scale.
- To provide information on relevance and influence of processes for implementation at disposal cell scale and for model abstraction (task 4).

For ILW waste we concentrate on the two most common types of cemented waste, a metallic waste form containing contaminated/activated steel/iron and an organic waste form:

- Anoxic metal corrosion and degradation of organic matter are depending on the pH of the aqueous phase, which in turn depends on the degradation state of cement materials. Most metals incl. steel and iron will be subject to anoxic corrosion which produces H₂ while water is consumed. The corrosion rates in contact with different cement materials and at different pH are investigated with experiments in task 2 at interface level and in task 3.1 on waste package level.
- Similarly, it is expected that during degradation of organic matter CH₄ and CO₂ are released and water is consumed. Degradation of organic matter is investigated in WP CORI and will be integrated via BRGM, which participates in both WP.
- The long term degradation of concrete has a major influence on metal corrosion and degradation of organic matter. There is a feedback loop between concrete degradation, metal corrosion and organic matter degradation, and associated processes like gas production or liquid saturation on waste package scale and on disposal cell scale. Experimental data on long term internal concrete degradation due to reactive aggregates and externally driven degradation due to ingress of formation waters will be collected in task 3.1 and will help to constrain the waste package models scale models in task 3.3.

For HLW waste, we concentrate on existing HLW concepts in Europe through the study of three systems: « Glass/steel/clay » to « Glass/steel/cement » with an intermediate case « Glass/steel/cement buffer/clay ». The glass alteration rate highly depends on the chemistry (pH, concentrations in silica, calcium and magnesium in solution) of the aqueous phase in the buffer material, and on the nature of corrosion products formed during the corrosion of the overpack before its breaking. Experimental data on glass/steel interactions in different environments will be collected in task 3.1 and combined with the experiments performed in Task 2 dedicated to steel/clay and steel/cement interface will help to constrain the waste package models scale models in task 3.2.

Subtask 3.1 – Experimental analysis

Start: Month 1 – End: Month 31 – Subtask Leader: [CEA]

Sub-Task Contributors: [CEA (EDF)] [CNRS-SUBATECH (IMT Atlantique) (ULorraine)] [SCK•CEN] [MTA EK] [VTT] [Covra] [JUELICH] [JSI (ZAG)] [PSI] [SCK•CEN] [VTT]

Total PM: 113,5

This subtask concerns experimental investigations that will generate data (characterization of HL/IL interfaces), which can be analysed within the duration of the WP and allow for model verification, or complement datasets which are used as input to different modelling teams (Subtask 3.2 and Subtask 3.3).

The analysis of currently running experiments highlighted that most of them are related to existing HLW concepts. The different systems are consistent with both the interfaces studied in Task 2 and the different existing HLW concepts. They will allow getting information about the chemical evolution at glass/steel/buffer interfaces, mainly the nature of newly formed phases, the glass alteration rate and the corrosion rate, according to the temperature, the nature of buffer (clay or cement). These systems from « Glass/steel/clay » to « Glass/steel/cement » with an intermediate case « Glass/steel/cement buffer/clay » are selected.

- An on-going experiment Glass/steel/clay (5 year, 50°C) that will be dismantled and characterized by [CEA] with the support of [CNRS-SUBATECH (IMT Atlantique)].

- A Glass/steel/cement buffer/clay experiment that is launched at 70°C in April 2018 by EDF. The characterization of the different interfaces at different steps is planned during the project by [CEA (EDF)] with the support of [CEA].
- Mock-up tests have been performed at SCK•CEN in which the evolution of a water saturated glass/steel/cement system was monitored for 30 months, for 2 reference waste glass types (SON68, SM539), at room temperature. The cells have already been dismantled and partially characterized: Samples are available for further characterization that will be performed by [SCK•CEN] with the support [CNRS-SUBATECH (IMT Atlantique) (ULorraine)].
- In parallel, a limited series of specific experiments will be performed by [MTA EK] in order to study the chemical evolution of a system borosilicate glass/steel/Boda-claystone formation (BCF) and compare it with these HLW-characteristic systems.

For ILW conditions, following experimental data will be used as input:

- [VTT] provides access to long-term experimental data collected since 21 years on ILW waste package evolution. There is an ongoing experiment of full scale steel drums filled with waste which are deposited in a concrete vault saturated with anoxic water. The experiment setup allows sampling for gas and pore water chemistry analyses. This data will allow calibrating long term degradation of waste package components, specifically gas generation due to metal corrosion and degradation of organic matter.
- [COVRA] has running experiments on backfill and functional concrete degradation due to contact with saline water. Properties of the water are observed over time. Concrete samples will be analysed by Jülich and [JSI (ZAG)] to give indication of long term progress of reaction fronts in high porosity backfill and high strength concrete. This data will be used to test and calibrate reactive transport models in Task 3.3. [JUELICH] [JSI (ZAG)] [COVRA].
- [JSI (ZAG)] will investigate 70 to 100 years old concretes from water saturated parts of hydroelectric power plant dams. Cores will be extracted and analysed by [JUELICH] and [JSI (ZAG)] specifically to get information on long-term reactivity of silica (carbonate) aggregates. Such data is essential to assess scenarios for ILW and HLW that consider internal degradation of concretes/mortars due to long-term aggregate reactivity. [JUELICH] [JSI (ZAG)].

The work will be organized as follows:

- (M3) Interaction with T3.2 T3.3, T4 on existing and expected experimental data for modelling.
- Milestone MS31 (M7) information on existing data for inclusion in T3.2 and T3.3. Describing the selected experiments and existing experimental results D2.10 and D2.11. Some data sets (identical experiment dismantled and characterized after shorter alteration times) will be already available at the beginning of the project as input data for the T3.2 and T3.3.
- Collection and preparation of samples
- Milestone MS55 (M12): distribution of experimental samples to partners
- Analysis of samples and interpretation of results
- (M31): Data freeze: Communication of interpreted experimental data for inclusion in T3.2 and T3.3
- Final reporting D2.12 and D2.13 as input for MS155 and task 1.2

Subtask 3.2 – Modelling of chemical evolution of HLW waste package scale

Start: Month 6 – End: Month 48 – Subtask Leader: [SCK•CEN]

Subtask Contributors: [CEA] [COVRA] [Andra (BRGM)] [MTA EK] [SCK•CEN]

Total PM: 33,3

This subtask concentrates on modelling the selected reference experiments studied in subtask 3.1 and the evolution of a HLW waste package for vitrified waste consisting of a glass core encapsulated in an iron/steel canister and in contact with a cement or cement/clay backfill.

It will involve testing and comparing different conceptual models including different features (description of heterogeneities, e.g. voids) and processes, and/or waste alteration models and/or different corrosion models and/or degradation of concrete materials models and/or different reactive transport codes (PhreeqC, Hytec, Crunch, OpenGeoSys-GEM, etc.).

The modelling of experiments will involve [MTA EK] [CEA] and [Andra (BRGM)]. First (m6), modelling will use the datasets already available at the beginning of the WP (Deliverable D2.10) and will progressively integrate the results of characterization (annual meetings + deliverable D2.11). [Andra (BRGM)] [COVRA] and [Andra] and [SCK•CEN] will model a reference HLW waste package by taking into account different representations: perfect interfaces, presence of voids and/or heterogeneities.... The definition and the conceptualization of this reference HLW waste package will be done during the first year of the project by taking into account existing HLW concepts, the experiments studied in Subtask 3.1 and systems studied in Task 4.

The following steps are planned:

- Milestone MS8 (M1) Specifications of waste package model concepts and links with and between model approaches and expected experimental results from T2 and T3.1
- Milestone MS31 (M7): First input from experiments and information exchange with T4 on expected results
- Implementation in numerical model and first simulations

- Milestone MS155 (M31) Data freeze: Update of model parameters and conceptual model based on input from T2 on T3.1
- Update implementation in numerical model and update of simulation results with final experimental data.
- Milestone MS167 (M36): Synthesis note on concepts and effective parameters for approximation of chemical evolution of waste packages on disposal cell scale (input to MS180) (Lead: SCK•CEN)
- Milestone MS180 (M37): Data freeze: Update of upscaling concepts and parameter for T4
- D2.14 (M46): Description of modelling results, upscaling concepts and recommendations for future experimental and numerical work.

Subtask 3.3 – Modelling of chemical evolution of ILW waste package scale

Start: Month 6 – End: Month 48 – Subtask Leader: [NRG]

Sub-Task Contributors: [Andra (BRGM)] [COVRA] [VTT] [PSI] [NRG]

Total PM: 27,8

This sub-task focus on modelling the long-term chemical evolution of ILW waste packages and to provide upscaled effective parameters for usage in disposal cell scale reactive transport models (Task 4).

All modelling teams [Andra (BRGM)] [NRG] [COVRA] [VTT] [PSI] work on the same waste types, but will investigate the chemical evolution considering different scenarios and different processes. This task will involve testing and comparing different models, including different features and processes, like waste alteration models, corrosion models or concrete degradation models with different reactive transport codes. The choice of scenarios and processes has to be coordinated with task 4 in order to avoid inconsistencies between waste package and disposal cell scale. The planned scenarios are related to intermediate storage of waste packages (important for definition of initial state at emplacement), after emplacement the evolution under fully liquid saturated conditions and the evolution under partially saturated conditions.

A major goal of this task is to define and provide – in close cooperation with task 4 - concepts and effective parameters for approximation of chemical evolution of waste packages on cell disposal scale.

The following steps are planned:

- Milestone MS8 (M2) Specifications of waste package model concepts and links with and between model approaches and expected experimental results from T2 and T3.1
- Milestone MS31 (M7): First input from experiments and information exchange with T4 on expected results
- Implementation in numerical model and first simulations
- Milestone MS158 (M31) Data freeze: Update of model parameters and conceptual model based on input from T2 on T3.1
- Update implementation in numerical model and update of simulation results with final experimental data.
- Milestone MS168 (M36): Synthesis note on concepts and effective parameters for approximation of chemical evolution of waste packages on disposal cell scale (input to MS180) (Lead: NRG, M36)
- Milestone MS180 (M37): Data freeze: Update of upscaling concepts and parameter for T4
- D2.15 (M46): Description of modelling results, upscaling concepts and recommendations for future experimental and numerical work.

Task 4 - Disposal cell scale

Start: Month 6 – End: Month 48 - Task Leader: [VTT] - Co-Leader: [SCK•CEN]

Task contributors: [Andra] [COVRA] [ENRESA] [JUELICH (UFZ)] [IRSN (Mines ParisTech)] [LEI] [NRG] [SÚRAO (UJV)] [SCK•CEN] [VTT]

Total PM: 81,5

Task Objectives

This task will look at the scale of a disposal cell simulating the interactions of the waste packages with each other and with the immediate surrounding near field environment and the host rock within the frame of the ILW or HLW disposal concepts. The objectives of this task are to:

- Integrate available knowledge on critical processes and features (from Tasks1-3) into a conceptual, mathematical and numerical model to simulate the chemical evolution at the disposal cell scale for representative ILW and HLW disposal concepts
- Apply model abstraction techniques in order to describe key features of the chemical evolution with more robust and manageable models
- Identify interactive processes, parameters and features affecting chemical evolution at the disposal cell scale

By doing this, this task will answer the following questions:

- How to upscale experimental degradation processes to the scale of a disposal cell?
- How the chemical deterioration processes interact with each other?
- How to transform this knowledge into a robust and manageable numerical model, which reflects the current state-of-the-art?

Subtask 4.1 – Conceptual and mathematical formulation for a mechanistic based model (reactive transport model) to simulate the chemical evolution at the disposal cell scale.

Start: Month 6 – End: Month 30 – Subtask Leader: [JUELICH (UFZ)]

Sub-Task Contributors: [Andra] [LEI] [COVRA] [JUELICH (UFZ)] [SCK•CEN] [ENRESA] [VTT] [NRG] [IRSN (MINES ParisTech)] [SÚRAO (UJV)]

Total PM: 37,5

The formulation of the model will be initiated by the initial SOTA knowledge (T1.2 and T1.5) on models and parameters. The resulting complexity of this model and the associated numerical limitations can serve as triggers for new developments in the WP Modelling or for abstraction methodologies in sub-task 4.2.

The complex model will subsequently be redefined based on current capabilities of the existing numerical tools. Then, the implementation into these tools, using the highest level of complexity as possible at that point in time, and interpretation of the results follows. In a second step, an update of the model is foreseen based on knowledge developed in T2 and T3 (and possible in other WPs) and numerical methods/tools in WP Modelling. This two-step approach guarantees an early start of T4.2 and T4.3. Related deliverables: D2.16 and D2.17.

List of Actions and Milestones:

- Description of conceptual models for reference ILW and HLW cell (M6-9)
- Implementation in baseline numerical model (M9-18)
- Simulation results as basis for T4.2 and T4.3 (M18) (MS96)
- Update of conceptual model based on T2, T3 (other WPs) (M24)
- Refinement of numerical model (M24-30)
- Simulation results as a basis for T4.2 and T4.3 (30) (MS149)

It is envisioned that all partners will collaborate to achieve the milestones listed above.

Subtask 4.2 – Model abstraction methodologies

Start: Month 13 – End: Month 45 - Task Leader: [ENRESA]

Sub-Task Contributors: [LEI] [COVRA] [SÚRAO (UJV)] [JUELICH (UFZ)] [SCK•CEN] [VTT] [NRG] [ENRESA]

Total PM: 25,5

This subtask will develop and evaluate robust and manageable models in order to efficiently represent complex and coupled processes at the disposal cell scale. Model abstraction methodologies will be tested to represent the complex interacting processes in the full 2D/3D geometry with more simple descriptions such as geometrical simplification, process simplification of equilibrium or kinetic processes, look-up tables etc. An important element in model abstraction is that the simplified models will still be able to simulate the key features of chemical evolution of a disposal cell as predicted by the complex model. This will allow for quantitative predictions of the chemical evolution as boundary conditions for radionuclide release/mobility and estimation of durability of barriers with less complex and computational demanding models applicable for other geometries, for optimization, or for sensitivity calculations. Different levels of model abstraction (ranging from “as realistic or detailed as possible” to “as simple as possible”) will be evaluated. The benefits and limitations of the resulting models will be described in order to assess the added-value of complex modelling in a safety case.

List of Actions and Milestones:

- Identification of key macroscale and up-scaling processes for which the methods will be applied (M13-18)
- Description of abstraction and simplification methods (M12-24)
- Integration of abstraction and simplification methods into models (M24-36)
- Demonstration of simulation results with abstracted models (M36) (MS169)
- Update of methods and model based on T2, T3 (other WPs) (M36-42)
- Updated simulation results with abstracted models (M42) (MS194)

It is envisioned that all partners will collaborate to achieve the milestones listed above.

Related deliverables: D2.18 and D2.19

Subtask 4.3 – Application of the model for a wide range of conditions and parameter values

Start: Month 18 – End: Month 48 – Subtask Leader: [SCK•CEN]

Sub-Task Contributors: [VTT] [JUELICH (UFZ)] [ENRESA] [LEI] [Andra] [SCK•CEN]

Total PM: 18,5

In this subtask, the abstracted models developed in T4.2 are applied to a wide range of conditions encountered in the disposal concepts, which result in a number of different chemical evolutions of the disposal cell. In order to apply the model for a wide range of conditions and parameter values, large number of model realizations has to be simulated within a limited time frame. This work also includes sensitivity analyses of the model parameters, mapping of critical parameters to performance targets (e.g. pH, permeability...) and/or risks (loss of containment...), as well as analysing the response of the system to different environmental conditions. These are believed to be essential input for

safety case. Partners have high-performance computing platforms are available for massive parallelized simulation of parameterization, model calibration and sensitivity analysis.

The subtask includes number of simulations with the developed model in safety case relevant conditions for the ILW/HLW disposal cell. Partners will work in close co-operation with operating companies/end-user groups to implement the knowledge gained in this WP to their safety case analyses and evaluate the full performance of the developed model. The collaboration will also provide repository performance targets that will be used in sensitivity analysis of them to the model parameters.

This task has also interaction with WP Modelling Task3 (sensitivity methods) via workshop 2 and workshop 3 defined in T1.1.

List of Actions and Milestones:

- Interactions with the end-users group in co-operation with Task 1.1 in form of a workshop (M19-24)
- Definition of calculation cases and parameter ranges (lead: Andra) (M24)
- Summary of calculation cases and parameter ranges from national HLW/ILW representative cases (M24-30)
- Performing simulations and sensitivity analyses from the models from Task 4.2 (M36-48)
- Simulation results and integration towards T1.2 (M42) MS195

It is envisioned that all partners will collaborate to achieve the milestones listed above.

Related deliverables: D2.20

Participation per Partner

Partner number and short name	WP2 effort
1 - ANDRA	11.80
BRGM	19.60
3 - BEL V	4.00
5 - CEA	56.00
EDF	6.50
6 - CIEMAT	19.50
UAM	31.00
8 - CNRS	14.00
ULorraine	6.00
IMT Atlantique	12.00
9 - COVRA	10.50
14 - ENRESA	1.00
15 - JUELICH	10.80
UFZ	10.00
19 - IRSN	26.00
MINES ParisTech	22.00
22 - JSI	0.00
ZAG	38.00
25 - LEI	11.00
26 - MTA EK	11.00
27 - NAGRA	0.00
UBERN	54.00
31 - NRG	20.00

Partner number and short name	WP2 effort
34 - PSI	18.00
38 - SCK•CEN	33.50
42 - SÚRAO	1.50
ÚJV	41.50
50 - VTT	27.00
Total	516.20

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D2.1	ACED - State-of-the-art report	9 - COVRA	Report	Public	6
D2.2	ACED - Updated State-of-the-art report & Summary of major conclusions from the work package	9 - COVRA	Report	Public	48
D2.3	ACED - Training materials	38 - SCK•CEN	Report	Public	36
D2.4	ACED - Treatment of chemical evolution in national programmes	9 - COVRA	Report	Public	5
D2.5	ACED - Experiments and numerical model studies on interfaces	15 - JUELICH	Report	Public	5
D2.6	ACED Task 2.1 - Technical report on the modelling approach proposed	42 - SÚRAO	Report	Public	15
D2.7	ACED Task 2.1 - Final technical report on the steel/cement material interactions	19 - IRSN	Report	Public	46
D2.8	ACED Task 2.2 - Technical report on the modelling approach proposed	31 - NRG	Report	Public	15
D2.9	ACED Task 2.2 - Final technical report on the steel/clay material interactions	19 - IRSN	Report	Public	46
D2.10	ACED Task 3.1 - HLW: Report describing the selected experiments and	26 - MTA EK	Report	Public	7

List of deliverables

Deliverable Number¹⁴	Deliverable Title	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
	the existing/expected experimental results				
D2.11	ACED Task 3.1 - ILW: Report describing the selected experiments and the existing/expected experimental results	22 - JSI	Report	Public	7
D2.12	ACED Task 3.1 - HLW: Report describing the results of characterization performed during the project	5 - CEA	Report	Public	31
D2.13	ACED Task 3.1 - ILW: Report describing the results of characterization performed during the project	22 - JSI	Report	Public	31
D2.14	ACED Task 3.2 - Report describing the results of modelling, and the recommendations for future experimental and numerical work	38 - SCK•CEN	Report	Public	46
D2.15	ACED Task 3.3 - Report describing the results of modelling, and the recommendations for future experimental and numerical work	1 - ANDRA	Report	Public	46
D2.16	ACED Task 4.1 - Report on the conceptual model formulation for a mechanistic based model on implementing the initial SOTA knowledge on models and parameters in existing numerical tools	14 - ENRESA	Report	Public	12
D2.17	ACED Task 4.1 - Report on the integrated model for assessing the chemical evolution in a disposal cell on the simulations with a reactive transport model of the chemical evolution at the disposal cell scale	19 - IRSN	Report	Public	30

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D2.18	ACED Task 4.2 - Report on the conceptualization of upscaling including upscaling & model abstraction methods for the integration of process-level knowledge to disposal cell scale knowledge	38 - SCK•CEN	Report	Public	24
D2.19	ACED Task 4.2 -Report on comparison of model abstraction results	15 - JUELICH	Report	Public	45
D2.20	ACED Task 4.3 - Integration report of the work on disposal cell scale chemical evolution	14 - ENRESA	Report	Public	45

Description of deliverables

D2.1 - ACED - State-of-the-art report – SOTA of model and experiment with identification of knowledge gaps of experimental data – Lead: [COVRA] (Month 6)

D2.2 - ACED - Updated State-of-the-art report & Summary of major conclusions from the work package – Lead: [COVRA] a final synthesis report that brings together all the work done and interprets it and [SCK•CEN]: Summary of major conclusions (Month 48)

D2.3 - ACED - Training materials – Lead: [SCK•CEN] (Month 36)

D2.4 - ACED - Treatment of chemical evolution in National Programmes – Lead: [COVRA] (Month 5)

D2.5 - Experiments and numerical model studies on interfaces – Lead: [JUELICH] Month 5

D2.6 - ACED Task 2.1 - Technical report on the modelling approach proposed –This report will provide the first modelling results and refinement of the model approach. It will identify the missing data for model validation. Lead: [SÚRAO (UJV)] Month 15)

D2.7 - ACED Task 2.1 - Final technical report on the steel/cement material interactions –This report will synthesize the key results, identifying the difficulties/differences between the model and the experimental results, and proposing detailed outlooks in terms of experimental and modelling approaches to overpass the remaining gaps. Lead: [IRSN] (Month 46).

D2.8 - ACED Task 2.2 - Technical report on the modelling approach proposed –This report will provide the first modelling results and refinement of the model approach. It will identify the missing data for model validation. Lead: [NRG] (Month 15)

D2.9 - ACED Task 2.2 - Final technical report on the steel/clay material interactions. This report will synthesize the key results, identifying the difficulties/differences between the model and the experimental results, and propose detailed outlooks in terms of experimental and modelling approaches to fill the remaining gaps. Lead: [IRSN] (Month 46).

D2.10 - ACED Task 3.1 - HLW: Report describing the selected experiments and the existing/expected experimental results as input for MS31 – Lead: [MTA EK] (Month 7)

D2.11 - ACED Task 3.1 - ILW: Report describing the selected experiments and the existing/expected experimental results as input for MS31– Lead: [JSI (ZAG)] (Month 7)

D2.12 - ACED Task 3.1 - HLW: Report describing the results of characterization performed during the project as input for MS152 and task 1.2 – Lead: [CEA] (Month 31)

D2.13 - ACED Task 3.1 - ILW: Report describing the results of characterization performed during the project as input for MS152 and task 1.2 – Lead: [JSI (ZAG)] (Month 31)

D2.14 - ACED Task 3.2 - Report describing the results of modelling, and the recommendations for future experimental and numerical work as input for task 1.2 – Lead: [SCK•CEN] (Month 46)

D2.15 - ACED Task 3.3 - Report describing the results of modelling, and the recommendations for future experimental and numerical work as input for task 1.2 - Lead: [Andra (BRGM)] (Month 46)

D2.16 - ACED Task 4.1 - Report on the conceptual model formulation for a mechanistic based model on implementing the initial SOTA knowledge on models and parameters (link to T1&T3) in existing numerical tools – Lead: [ENRESA] (Month 12)

D2.17 - ACED Task 4.1 - Report on the integrated model for assessing the chemical evolution in a disposal cell on the simulations with a reactive transport model of the chemical evolution at the disposal cell scale – Lead: [IRSN (MINES ParisTech)] (Month 30)

D2.18 - ACED Task 4.2 - Report on the conceptualization of upscaling including upscaling & model abstraction methods for the integration of process-level knowledge to disposal cell scale knowledge – Lead: [SCK•CEN] (Month 24)

D2.19 - ACED Task 4.2 - Report on comparison of model abstraction results obtained with different methods and best practice of methodology for model abstraction, recommendation of upscaling and model abstraction methodologies– Lead: [JUELICH (UFZ)] (Month 45)

D2.20 - ACED Task 4.3 - Integration report of the work on disposal cell scale chemical evolution performed in subtask 4.3 as input for task 1.2. Lead: [ENRESA] (Month 45)

D2.1 : ACED - State-of-the-art report [6]
ACED - State-of-the-art report

D2.2 : ACED - Updated State-of-the-art report & Summary of major conclusions from the work package [48]
ACED - Updated State-of-the-art report & Summary of major conclusions from the work package

D2.3 : ACED - Training materials [36]
ACED - Training materials

D2.4 : ACED - Treatment of chemical evolution in national programmes [5]
ACED - Treatment of chemical evolution in national programmes

D2.5 : ACED - Experiments and numerical model studies on interfaces [5]
ACED - Experiments and numerical model studies on interfaces

D2.6 : ACED Task 2.1 - Technical report on the modelling approach proposed [15]
ACED Task 2.1 - Technical report on the modelling approach proposed

D2.7 : ACED Task 2.1 - Final technical report on the steel/cement material interactions [46]
ACED Task 2.1 - Final technical report on the steel/cement material interactions

D2.8 : ACED Task 2.2 - Technical report on the modelling approach proposed [15]
ACED Task 2.2 - Technical report on the modelling approach proposed

D2.9 : ACED Task 2.2 - Final technical report on the steel/clay material interactions [46]
ACED Task 2.2 - Final technical report on the steel/clay material interactions

D2.10 : ACED Task 3.1 - HLW: Report describing the selected experiments and the existing/expected experimental results [7]
ACED Task 3.1 - HLW: Report describing the selected experiments and the existing/expected experimental results

D2.11 : ACED Task 3.1 - ILW: Report describing the selected experiments and the existing/expected experimental results [7]
ACED Task 3.1 - ILW: Report describing the selected experiments and the existing/expected experimental results

D2.12 : ACED Task 3.1 - HLW: Report describing the results of characterization performed during the project [31]
ACED Task 3.1 - HLW: Report describing the results of characterization performed during the project

D2.13 : ACED Task 3.1 - ILW: Report describing the results of characterization performed during the project [31]
ACED Task 3.1 - ILW: Report describing the results of characterization performed during the project

D2.14 : ACED Task 3.2 - Report describing the results of modelling, and the recommendations for future experimental and numerical work [46]
ACED Task 3.2 - Report describing the results of modelling, and the recommendations for future experimental and numerical work

D2.15 : ACED Task 3.3 - Report describing the results of modelling, and the recommendations for future experimental and numerical work [46]
 ACED Task 3.3 - Report describing the results of modelling, and the recommendations for future experimental and numerical work

D2.16 : ACED Task 4.1 - Report on the conceptual model formulation for a mechanistic based model on implementing the initial SOTA knowledge on models and parameters in existing numerical tools [12]
 ACED Task 4.1 - Report on the conceptual model formulation for a mechanistic based model on implementing the initial SOTA knowledge on models and parameters in existing numerical tools

D2.17 : ACED Task 4.1 - Report on the integrated model for assessing the chemical evolution in a disposal cell on the simulations with a reactive transport model of the chemical evolution at the disposal cell scale [30]
 ACED Task 4.1 - Report on the integrated model for assessing the chemical evolution in a disposal cell on the simulations with a reactive transport model of the chemical evolution at the disposal cell scale

D2.18 : ACED Task 4.2 - Report on the conceptualization of upscaling including upscaling & model abstraction methods for the integration of process-level knowledge to disposal cell scale knowledge [24]
 ACED Task 4.2 - Report on the conceptualization of upscaling including upscaling & model abstraction methods for the integration of process-level knowledge to disposal cell scale knowledge

D2.19 : ACED Task 4.2 -Report on comparison of model abstraction results [45]
 ACED Task 4.2 -Report on comparison of model abstraction results

D2.20 : ACED Task 4.3 - Integration report of the work on disposal cell scale chemical evolution [45]
 ACED Task 4.3 - Integration report of the work on disposal cell scale chemical evolution

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	EURAD Kick-off meeting (General Assembly n°1)	1 - ANDRA	1	EURAD Kick-off meeting (General Assembly n°1)
MS2	ACED Kick-off meeting (WPM1)	38 - SCK•CEN	1	ACED Kick-off meeting (WPM1)
MS8	ACED Specifications of representative disposal cell systems and links with and between model approaches and expected experimental results M1.1.1	38 - SCK•CEN	2	ACED Specifications of representative disposal cell systems and links with and between model approaches and expected experimental results M1.1.1
MS11	ACED Task 2 workshop 1	38 - SCK•CEN	3	ACED Task 2 workshop 1
MS12	EURAD EJP Newsletters	1 - ANDRA	3	EURAD EJP Newsletters (Due date : M3 and then every quarter)
MS16	ACED - note on the specific experimental conditions at the steel/clay material interface, parameters and modelling approaches	38 - SCK•CEN	6	ACED - note on the specific experimental conditions at the steel/clay material interface, parameters and modelling approaches with detailed information on set-ups and work flow, variables to measure and a dismantling and characterization plan. It will also define the link

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
				between the experiments and the model approaches (also input to general workshop 1, and MS31)
MS30	EURAD General Assembly n°2	1 - ANDRA	7	EURAD General Assembly n°2
MS31	ACED Experimental data as a first input for modelling and information exchange towards other scales M1.1.2	38 - SCK•CEN	7	ACED Experimental data as a first input for modelling and information exchange towards other scales M1.1.2
MS32	ACED WP meeting 2 + Workshop 1	38 - SCK•CEN	7	ACED WP meeting 2 + Workshop 1
MS42	EURAD Annual Work Plan 2	1 - ANDRA	9	EURAD Annual Work Plan 2
MS43	ACED Identification of integration and upscaling strategies M1.1.3	38 - SCK•CEN	9	ACED Identification of integration and upscaling strategies M1.1.3
MS55	ACED T3.1 - distribution of experimental samples to partners	38 - SCK•CEN	12	ACED T3.1 - distribution of experimental samples to partners
MS72	ACED Workshop 2 – Joint workshop with GAS and DONUT	38 - SCK•CEN	13	ACED Workshop 2 – Joint workshop with GAS and DONUT (Month 13 - 18)
MS81	EURAD General Assembly n°3 + EURAD Annual Meeting 1	1 - ANDRA	13	EURAD General Assembly n°3 + EURAD Annual Meeting 1
MS85	EURAD Periodic Report 1	1 - ANDRA	14	EURAD Periodic Report 1
MS94	ACED - GAS - DONUT Joint Workshop - 1	32 - ONDRAF/NIRAS	16	ACED - GAS - DONUT Joint Workshop
MS95	ACED Task 2 workshop 2	38 - SCK•CEN	18	ACED Task 2 workshop 2
MS96	ACED T4.1 - Simulation results as basis for ACED T4.2 and T4.3	38 - SCK•CEN	18	ACED T4.1 - Simulation results as basis for ACED T4.2 and T4.3
MS103	EURAD General Assembly n°4	1 - ANDRA	19	EURAD General Assembly n°4
MS104	ACED WP meeting 3	38 - SCK•CEN	19	ACED WP meeting 3
MS112	EURAD Annual Work Plan 3	1 - ANDRA	21	EURAD Annual Work Plan 3
MS119	ACED T4.3 - Definition of calculation cases and parameter ranges	38 - SCK•CEN	24	ACED T4.3 - Definition of calculation cases and parameter ranges
MS136	EURAD General Assembly n°5 + EURAD Annual Meeting 2	1 - ANDRA	25	EURAD General Assembly n°5 + EURAD Annual Meeting 2

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS140	EURAD Periodic Report 2	1 - ANDRA	26	EURAD Periodic Report 2
MS148	ACED Task 2 workshop 3	38 - SCK•CEN	30	ACED Task 2 workshop 3
MS149	ACED T4.1 - Simulation results as a basis for ACED T4.2 and T4.4	38 - SCK•CEN	30	ACED T4.1 - Simulation results as a basis for ACED T4.2 and T4.4
MS150	ACED Workshop 4 – Joint workshop with GAS and DONUT	38 - SCK•CEN	30	ACED Workshop 4 – Joint workshop with GAS and DONUT (Month 30 - 37)
MS153	EURAD General Assembly n°6	1 - ANDRA	31	EURAD General Assembly n°6
MS154	ACED WP meeting 4 + Workshop 3	38 - SCK•CEN	31	ACED WP meeting 4 + Workshop 3
MS155	ACED Updated experimental data, model concepts and parameters as input for modelling and for information transfer towards other scales including update upscaling approach M1.1.4	38 - SCK•CEN	31	ACED Updated experimental data, model concepts and parameters as input for modelling and for information transfer towards other scales including update upscaling approach M1.1.4
MS162	EURAD Annual Work Plan 4	1 - ANDRA	33	EURAD Annual Work Plan 4
MS165	ACED - GAS - DONUT Joint Workshop	32 - ONDRAF/NIRAS	33	ACED - GAS - DONUT Joint Workshop
MS167	ACED T3.2 - Synthesis note on concepts and effective parameters for approximation of chemical evolution of waste packages on disposal cell scale (input to milestone M1.1.5)	38 - SCK•CEN	36	ACED T3.2 - Synthesis note on concepts and effective parameters for approximation of chemical evolution of waste packages on disposal cell scale (input to milestone M1.1.5)
MS168	ACED T3.3 - Synthesis note on concepts and effective parameters for approximation of chemical evolution of waste packages on disposal cell scale (input to milestone M1.1.5)	38 - SCK•CEN	36	ACED T3.3 - Synthesis note on concepts and effective parameters for approximation of chemical evolution of waste packages on disposal cell scale (input to milestone M1.1.5)
MS169	ACED T4.2 - Demonstration of simulation results with abstracted models	38 - SCK•CEN	36	ACED T4.2 - Demonstration of simulation results with abstracted models
MS180	ACED Final freeze of data and models mainly for transfer towards other scales M1.1.5	38 - SCK•CEN	37	ACED Final freeze of data and models mainly for transfer towards other scales M1.1.5

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS185	EURAD General Assembly n°7 + EURAD Annual Meeting 3	1 - ANDRA	37	EURAD General Assembly n°7 + EURAD Annual Meeting 3
MS189	EURAD Periodic Report 3	1 - ANDRA	38	EURAD Periodic Report 3
MS193	ACED Task 2 workshop 4	38 - SCK•CEN	42	ACED Task 2 workshop 4
MS194	ACED T4.2 - Updated simulation results with abstracted models	38 - SCK•CEN	42	ACED T4.2 - Updated simulation results with abstracted models
MS195	ACED T4.3 - Simulation results and integration towards T1.2	38 - SCK•CEN	42	ACED T4.3 - Simulation results and integration towards T1.2
MS199	EURAD General Assembly n°8	1 - ANDRA	43	EURAD General Assembly n°8
MS200	ACED WP meeting 5 + Workshop 6	38 - SCK•CEN	43	ACED WP meeting 5 + Workshop 6
MS206	EURAD Annual Work Plan 5	1 - ANDRA	45	EURAD Annual Work Plan 5
MS210	ACED Closure meeting	38 - SCK•CEN	48	ACED Closure meeting
MS222	EURAD General Assembly n°9 + EURAD Annual Meeting 4	1 - ANDRA	49	EURAD General Assembly n°9 + EURAD Annual Meeting 4
MS224	EURAD Periodic Report 4	1 - ANDRA	50	EURAD Periodic Report 4
MS234	EURAD General Assembly n°10	1 - ANDRA	55	EURAD General Assembly n°10
MS240	EURAD General Assembly n°11 + EURAD Annual Meeting 5	1 - ANDRA	60	EURAD General Assembly n°11 + EURAD Annual Meeting 5
MS241	EURAD Periodic Report 5	1 - ANDRA	60	EURAD Periodic Report 5 (Due date: 60+2)

Work package number ⁹	WP3	Lead beneficiary ¹⁰	24 - KIT
Work package title	Cement-Organic-Radionuclide-Interactions (CORI)		
Start month	1	End month	48

Objectives

Objectives

CORI aims to improve the knowledge on the organic release issues which can accelerate the radionuclide migration in the context of the post closure phase of geological repositories for ILW and LLW/VLLW, including surface/shallow disposal. The RD&D in CORI is expected to extend the current state-of-the-art, contribute to optimized disposal solutions and consider questions of regulatory concern. CORI will help Member-States to further develop their national RD&D programmes and support programmes at an early implementation stage. Enhancing cooperation between the different participating beneficiaries and countries is an important objective in CORI. Knowledge transfer and training of young researchers in view of future demands for qualified staff is likewise a key aspect of CORI.

CORI objectives are addressing topics in the context of cement-organic-radionuclide-interactions. Organic materials are present in some nuclear waste and as admixtures in cement-based materials and can potentially influence the performance of a geological disposal system, especially in the context of low and intermediate level waste disposal. This potential effect of organic molecules is related to the formation of complexes in solution with some radionuclides of interest (actinides and lanthanides) which can (i) increase the radionuclide solubility and (ii) decrease the radionuclide sorption. Organic substances require increased attention since a significant quantity exists in the waste and in the cementitious materials, with a large degree of chemical diversity. Cement-based materials will be degraded with time in the context of waste disposal inducing a large range of alkaline pH conditions according to their degradation state. Alkaline pH provides specific conditions under which the organics can degrade, which contributes to increasing their impact on repository performance. The most critical open topics and data needs required to better assess and quantify cement-organic-radionuclide-interactions are reflected in the three R&D oriented CORI Tasks:

- Organic Degradation
- Organic-Cement-Interactions
- Radionuclide-Organic-Cement-Interactions

Expected impacts of the WP

Predicting and assessing radionuclide transport is a key topic in nuclear waste disposal. For radionuclide behaviour in cementitious environments where large inventories of organic materials may be present, CORI has identified that the present knowledge can be significantly improved. An improved quantification of radionuclide solubility and sorption phenomena in cementitious environments can provide important input into predicting radionuclide transport. Against this general motivation in CORI, specific benefits in terms of impacting implementation or safety are described below.

Regarding Radioactive Waste Management (RWM) implementation needs

Issues of interest at the repository scale are identified:

- o Improved scientific basis for the Safety Case for L/ILW waste repositories featuring high organic content.
- o Co-storage of waste: support decisions regarding the question whether or not a mix of various wastes (organics, soluble salts, exothermic waste) can be foreseen.
- o Optimization of vault design: limitations of interactions between the vaults regarding their content. CORI will provide information on the organic plume by characterizing the transfer behaviour in cement-based materials.
- o Optimization of concrete formulations as regards the potential effect of superplasticizers on radionuclide transfer properties.

The WP is linked to the Roadmap Theme 3 (EBS properties, function and long-term performance) phases 2 -4 and Theme 4 (Geoscience to understand rock properties, radionuclide transport and long-term geological evolution) phases 1 and 2.

Regarding safety

- o Characterizing the effect of the organic plume on the behavior of radionuclides in terms of:

- (i) Solubility (limitation of solubility increase), and
- (ii) Sorption (limitation of retention decrease) in terms of K_d values.
- (iii) The retention of potentially ¹⁴C-bearing organic molecules (determined in CAST project) in cementitious environments in the case of specific waste.

- o This project aims to:

- (i) Reduce the uncertainties on the current knowledge, which is mainly based on K_d values,

(ii) Improve the knowledge on the known organic molecules present in degradation solutions (not considered so far) with their complexing properties: better definition of the organic inventory regarding the waste and the concrete vault (geological and surface repositories).

Description of work and role of partners

WP3 - Cement-Organic-Radionuclide-Interactions (CORI) [Months: 1-48]

KIT, ANDRA, CEA, CIEMAT, CNRS, FTMC, CV REZ, JUELICH, JSI, PSI, RATEN, SCK•CEN, SÚRAO, UCyprus

Task 1 – S/T coordination, State-of-the-art and training material

Start: Month 1 – End: Month 48 - Task Leader: [KIT] (WP Leader)

Task contributors: [Andra] [CEA] [CIEMAT] [CNRS-SUBATECH] [KIT (Amphos 21)]

Total PM: 9,9

Subtask 1.1 – S/T coordination

Start: Month 1 – End: Month 48 – Subtask Leader: [KIT]

Subtask contributors: [Andra] [CEA] [CIEMAT] [CNRS-SUBATECH] [KIT (Amphos 21)]

Total PM: 3,6

The S/T coordination of CORI will be performed by the WP Leader [KIT]. The WP Leader will be supported by the Sub-Task leaders [Andra] and [CNRS-SUBATECH] for Task 2, [KIT (Amphos21)] and [Andra] for Task 3, and [CEA] and [CIEMAT] for Task 4, which together constitute the WP Board of CORI.

The WP leader will ensure that the WP is progressing according to the agreed planning, milestones and deliverables. All meetings will be documented in minutes prepared by [KIT]. The WP Leader is also responsible to report the work progress, any WP deliverables and eventual modifications of the WP work plan to the Programme Management Office (PMO). This will be done in close consultation with WP Board. The CORI WP Board will also be responsible to communicate CORI to other WPs and stakeholders in EURAD-1.

In order to reach these aims, the CORI WP Board will have regular meetings every 6 month, which will be captured in minutes to be distributed to CORI partners and the PMO. These meetings can be organised by specific side-meetings during the Annual CORI WP Meetings at Month 12, 24, 36 and 48 (see below). The additional meetings of the CORI WP Board at Months 1, 6, 18, 30 and 42 can be arranged as meetings in person and using video conferencing options whenever required.

The Annual CORI Work Package Meetings (WPM) are key events in CORI which will be arranged as cluster meetings with all partners to allow for information exchange, monitoring of work progress, dissemination of results, interaction with End Users and other stakeholders, amongst others. To ensure effective meetings, the Annual CORI WP Meetings will be prepared on the basis of a synthesis report prepared by the Task leaders after exchanging with all the partners prior to the workshop. Plenary meetings highlighting main RD&D results from CORI participants will constitute a key part of the meetings, which also will allow sufficient time for exchange and detailed discussions with interested WMOs, TSOs or REs not part of CORI). These activities will be complemented by dedicated technical meetings on Task level, topical sessions focussing on specific aspects of general interest in CORI, poster sessions or sessions focusing specifically on young researchers, as required. Integration at Task level will thus be organized at the Annual CORI WP Meetings. The Annual CORI WP Meetings will be documented in Proceedings which will summarize overall R&D progress, also by featuring selected S&T contributions from the CORI partners, in addition to the technical deliverables defined in the individual Tasks. [KIT] with the support of local organizers will organize The Annual CORI WP Meetings.

The foreseen Annual CORI WP Meetings and the Meetings of the CORI WP Board are

- WP Board Meeting 1 (Month 1)
- WP Board Meeting 2 (Month 6)
- First Annual CORI WP Meeting (including technical meetings on Task Level) with WP Board Meeting 3 (Month 12).

Task technical meetings focus on:

- Organic retention studies onto cementitious material (task 3)
- Radionuclide retention studies onto cementitious material in presence of organics (task 4)
- WP Board Meeting 4 (Month 18)
- Second Annual CORI WP Meeting (including technical meetings on Task Level) with WP Board Meeting 5 (Month 24), Task technical meetings focus on:
 - Radionuclide speciation in cementitious media in presence of organics. (Task 2).
 - Studies on the role of iron (and/or calcium) on organic retention in cementitious media (Task 3)
 - Radionuclide speciation in cementitious media in presence of organics. (Task 4).
- WP Board Meeting 6 (Month 30)

- Third Annual CORI WP Meeting (including technical meetings on Task Level) with WP Board Meeting 7 (Month 36), Task technical meetings mainly focus on:
 - Transport of organic molecules in cementitious material. (Task 3)
 - Radionuclide transport in cementitious material in presence of organics. (Task 4).
 - WP Board Meeting 8 (Month 42)
 - Fourth and Final CORI WP Meeting (including technical meetings on Task Level) with WP Board meeting 9 (Month 48), Focus on technical deliverables preparation

[KIT] will establish an electronic data deposit to make the experimental data generated in Task 2, 3, 4 of CORI available in electronic form for use in later upscaling/PA related modelling activities. During the development of CORI, it was decided that a comprehensive modelling of the generated results will not be performed within CORI. However, it was clarified that this aspect is important and could be integrated in potential follow up activities focused on modelling. The data deposit will mainly be based on easily accessible Excel-type data tables in formats commonly used.

As Coordinator, [KIT] will be responsible for preparing the Deliverable D3.5, which is the Final Report on the RD&D results, main outcome and conclusions in CORI. This Deliverable will integrate the information from Task 2, 3, and 4, and highlight potential applications to the Safety Case arising from the work in CORI.

Subtask 1.2 – State-of-the-art

Start: Month 1 – End: Month 48 – Subtask Leader: [KIT]

Subtask contributors: [Andra] [CEA] [CIEMAT] [CNRS-SUBATECH] [KIT (Amphos21)]

Total PM: 3,1

The WP CORI will prepare an initial state-of-the-art report (SOTA) at Month 6 (D3.1) with updating at Month 48 (D3.2) which will feed into Knowledge Management in EURAD-1 and is communicated to other WPs in EURAD for information exchange. The writing of the SOTA reports will be led by the respective CORI Task leaders (meaning in teams of 2 partners), with support by the Coordinator. Information exchange with the respective Task partners will be organised at Task level.

The content of the SOTA will mainly reflect the content of the three R&D Tasks defined in CORI and build up on technical documents prepared on the Task level (M.2.1, M.3.1, M.4.1). Consequently, sub-chapters of the SOTA will address (i) organic degradation by hydrolytic and radiolytic processes, (ii) cement-organic-interactions, and (iii) cement-organic-radionuclide-interactions. Considering that the general context of the studies is related to cementitious environments, CORI D3.1 and D3.2 will also include a critical summary on “fundamental cement chemistry” to provide basic information relevant in this particular context, which is expected to be a valuable part of the training materials developed in Subtask 1.3 of CORI. The updating of the SOTA at Month 48 will reflect the improved knowledge base generated in CORI on these topics and implement the new information in the SOTA (D3.2) document.

Subtask 1.3 – Training materials

Start: Month 1– End: Month 48 – Subtask Leader: [KIT]

Subtask contributors: [Andra] [CEA] [CIEMAT] [CNRS-SUBATECH] [KIT (Amphos21)]

Total PM: 3,1

CORI will contribute to Training activities in EURAD-1 in close interactions with Training/Mobility KM WP. For this reason, specific training materials on topics addressed in CORI will be prepared. The approach to prepare training materials will follow two lines of activity.

First, it is planned to develop material for tutorials based on the information detailed in the SOTA reports generated in CORI Task 1.2 (D3.1 and D3.2). This Training material will be made available in the form of ppt-files or pdf-files (from about two months after the respective SOTA) and will eventually be presented at EURAD Training activities by CORI WP Board members. D3.3 will be updated at Month 48 as D3.4.

Second, depending on the specific focus of future Training activities in EURAD, CORI WP Board is also willing to contribute more detailed technical training material (for example considering PhD courses, e.g. on analytical tools and techniques, data treatment, ...), which however will later need to be developed in direct exchange with the future Training Event organisers. There is no Deliverable or Milestone formally placed for this highly flexible activity.

The preparation of the Training material will be led by the respective CORI Task leaders (meaning in teams of 2 partners), with support by the Coordinator. Information exchange with the respective Task partners will be organised at Task level.

Task 2 - ORGANIC DEGRADATION

Start: Month 1 – End: Month 48 - Task Leader: [CNRS-SUBATECH] [Andra]

Task Contributors: [Andra (BRGM)] [CNRS-SUBATECH (UOrléans)] [FTMC] [JSI] [JUELICH] [KIT] [PSI] [SÚRAO (CTU) (UJV)] [CV REZ] [SCK•CEN]

Total PM: 155,1

Task objectives:

- Improve knowledge of degradation of organic wastes in conditions representative of disposal facilities.
- Improve understanding of radiolytic/hydrolytic degradation of organic materials.
- Provide characterization and quantification of soluble organic species generated by degradation.

Task description

This Task aims to improve the knowledge about soluble organic species released due to the degradation of organic materials under disposal conditions and better describe their chemical characteristics. The available literature data concern the degradation of polymers and its impact on the structural and mechanical properties. Only very few publications consider the identification and characterisation of soluble organic species in solution. The two important degradation processes to be studied in Task 2 are radiolysis and hydrolysis. The organic materials considered in CORI are polyvinylchloride (PVC), cellulose, ion exchange resins (IER), and superplasticizers (as poly-carboxylate-ether). These materials have been selected by CORI partners with support of WMOs, considering that these are abundant organics in national waste inventories and can be expected to generate species with potentially high complexing properties. In order to be representative of the materials actually present in the waste inventories, the organic degradation studies will also consider selected industrial materials (formulated materials). Task 2 of CORI will provide a comprehensive summary report on the outcome of the RD&D studies as D3.6. This Deliverable will also feed into the integrated Final Report including application to the Safety Case, defined as D3.5.

The Technical document prepared under MS17 will provide an overview on organic degradation under hydrolytic and radiolytic conditions and discuss the related release of soluble organic species. This report will also be used as input to the SOTA D3.1 and D3.3. The description will cover the organic materials considered by partners in the Task 2 of CORI and also reflect the different experimental systems used for degradation studies.

The degradation studies performed in CORI will focus on two main experimental conditions and include detailed analysis of the degradation products.

(i) Radiolytic degradation: Irradiation of organic materials will be performed under dry conditions and in basic solution (alkaline media pH > 12) in order to be representative of different national disposal conditions. All organic materials (PVC, cellulose, IER and superplasticizers) will be irradiated by gamma irradiation; superplasticizers will be also degraded by using alpha particles (He-particles). Different irradiation conditions (regarding total dose, dose rate and atmosphere) will be investigated in order to identify specific effects of the irradiation conditions on organic degradation. [BRGM/ISTO] [CTU/CV REZ/UJV/SÚRAO] [JSI] [JUELICH] [SCK•CEN] [CNRS-SUBATECH].

(ii) Hydrolytic degradation: For materials irradiated under dry conditions, hydrolysis will be carried out after irradiation. Hydrolysis of pre-irradiated materials will be performed in basic solution characteristic for cementitious environments (alkaline media pH > 12 and under both oxic and anoxic atmosphere). For materials irradiated in solution, radiolysis and hydrolysis occurs simultaneously as both processes are coupled. Hydrolysis will be also performed on initial materials (non-irradiated materials) for purposes of results comparison. Hydrolysis of pre-irradiated materials will be studied by [Andra (BRGM)] [CNRS-SUBATECH (UOrléans)] [JUELICH] [SCK•CEN]. Hydrolysis of non-irradiated materials will be investigated by [Andra] [FTMC] [CV REZ] [KIT] [PSI] [SÚRAO (CTU)] [SÚRAO (UJV)]. Organic material will include superplasticizers, PVC, IER and cellulose.

(iii) Characterisation and quantification of soluble organic species in solution will be performed via complementary analytical techniques for the following solutions generated in CORI Task 2 containing degraded organic material: (i) solutions obtained by hydrolysis of pre-irradiated samples, (ii) solution obtained by simultaneous radiolysis/hydrolysis (irradiation of materials in solution), and (iii) simple hydrolysis without any irradiation. Partners intend to use TOC analysis, ionic/liquid chromatography, AES-OES or induced-coupled-plasma techniques, GC/ICP/LC mass spectrometry, UV-Vis or IR spectrometry, amongst others [all partners].

(iv) Gas measurements will be performed by some partners in order to determine radiolytic gas yields (H₂, HCl, CO₂...) by using gas-chromatography. Organic materials will include superplasticizer, PVC, IER and cellulose. [Andra] [Andra (BRGM)] [CNRS (UOrléans)] [CNRS-SUBATECH] [CV REZ] [JUELICH] [SCK•CEN].

Task 3 - ORGANIC-CEMENT-INTERACTIONS

Start: Month 1 – End: Month 48 - Task Leader: [KIT (Amphos21)] [Andra]

Task Contributors: [CEA] [CIEMAT (CSIC)] [CV REZ] [JSI] [KIT (Amphos 21)] [PSI (EMPA)] [RATEN] [SCK•CEN] [SÚRAO (CTU) (UJV)] [Andra]

Total PM: 163,5

Task objectives:

- Improve the understanding of the behaviour of anthropogenic organic molecules within cementitious systems.
- Study the sorption and transfer properties of organic molecules that might be released from the organics inventories (including polymers and superplasticizers) present in cement-based materials.

Task description

CORI Task 3 will investigate the sorption and diffusion processes of different organic molecules onto cement-based materials. The investigated organic molecules were defined to include (i) main degradation products such as ISA, phthalates [Andra] [CEA] [CIEMAT (CSIC)] [KIT (Amphos21)] [SCK•CEN] (ii) C14-bearing molecules identified in the European project CAST [RATEN] and (iii) degradation products resulting from Task 2 (during the second part of the project) [KIT (Amphos21)] [RATEN]. (iv) EDTA will be also studied as strong complexing molecule [CEA] [CIEMAT (CSIC)] [SÚRAO (CTU)] CTU as well as low molecular weight molecules [Andra] [KIT (Amphos21)].

Regarding the investigated cementitious materials, CORI partners will investigate selected systems of high interest. CEM I [JSI] [KIT] [RATEN] [SCK•CEN] [UCY] and CEM V [CEA] [CIEMAT (CSIC)] [JSI] [RATEN] will be used at various degradation states (including altered/carbonated states) according to the requirements by WMOs, as well as pure solid phases such as C-(A)-S-H KIT (Amphos21)] [PSI (EMPA)] and AFm-phases/ettringite [CIEMAT] [PSI (EMPA)] to allow for improved process understanding. Additionally, [CIEMAT] will study cement CEM IV.

Two prominent cations present in cementitious systems will be included in some of the Task 3 investigations, (i) iron, which is present in both, cement phases and steel corrosion phases generated by the corrosion of iron-based materials, and (ii) calcium, which is one of the main elements in cement components. The aim of including Fe and Ca systems is to elucidate their potential role as competitors of radionuclides (investigated in Task 4) for complexing organics. [CIEMAT (CSIC)] [KIT (Amphos21)] [RATEN] [SÚRAO (UJV)]. Some specific efforts will be made to integrate the experimental results with adequate models [Andra].

All contributors of this task have considered the priorities defined in Task 3 in terms of relevant organic molecules and cementitious materials to be studied in order to reduce and optimize the number of systems. Thus, dedicated experimental work combining batch sorption, diffusion, column systems, speciation, solubility and spectroscopic studies to allow fundamental model development and application oriented analyses is proposed. In particular, batch and diffusion experiments investigating the behavior in cement-based materials can lead to significant differences regarding K_d values. CORI has the objective to provide understanding on this experimental observation on the basis of spectroscopic techniques and phenomenological models such as reactive transfer and double layer models. Consequently, conceptual models will be derived within CORI Task 3 to serve as a basis for the more complex systems studied in Task 4. Overall, the work proposed by the partners enrolled in this Task will aim to produce a robust understanding of cement-organic interactions in cement-based systems. Task 3 of CORI will prepare a comprehensive summary report on the main results as D3.7. This Deliverable will also feed into the integrated Final Report including application to the Safety Case, defined as D3.5.

Task 4 - RADIONUCLIDE-ORGANIC-CEMENT-INTERACTIONS

Start: Month 1 – End: Month 48 - Task Leader: [CEA] [CIEMAT]

Task Contributors [Andra] [CNRS-SUBATECH] [FTMC] [JUELICH (HZDR)] [KIT (Amphos21) (JGU-INC) (UPOTSDAM)] [SÚRAO (CTU) (UJV)] [RATEN] [SCK•CEN] [UCY] [CEA] [CIEMAT]

Total PM: 205,7

Task objectives:

- Improving the knowledge on organic-radionuclide complexes mobility in cement-based systems.
- Studying the competition or synergetic effect in ternary systems (i.e. organic/ radionuclide/ cement).
- Providing a mechanistic understanding of radionuclide interactions and quantitative transfer data in cementitious environments.

Task description

CORI Task 4 aims to improve the knowledge on organic-radionuclide complexes mobility in cement-based systems by providing mechanistic understanding of radionuclide interactions and detailed experimental data to quantitatively assess the impact of organics on radionuclide transport in the cementitious environment. CORI Task 4 will prepare a comprehensive summary report on the main results as D3.8. This Deliverable will also feed into the integrated Final Report including application to the Safety Case, defined as D3.5.

All contributors have considered the priorities defined in Task 4 in terms of critical radionuclides (or toxic heavy metals), relevant organic molecules and cementitious materials to be studied.

The main radionuclides that will be studied in Task 4 of CORI are: Nickel isotopes [CEA] [CIEMAT] [KIT (Amphos21)] [RATEN] [SÚRAO (UJV)] [SCK•CEN] Uranium isotopes [CEA] [CIEMAT] [CNRS-SUBATECH] [JUELICH (HZDR)] [KIT (Amphos21) (UPOTSDAM)] [SÚRAO (CTU) (UJV)] [SCK•CEN] [UCY] Actinides(III/ IV) and/or homologues [CIEMAT] [FTMC] [JUELICH] [JUELICH (HZDR)] [KIT (Amphos21)] [KIT (JGU INC)] [KIT (UPOTSDAM)] [UCY].

The organic and cementitious materials are consistent with those analyzed in Task 2 and Task 3 of CORI. In particular, ISA will be studied by [CIEMAT] [CNRS-SUBATECH] [JUELICH (HZDR)] [KIT (Amphos21) (JGU INC)] (UPOTSDAM)] [SCK•CEN] EDTA by [CEA] [JUELICH (HZDR)] [KIT (JGU INC)] [KIT (UPOTSDAM)] [SÚRAO (CTU)] [UCY] PAN degradation products by [KIT] adipate, phthalate or short-chained carboxylic acid by [CEA] [FTMC] [JUELICH] [KIT (Amphos21) (JGU INC)] (UPOTSDAM)] [RATEN] [SÚRAO (CTU)].

CEM I [CIEMAT] [FTMC] [KIT (JGU INC)] [SÚRAO (ÚJV)] [SCK•CEN] and CEM V [CEA] [CIEMAT] [CNRS-SUBATECH] [JUELICH] [FTMC] [KIT (JGU INC)] [RATEN] will be the main cementitious material analyzed considering different degradation states (mainly II and III). Amongst the main mineral phases considered in CORI, CSH and CASH [CIEMAT] [CNRS-SUBATECH] [JUELICH (HZDR)] [KIT (Amphos21)] (JGU INC)] (UPOTSDAM)] [UCY] will be studied considering different C/S ratios.

A dedicated experimental work has been proposed combining batch sorption (on powder and small blocks), diffusion, column, speciation, solubility and advanced spectroscopic studies to allow fundamental model development and application-oriented analyses. The wide possibility of combinations of radionuclide /organic/ cementitious material / chemical conditions and experimental techniques resulted in a very limited overlap on the system studied by the different partners.

Numerical interpretation and conceptual modelling of experimental data and observations are included in Task 4. All partners' contributions will aim to give a complete and consistent set of data and therefore will contribute to update the state-of-art for organic-radionuclide complexes mobility in cement-based systems D3.3.

The Task leaders will ensure that the work programme is progressing accordingly to the agreed milestones and deliverables planning. They will be responsible to communicate to all Task 4 partners important information coming from CORI Tasks 1, 2 and 3, which is required as input for the detailed work programme.

Participation per Partner

Partner number and short name	WP3 effort
1 - ANDRA	10.40
BRGM	13.40
5 - CEA	35.40
6 - CIEMAT	44.40
CSIC	30.00
8 - CNRS	44.00
UOrléans	16.00
10 - FTMC	20.00
11 - CV REZ	12.00
15 - JUELICH	19.00
HZDR	8.00
22 - JSI	26.40
24 - KIT	47.90
AMPHOS 21	21.40
Uni Mainz	24.00
Uni Potsdam	12.00
34 - PSI	13.00
EMPA	11.00
36 - RATEN	17.00
38 - SCK•CEN	18.30
42 - SÚRAO	4.60
CTU	40.00
ÚJV	42.00

Partner number and short name	WP3 effort
47 - UCyprus	4.00
Total	534.20

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D3.1	CORI - SOTA on cement-organic-radionuclide-interactions in the content of L/ILW disposal	24 - KIT	Report	Public	6
D3.2	CORI - SOTA UPDATE on cement-organic-radionuclide-interactions in the content of L/ILW disposal	24 - KIT	Report	Public	48
D3.3	CORI - Training Materials	24 - KIT	Report	Public	8
D3.4	CORI - Training Materials UPDATE	24 - KIT	Report	Public	48
D3.5	CORI - Final Report integrating the RD&D performed in CORI, including application to the Safety Case	24 - KIT	Report	Public	48
D3.6	CORI - Final Report on results generated in Task 2 of CORI	8 - CNRS	Report	Public	44
D3.7	CORI - Final Report on organic retention in cementitious systems	1 - ANDRA	Report	Public	44
D3.8	CORI - Final Report on radionuclide mobility in cementitious materials in the presence of organics	5 - CEA	Report	Public	46

Description of deliverables

D3.1 CORI - SOTA on cement-organic-radionuclide-interactions in the content of L/ILW disposal. Chapters to include: (i) Organic degradation by hydrolytic and radiolytic processes; (ii) Organic-cement-interactions; (iii) Radionuclide-organic-cement-interactions; (iv) Fundamental Cement Chemistry. [KIT] (Months 6)

D3.2 CORI - SOTA UPDATE on cement-organic-radionuclide-interactions in the content of L/ILW disposal. Chapters to include: (i) Organic degradation by hydrolytic and radiolytic processes; (ii) Organic-cement-interactions; (iii) Radionuclide-organic-cement-interactions; (iv) Fundamental Cement Chemistry . [KIT] (Months 48).

D3.3 CORI - Training Materials. [KIT] (Month 8).

D3.4 CORI - Training Materials UPDATE. [KIT] Month 48).

D3.5 CORI - Final Report integrating the RD&D performed in CORI, including application to the Safety Case. [KIT] (Month 48).

D3.6 CORI - Final Report on results generated in Task 2 of CORI on (i) Degradation of organic materials by hydrolytic and radiolytic processes, and (ii) identification and quantification of degradation products. [CNRS-SUBATECH] (Month 44).

D3.7 CORI - Final Report on organic retention in cementitious systems. [Andra] and [KIT (Amphos21)] (Month 44).

D3.8 CORI - Final Report on radionuclide mobility in cementitious materials in the presence of organics, including (i) Radionuclide speciation under alkaline conditions in presence of organics, and (ii) Evaluation of radionuclide mobility in cementitious materials in the presence of organics. [CEA] and [CIEMAT] (Month 46).

D3.1 : CORI - SOTA on cement-organic-radionuclide-interactions in the content of L/ILW disposal [6]
CORI - SOTA on cement-organic-radionuclide-interactions in the content of L/ILW disposal

D3.2 : CORI - SOTA UPDATE on cement-organic-radionuclide-interactions in the content of L/ILW disposal [48]
CORI - SOTA UPDATE on cement-organic-radionuclide-interactions in the content of L/ILW disposal

D3.3 : CORI - Training Materials [8]
CORI - Training Materials

D3.4 : CORI - Training Materials UPDATE [48]
CORI - Training Materials UPDATE

D3.5 : CORI - Final Report integrating the RD&D performed in CORI, including application to the Safety Case [48]
CORI - Final Report integrating the RD&D performed in CORI, including application to the Safety Case

D3.6 : CORI - Final Report on results generated in Task 2 of CORI [44]
CORI - Final Report on results generated in Task 2 of CORI

D3.7 : CORI - Final Report on organic retention in cementitious systems [44]
CORI - Final Report on organic retention in cementitious systems

D3.8 : CORI - Final Report on radionuclide mobility in cementitious materials in the presence of organics [46]
CORI - Final Report on radionuclide mobility in cementitious materials in the presence of organics

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	EURAD Kick-off meeting (General Assembly n°1)	1 - ANDRA	1	EURAD Kick-off meeting (General Assembly n°1)
MS12	EURAD EJP Newsletters	1 - ANDRA	3	EURAD EJP Newsletters (Due date : M3 and then every quarter)
MS17	CORI Technical Report - Task 2 State-of-art report on organic degradation by radiolytic and hydrolytic processes	24 - KIT	6	CORI Technical Report - Task 2 State-of-art report on organic degradation by radiolytic and hydrolytic processes.
MS18	CORI Technical Report- Task 3 with (i) Final documentation of the systems to be studied and (ii) State-of-art summary on organic-cement-interactions	24 - KIT	6	CORI Technical Report- Task 3 with (i) Final documentation of the systems to be studied and (ii) State-of-art summary on organic-cement-interactions.
MS19	CORI Technical Report- Task 4 with (i) Final documentation of the systems	24 - KIT	6	CORI Technical Report- Task 4 with (i) Final documentation of the systems

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
	to be studied and (ii) State-of-art summary on organic-cement-interactions			to be studied and (ii) State-of-art summary on organic-cement-interactions
MS26	SOTA from RD&D CORI WP as input to UMAN T3.2	24 - KIT	6	SOTA from RD&D CORI WP as input to UMAN T3.2
MS30	EURAD General Assembly n°2	1 - ANDRA	7	EURAD General Assembly n°2
MS33	CORI Start of experimental RD&D programme (task 2, 3 and 4)	24 - KIT	7	CORI Start of experimental RD&D programme (task 2, 3 and 4)
MS42	EURAD Annual Work Plan 2	1 - ANDRA	9	EURAD Annual Work Plan 2
MS56	CORI First Annual WP Meeting (including technical meetings on Task level)	24 - KIT	12	CORI First Annual WP Meeting (including technical meetings on Task level)
MS57	CORI Technical Report- Task 4 (i) Radionuclide retention on CSH or CASH or AFm/AFt in the presence of organics, (ii) Radionuclide retention on HCP in the presence of organics	24 - KIT	12	CORI Technical Report- Task 4 (i) Radionuclide retention on CSH or CASH or AFm/AFt in the presence of organics, (ii) Radionuclide retention on HCP in the presence of organics.
MS81	EURAD General Assembly n°3 + EURAD Annual Meeting 1	1 - ANDRA	13	EURAD General Assembly n°3 + EURAD Annual Meeting 1
MS85	EURAD Periodic Report 1	1 - ANDRA	14	EURAD Periodic Report 1
MS86	CORI Technical Report- Task 3 (i) Organic retention on cement hydrates (AFm, AFt, CSH/CASH), (ii) Organic retention on hardened cement pastes (HCP), (iii) Effect of iron on organic sorption in cementitious systems	24 - KIT	14	CORI Technical Report- Task 3 (i) Organic retention on cement hydrates (AFm, AFt, CSH/CASH), (ii) Organic retention on hardened cement pastes (HCP), (iii) Effect of iron on organic sorption in cementitious systems
MS97	CORI Technical Report - Task 2 Hydrolytic/radiolytic degradation of organics: description of first results on hydrolytic and radiolytic organic degradation and identification of released species	24 - KIT	18	CORI Technical Report - Task 2 Hydrolytic/radiolytic degradation of organics: description of first results on hydrolytic and radiolytic organic degradation and identification of released species
MS98	CORI Technical Report- Task 4 (i) Radionuclide transport in HCP in the presence of organics, (ii) Radionuclide speciation under alkaline	24 - KIT	18	CORI Technical Report- Task 4 (i) Radionuclide transport in HCP in the presence of organics, (ii) Radionuclide speciation under alkaline

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
	conditions in presence of organics			conditions in presence of organics.
MS103	EURAD General Assembly n °4	1 - ANDRA	19	EURAD General Assembly n °4
MS112	EURAD Annual Work Plan 3	1 - ANDRA	21	EURAD Annual Work Plan 3
MS120	CORI Second Annual WP Meeting (including technical meetings on Task level)	24 - KIT	24	CORI Second Annual WP Meeting (including technical meetings on Task level)
MS121	CORI Technical Report - Task 2 Identification/quantification of soluble organic species generated by degradation of organic matter	24 - KIT	24	CORI Technical Report - Task 2 Identification/quantification of soluble organic species generated by degradation of organic matter: description and discussion of results acquired about identification of soluble species generated by radiolysis/hydrolysis.
MS136	EURAD General Assembly n °5 + EURAD Annual Meeting 2	1 - ANDRA	25	EURAD General Assembly n °5 + EURAD Annual Meeting 2
MS140	EURAD Periodic Report 2	1 - ANDRA	26	EURAD Periodic Report 2
MS141	CORI Technical Report-Task 3 (i) Organic transport in HCP, (ii) Update on organic retention studies on cementitious materials including iron/calcium effect	24 - KIT	26	CORI Technical Report-Task 3 (i) Organic transport in HCP, (ii) Update on organic retention studies on cementitious materials including iron/calcium effect
MS142	CORI Technical Report. Update on radionuclide retention studies on cementitious materials in the presence of organics	24 - KIT	26	CORI Technical Report. Update on radionuclide retention studies on cementitious materials in the presence of organics.
MS153	EURAD General Assembly n °6	1 - ANDRA	31	EURAD General Assembly n °6
MS162	EURAD Annual Work Plan 4	1 - ANDRA	33	EURAD Annual Work Plan 4
MS170	CORI Third Annual WP Meeting (including technical meetings on Task level)	24 - KIT	36	CORI Third Annual WP Meeting (including technical meetings on Task level)
MS171	CORI Technical Report - Task 2 Update of soluble organics species generated by degradation of organic matter: update of results on the identification of soluble organic species generated by radiolysis/hydrolysis	24 - KIT	36	CORI Technical Report - Task 2 Update of soluble organics species generated by degradation of organic matter: update of results on the identification of soluble organic species generated by radiolysis/hydrolysis

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS185	EURAD General Assembly n°7 + EURAD Annual Meeting 3	1 - ANDRA	37	EURAD General Assembly n°7 + EURAD Annual Meeting 3
MS189	EURAD Periodic Report 3	1 - ANDRA	38	EURAD Periodic Report 3
MS190	CORI Technical Report- Task 3Update on organic transport studies in HCP	24 - KIT	38	CORI Technical Report- Task 3Update on organic transport studies in HCP
MS191	CORI Technical Report. Update on radionuclide transport studies in HCP in the presence of organics.	24 - KIT	38	CORI Technical Report. Update on radionuclide transport studies in HCP in the presence of organics
MS196	CORI End of experimental RD&D programme (Task 2, 3 and 4)	24 - KIT	42	CORI End of experimental RD&D programme (Task 2, 3 and 4)
MS199	EURAD General Assembly n°8	1 - ANDRA	43	EURAD General Assembly n°8
MS206	EURAD Annual Work Plan 5	1 - ANDRA	45	EURAD Annual Work Plan 5
MS211	CORI Fourth and Final WP Meeting (including technical meetings on Task level)	24 - KIT	48	CORI Fourth and Final WP Meeting (including technical meetings on Task level)
MS212	CORI Electronic data deposit	24 - KIT	48	CORI Electronic data deposit
MS213	CORI Conclusive Technical Meeting of Task 2 (integrated into the Fourth Annual CORI WP Meeting). Preparation of technical	24 - KIT	48	CORI Conclusive Technical Meeting of Task 2 (integrated into the Fourth Annual CORI WP Meeting). Preparation of technical
MS214	CORI Conclusive Technical Meeting on Task 3 (integrated into the Fourth Annual CORI WP Meeting). Preparation of technical Deliverable	24 - KIT	48	CORI Conclusive Technical Meeting on Task 3 (integrated into the Fourth Annual CORI WP Meeting). Preparation of technical Deliverable. (48).
MS222	EURAD General Assembly n°9 + EURAD Annual Meeting 4	1 - ANDRA	49	EURAD General Assembly n°9 + EURAD Annual Meeting 4
MS224	EURAD Periodic Report 4	1 - ANDRA	50	EURAD Periodic Report 4
MS234	EURAD General Assembly n°10	1 - ANDRA	55	EURAD General Assembly n°10
MS240	EURAD General Assembly n°11 + EURAD Annual Meeting 5	1 - ANDRA	60	EURAD General Assembly n°11 + EURAD Annual Meeting 5
MS241	EURAD Periodic Report 5	1 - ANDRA	60	EURAD Periodic Report 5 (Due date: 60+2)

Work package number ⁹	WP4	Lead beneficiary ¹⁰	1 - ANDRA
Work package title	Development and Improvement Of NUmERical methods and Tools for modelling coupled processes (DONUT)		
Start month	1	End month	48

Objectives

Objectives

Improvement of numerical methods and tools for modelling multi-physical Thermo-Hydro-Mechanical-Chemical coupled processes (THMC) occurring in radioactive waste disposal is a major and permanent issue to support its optimization of design. It is worth noticing that the R&D objectives, later described in the document, are a not direct input of safety case, but contributes to improve scientific knowledge, which could if appropriate support safety case abstraction.

Numerical simulations are necessary to make predictive multi-physical assessments, at time frames and space scales larger than experiments can cover. These numerical simulations require integrating, in a consistent framework, an increasing scientific knowledge acquired for each of the individual components of a system for radioactive waste disposal. This implies to consider couplings of different and non-linear processes, applied to a wide range of materials with contrasting properties as a function of time and space in ever-larger systems.

The development of cutting-edge and efficient numerical methods is thus necessary, in the scope of development and use of powerful and relevant numerical tools for assessments. In parallel, it is also necessary to manage the uncertainties associated to the input data that feed the models, and to the representation of the processes, in order to assess the range of variability of the results and to identify the main parameters and processes that drive the behaviour of the systems of interest. Managing uncertainties in these complex systems requires the improvement and the development of innovative, appropriate and efficient methods.

According to the needs described previously, main objectives of this WP are:

- The development of relevant, performant and cutting-edge numerical methods that can easily be implemented in existing or new tools, in order to carry out high-performance computing to facilitate the study of highly coupled processes in large systems. These methods and their implementation in tools will be mainly applied to reactive transport, 2-phase flow, and THM modelling in porous and fractured media;
- The development of numerical scale transition schemes for coupled processes (meso to macro scale), supporting the study of specific multi-scale couplings such as chemo-mechanics;
- The development of innovative numerical methods to carry out uncertainty and sensitivity analyses;
- The set-up and the achievement of benchmark exercises, on representative test cases, to test the efficiency of developed methods (robustness, accuracy, time computational) on relevant tools.

Expected impacts

- Regarding RWM implementation needs

The understanding of couplings between thermal, hydraulic, mechanical and chemical processes of a radioactive waste disposal is based on the scientific and technical knowledge gained by combining both experimental approaches at different scales (from the sample to the underground research laboratory) and numerical simulations, which allow access at space and time scales out of range for experiments. Hence, the improvement of numerical methods and tools that are able to manage multi-physicals couplings appears to be necessary to support and to optimize the design of a nuclear waste repository. The work conducted in this WP is both relevant for design optimization of deep geological disposal of nuclear waste and near surface repository systems. The WP is linked to the Roadmap Theme 7 (performance assessment, safety case development, safety analyses) phases 2 -4.

- Regarding safety

DONUT will, by providing numerical means for analysis, contribute to:

- increase the multi-physical description of processes within radioactive waste disposal, and thus, ability to manage integrated scientific knowledge in the scope of safety assessment abstraction,
- (Understand the consequence of coupled processes and qualify long-term expected safety functions of components.

Description of work and role of partners

WP4 - Development and Improvement Of NUmERical methods and Tools for modelling coupled processes (DONUT) [Months: 1-48]

ANDRA, CEA, CNRS, COVRA, ENRESA, JUELICH, GRS, IRSN, LEI, MTA EK, NRG, PSI, SCK•CEN, SÚRAO, TS Enercon, TUS, UHelsinki

Task 1 – S/T coordination, State-of-the-art and training material

Start: Month 1 – End: Month 48 - Task Leader: [Andra (BRGM)]

Task contributors: [Andra (BRGM)] [CNRS (ULille)] [JUELICH (UFZ)] [SÚRAO] [TS ENERCON]

Total PM: 8,5

Task Objectives:

- S/T coordination of the WP
- Developing/updating State-of-the-art
- Developing training materials as an input to KM

Subtask 1.1 – S/T coordination Start: Month 1 – End: Month 48 Subtask Leader: [Andra (BRGM)]

Subtask Contributors: [Andra (BRGM)] [CNRS (ULille)] [JUELICH (UFZ)] [SÚRAO] [TS Enercon]

Total PM: 3,5

The scientific and technical coordination of DONUT will be performed by the WP Leader [Andra (BRGM)]. The WP Leader will be supported by the Task leaders and co-leaders: [CNRS (ULille)] [JUELICH (UFZ)] [PSI] [TS Enercon] [SÚRAO] [Andra] [GRS] and [PSI] which together with [Andra (BRGM)] constitute the WP Board of DONUT. The WP Leader will make sure that EURAD rule are followed by all partners, that the scientific milestones and deliverables are reached timely, and that the results are disseminated efficiently inside and outside the project. It includes also participation to PMO meetings twice a year. Subtask 1.1 consists of ensuring information transfer between different (sub)tasks. This is accomplished by a number of WP meetings, workshops and general milestones.

Subtask 1.2 – State-of-the-art Start: Month 1 – End: Month 48 Subtask Leader: [Andra (BRGM)]

Subtask Contributors: [Andra (BRGM)] [CNRS (ULille)] [JUELICH (UFZ)] [SÚRAO] [TS Enercon]. All WP participants will contribute to this subtask.

Total PM: 2,5

State-of-the-art will demonstrate the novelty of the research results gathered within DONUT. Besides demonstrating the novelty of the research conducted in DONUT, the state-of-the-art will be a direct input to EURAD KM programme. Indeed, it will inform interested scientists, engineers, student, etc. about the research problems that we try to solve, and about the developed approaches.

All organizations involved in task 1, 2 and 3 will contribute to the state-of-the-art (initial and updated) reports (D4.1 and D4.2). Self-consistency of the state-of the art report will be ensured by the coordination team. State-of-the-art report will also describe the representative experimental data that are needed for upscaling.

Subtask 1.3 – Training materials Start: Month 24 – End: Month 48 Subtask Leader: [Andra (BRGM)]

Subtask Contributors: [Andra (BRGM)] [CNRS (ULille)] [JUELICH (UFZ)] [SÚRAO] [TS Enercon]

Total PM: 2,5

A series of Network meetings and scientific workshops are planned. The WP Board will organize sessions on the topics tackled within the project, e.g. at the Goldschmidt and Interpore conferences. The DONUT results will be at the heart of the topics explored by the Subsurface Environmental Simulation Benchmarking Initiative (Steeff et al., 2015; Dwivedi et al., 2016). The participation of world-leading researchers in the domain of RTM also ensures an efficient dissemination of the outcome of the project in the scientific community of numerical modelling.

In order to promote the improved and developed methods and tools, a transferable skills seminar will be organized in close collaboration with the KM WP Training/Mobility. This will involve lectures by partners, presentations by stakeholders, exchange on modelling approaches and tools demonstration, both at the workshop and benchmark levels and discussion groups. Finally, these events, as well as major results, will be advertised using generic and specialized ‘social media’, in order to increase the visibility of the WP results (D4.3)

Within task 1, a report describing the benchmarks to be carried out during the project (in each task) will be delivered at Month 24. This deliverable will be coordinated by the WP Coordinator [Andra (BRGM)] in cooperation with all tasks (D.4.4). It is worth noticing that prior to benchmarks definition a workshop will be organized with other WP to set up and defined relevant benchmarks.

Task 2 - Numerical methods for high performance computing of coupled processes

Start: Month 1 – End: Month 48 - Task Leader: [CNRS (ULille)]

Task Contributors: [CNRS-LJAD (ULille) (UNice)] [PSI] [SÚRAO (CTU) (CU) (IGN) (TUL)] [CEA (EDF)] [MTA EK (SORC)] [Andra (BRGM)] [IRSN] [NRG]

Total PM: 262

The goal of task 2 is to design and implement efficient numerical algorithms taking advantage of the latest research achievements for solving complex coupled problems. In particular, the following axes play a central role in this task:

- numerical algorithms for parallel computing (e.g., linear solvers, domain decomposition, ...)
- efficient multiscale numerical methods for coupled problems
- grid adaptivity and adaptive stopping criteria based on a posteriori error estimates

The aimed applications are reactive multiphase porous media flows, the coupling of porous media flows with poromechanics, THGas couplings at repository scales, coupling of free flows in the galleries with flows in the surrounding porous medium, and the simulation of reactive processes like for instance corrosion.

At last but not least, the methods and tools that are developed will be made available within the other tasks of the WP to benchmark their efficiency and to the whole community (others WP and beyond) thanks to scientific publications, versatile codes development associated to a thorough documentation.

This task focuses on several axes of great importance in the strongly nonlinear and coupled processes occurring in the context of nuclear waste repository management. Getting mathematically founded results is one of the priority of this task, as well as the development of efficient tools taking advantage of the last advances in HPC.

Some contributions [CNRS (ULille)] [Andra (BRGM)] [NRG] will focus on reactive processes where electrical interactions with self-consistent potential occur. This encompasses corrosion and reactive transport in nanoporous materials.

A great effort will be devoted to the numerical modelling and simulation for Thermo-Hydro-Mechanics (THM). This includes modelling issues on the material constitutive laws [SÚRAO (CU)] as well as HPC issues related to parallelism based on domain decomposition [SÚRAO (CTU) (IGN)].

Taking chemistry into account is also fundamental in our context. Open access massively parallel numerical tools will be developed [CNRS-LMAP] for coupling thermo-hydro with chemistry.

In close relation to Task 3 on upscaling, the design of numerical methods taking pore size mechanical effects into account in THMC modelling will be realized [PSI]. This will yield bulk coupling effects, in opposition to physical phenomena occurring at different places and that should be coupled spatially. This is for instance the case of the free flow in the ventilation galleries and the surrounding porous matrix [CNRS-LJAD]. Fractures play a major role in transport phenomena, motivating the development of tools [SÚRAO (TUL)] where complex flows may occur in lower dimension structures. Still related to heterogeneity hydro-mechanical behaviour of interfaces between seal materials might play a role on gas transport and this issue need to be tackled [IRSN].

The development of efficient a posteriori error estimators is of paramount interest in order to better allocate the computational effort. Contributions on this topic [CEA (EDF)] will be addressed for porous media flow problems.

The results and outcomes of this task will be documented in D4.5.

Task 3 – Scale transition schemes for coupled processes

Start: Month 1 – End: Month 48 - Task Leaders : [JUELICH (UFZ)] [PSI]

Task Contributors : [SÚRAO (TUL)] [Andra (BRGM)] [JUELICH (UFZ)] [PSI]

Total PM: 73

Many coupled processes in fractured porous media are inherently multi-scale due to dynamic localization effects of, e.g., flow and deformation in narrow bands or faults. Their description requires special constitutive models and numerical methods. Secondly, individual processes are often best described on different scales depending on their specific phenomenology and the scales of their experimental characterization. Consequently, different process codes and scientific communities have evolved for, e.g., reactive transport and geomechanics. As a result, such couplings (e.g. chemo-mechanical couplings) are most often neglected despite their importance, not for scientific reasons but due to a lack of technical capabilities and of interaction/collaboration between experts in the relevant distinct fields.

This task aims at collecting, improving and developing numerical methods and tools that close this capability gap and address the described issues. Examples include numerical homogenization approaches, multi-scale simulation frameworks, coupling of scale-disparate numerical simulators, methods to represent material or phase interfaces across scales, etc. Developed methods and tools will be made available to the wider community for European added value. Specifically, main objectives of this task are to:

- Provide numerical methods to bridge spatial scales
- Provide tools that enable the consideration of chemo-mechanical process couplings

Task 3 studies the coupling between hydraulic, mechanical and chemical processes. Activities are of this task are coordinated by [UFZ] and [PSI]. The different partners address this topic with complementary emphasis. The description is split into three parts:

H-M processes in with localized transport (multiscale simulations in fractured porous media):

Fractures represent an inherently multi-scale problem with strongly localized flow and therefore different transport properties. [SÚRAO (TUL)] develops methods to couple fracture flow to continuum (matrix) flow including HM couplings like fracture opening/closure, channelling, etc. Based on numerical methods developed in Task 2 (Fig.1) for Flow123 (<http://flow123d.github.io/>), here transport experiments performed at different scales incl. fracture borehole pressure tests, inter-borehole fracture tracer tests, etc., will be simulated. Different numerical concepts (dual porosity,

co-dimensional entities) will be compared in their effectiveness to describe multi-scale transport phenomena and to transfer data from detailed models to repository scale models.

H-C processes from pore-scale to Darcy-scale (including electrochemical transport)

[Andra (BRGM)] will use real pore-scale geometries by assimilating 3D image datasets of nanoporous materials, already available, into a simulation framework for flow and electrochemical transport. Pore scale models using the open-source framework OpenFoam (www.openfoam.com) and micro-continuum models developed in Task 2 by [Andra (BRGM)] will be used to derive macroscopic coupling terms for (large) Darcy-scale calculations. This upscaling of pore-scale to continuum transport will inform the methods used in the HMC section.

Multiscale HMC processes (coupling precipitation/dissolution processes to fracture mechanics):

[JUELICH] will provide available experimental data stemming from plug-flow column and tank experiments that feature dissolution/precipitation processes leading to clogging and eventually fracturing. Changing pathways will be visualized by tracers, by live monitoring of pore-connectivity changes using different imaging techniques at different scales (i.e. MRI, SEM). They will then model reactive transport processes separately on the pore-scale and the continuum scale with state-of-the-art tools (e.g. OpenGeoSys-GEM) and highlight where these existing approaches fail and where the parameterization between different experiments becomes inconsistent. These reactive transport models motivate the developments on chemo-mechanical coupling in this task and serve as test cases to show improvements brought by the new methods developed by [PSI] and [JUELICH (UFZ)].

To link the scale-separate simulations, [JUELICH (UFZ)] will develop and implement in OpenGeoSys (www.opengeosys.org) the FE² method for coupled processes to perform explicitly multi-scale simulations of heterogeneous materials. While the method will be set up using OGS, it will be implemented as a control scheme such that it can link different numerical tools for each scale. Due to the characteristics of the FE² scheme, the method can be parallelized efficiently. This will be demonstrated on in-house HPC infrastructure.

[PSI] in conjunction with the Lattice-Boltzmann Finite-Element coupling they developed in Task 2, will apply the method to the data provided by [JUELICH]. In analysing HMC coupled processes, the scientific expertise on thermo-hydro-mechanical processes (incl. fracture mechanics) of [JUELICH (UFZ)] and the geochemical expertise of [PSI] the developed tools will be applied to existing experimental data and benchmark with continuous FE codes coupled with geochemical solvers (i.e. OpenGeoSys-PHREEQC, OpenGeoSys – GEMS, FENICS, MCOTAC).

The results and outcomes of this task will be documented in D4.6.

Task 4 - Tools and methods to quantify/derive uncertainties induce by coupled processes

Start: Month 1 – End: Month 48 Task Leader: [TS Enercon]

Contributors: [SCK•CEN] [SÚRAO (IGN) (TUL) (ÚJV Řež)] [Andra (BRGM)] [GRS] [UHelsinki (TUT)] [ENRESA] [JUELICH (HZDR)] [TS Enercon]

Total PM: 154,2

Simulations of THMC process couplings of radioactive waste disposal involves many input models and data whose level of couplings vary in space and time and could be weak and strong. Effects of uncertainties of input data and models on final indicators are difficult to take into account as there are strong non-linearities, and classical methods have thus some limitations. Relevant methods and tools should be defined and set up to assess (i) effect of all kinds of uncertainties on uncertainty of results indicators (uncertainty analysis) and (ii) relevant input data and models which manage the result (sensitivity analysis).

Task 4 will focus on:

- Developments of innovating numerical methods to treat uncertainty and sensitivity analysis on complex coupled representative cases (big system, many media and input data) with strong non-linearities: global/local sensitivity analysis with specific tools (surrogate/metamodels such as Chaos polynomials, neural network, adjoint state methods, ...)
- Developments of mathematical representations of uncertain parameters applied for coupled processes (correlations, ...)

In order to fulfil objective to carry out uncertainty and sensitivity analyses on problems involving coupled processes that required high CPU time-consuming because both nonlinearities and big size grid have to be managed, R&D development of surrogates models and metamodels are proposed (including models reduction). They will be applied in the field of local and global sensitivity, and will be tested on relevant test-cases (reactive transport, THGas, THM).

[SCK•CEN] aims to develop a novel, robust and accurate emulation-based method to make sensitivity analysis and uncertainty propagation of CPU-demanding reactive transport models (machine learning (ML) algorithms for nonlinear regression, with last generation Gaussian processes (GP), random forest and (extreme) gradient boosting). [Andra (BRGM)] aims to develop surrogates time-space-parametric models (such as polynomial chaos expansions (PCEs)), adapted method to sensitivity analysis with dependent parameters, and test it to THM test-case including applications to inverse problems. [SÚRAO (IGN) (TUL)] [UHelsinki (TUT)] [GRS] will develop techniques to variance reduction techniques, and surrogate models construction, and contribute to test their efficiency with relevant global sensitivity indicators (Sobol, EFAST, etc.).

We intend to compare efficiency of some developed methods by partners (especially accuracy and range of applications) by benchmarking surrogate methods in the scope of non-intrusive global sensitivity, and examine ability to perform local sensitivity.

To complete this large R&D development on numerical methods, [TS-Enercon] plans to carry out understanding nonlinearities and inter-dependencies of uncertain parameters in coupled processes, and [ENRESA] contributes with innovative numerical methods for adjoint-state methods and Uncertainty quantification.

About developments of mathematical representations of uncertain parameters applied for coupled processes, a joint programme is outlined, since [SÚRAO [ÚJV Řež]] [GRS] [JUELICH (HZDR)] plan to collaborate to carry out a complex uncertainty treatment and sensitivity analysis effort based on a coordinated data collection, uncertainty quantification and testing sensitivity analysis methods, applied to geochemical application.

The results and outcomes of this task will be documented in D4.7.

Task 5 - Benchmarks of methods and tools for coupled processes

Start: Month 18 – End: Month 48 Task Leader: [SÚRAO]

Contributors: [COVRA] [ENRESA] [LEI] [SÚRAO (TUL)] [TUS] [Andra] [GRS]

Total PM : 40,9

The main objective of the Task 5 is to test efficiency of numerical methods developed in tasks 2, 3 and 4, on relevant test-cases defined in concertation with other WPs. This task will thus focus on :

- development of suitable benchmarks, mainly derived from THGas, THM, and reactive transport test-cases at large time and space scales (porous/fractured and free media),
- implementation of numerical methods developed at task 2, 3 and 4 in existing tools used by each involved partner,
- benchmarks of methods and tools to quantify efficiency and added-value in terms of :
 - o increase of knowledge (better physical representation, more integrated systems, ...)
 - o accuracy, robustness, computational cost,
 - o robustness of scale-transition approaches
 - o ability to manage uncertainty and sensitivity analyses

All the involved partners in this task will contribute supporting the development of benchmarks for the evaluation of the methods and numerical tools described in the other tasks considering their relevance in the scope of multi-physical assessment. Regarding the different partner's contribution in the different tasks, THM, THC (reactive transfer) and THGas benchmarks are considered being the most relevant and their exact setting up will be defined in close collaboration with the concerned WPs through a workshop.

[COVRA] [ENRESA] [SÚRAO] [Andra] and [GRS TSO] will prepare benchmarks from the point of view of the implementers and evaluators. These organisations and their partners participate in most of other work-packages, and the work will be carried out in close cooperation with the linked WPs and the RE involved in this WP. The prepared benchmarks will help to quantify how (e.g. among others accuracy and time calculation improvements) numerical methods developed in DONUT are relevant regarding current used methods, and to compare tools in which these methods are implemented. In order to make the benchmarks relevant for a large community they will address coupled processes representative in different kind host rocks (e.g. clay, crystalline rocks, salt).

The results and outcomes of this task will be documented in D4.8.

Participation per Partner

Partner number and short name	WP4 effort
1 - ANDRA	2.50
BRGM	34.50
5 - CEA	0.00
EDF	9.50
8 - CNRS	39.00
UNice	6.00
ULille	31.00
9 - COVRA	0.60
14 - ENRESA	4.80

Partner number and short name	WP4 effort
15 - JUELICH	17.00
HZDR	14.50
UFZ	27.50
16 - GRS	18.70
19 - IRSN	24.00
25 - LEI	5.00
26 - MTA EK	0.00
SORC	12.00
31 - NRG	5.00
34 - PSI	18.00
38 - SCK•CEN	26.00
42 - SÚRAO	6.50
CU	19.00
CTU	35.00
ÚJV	10.00
TUL	45.00
IGN	64.00
45 - TS Enercon	20.00
46 - TUS	4.00
48 - UHelsinki	0.00
TUT	20.00
Total	519.10

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D4.1	DONUT - State-of-the-art in the fields of numerical analysis and scientific computing	1 - ANDRA	Report	Public	6
D4.2	DONUT - Updated State-of-the-art in the fields of numerical analysis and scientific computing	1 - ANDRA	Report	Public	48
D4.3	DONUT - Training materials	1 - ANDRA	Report	Public	36
D4.4	DONUT - Report describing the	1 - ANDRA	Report	Public	24

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
	benchmarks to be carried out during the WP				
D4.5	DONUT - Technical report describing numerical method improvement and their transferability in numerical tools as well as benchmarks realization	8 - CNRS	Report	Public	46
D4.6	DONUT - Final report describing improvement and implementation of scale transition methods to model coupled processes	1 - ANDRA	Report	Public	46
D4.7	DONUT - Report describing numerical improvement and developments and their application to treat uncertainty when dealing with coupled processes	1 - ANDRA	Report	Public	46
D4.8	DONUT - Final report describing benchmark realisations and (i) influence of the development carried out in other tasks on the quantification of improvement (ii) comparison, when possible, of tools on which numerical methods have been implemented	1 - ANDRA	Report	Public	46

Description of deliverables

Deliverables (brief description and month of delivery)

Deliverable 4.1 - State-of-the-art in the fields of numerical analysis and scientific computing

It will identify numerical solutions taking advantage of the recent breakthrough in the fields of numerical analysis and scientific computing. It will also describe representative experimental data needed for the upscaling procedure.

[Andra (BRGM)] –Month 6

Deliverable 4.2 - Updated State-of-the-art in the fields of numerical analysis and scientific computing [Andra (BRGM)] – Month 48

Deliverable 4.3 - Training materials (Month 36) [Andra (BRGM)]

Deliverable 4.4 - Report describing the benchmarks to be carried out during the WP (with inputs from all tasks) [Andra (BRGM)] – Month 24

D4.5 – Technical report describing numerical method improvement and their transferability in numerical tools as well as benchmarks realization will describe how the developments can be linked and implemented in existing tools used

by partners and it will document input/output interface. All partners involved in this task will contribute to this report. All partners including in task 2 will contribute to this report. [CNRS (Lille University)] - Month 46

D4.6 - Final report describing improvement and implementation of scale transition methods to model coupled processes [Task leaders] – Month 46. All partners involved in this task will contribute to this report.

4.7: Report describing numerical improvement and developments and their application to treat uncertainty when dealing with coupled processes. [TS Enercon] -Month 46. All partners including in this task will contribute to this report.

D4.8 - Final report describing benchmark realisations and (i) influence of the development carried out in other tasks on the quantification of improvement (ii) comparison, when possible, of tools on which numerical methods have been implemented [SÚRAO] -Month 46. All partners involved in this task will contribute to this report.

D4.1 : DONUT - State-of-the-art in the fields of numerical analysis and scientific computing [6]

DONUT - State-of-the-art in the fields of numerical analysis and scientific computing

D4.2 : DONUT - Updated State-of-the-art in the fields of numerical analysis and scientific computing [48]

DONUT - Updated State-of-the-art in the fields of numerical analysis and scientific computing

D4.3 : DONUT - Training materials [36]

DONUT - Training materials

D4.4 : DONUT - Report describing the benchmarks to be carried out during the WP [24]

DONUT - Report describing the benchmarks to be carried out during the WP

D4.5 : DONUT - Technical report describing numerical method improvement and their transferability in numerical tools as well as benchmarks realization [46]

DONUT - Technical report describing numerical method improvement and their transferability in numerical tools as well as benchmarks realization

D4.6 : DONUT - Final report describing improvement and implementation of scale transition methods to model coupled processes [46]

DONUT - Final report describing improvement and implementation of scale transition methods to model coupled processes

D4.7 : DONUT - Report describing numerical improvement and developments and their application to treat uncertainty when dealing with coupled processes [46]

DONUT - Report describing numerical improvement and developments and their application to treat uncertainty when dealing with coupled processes

D4.8 : DONUT - Final report describing benchmark realisations and (i) influence of the development carried out in other tasks on the quantification of improvement (ii) comparison, when possible, of tools on which numerical methods have been implemented [46]

DONUT - Final report describing benchmark realisations and (i) influence of the development carried out in other tasks on the quantification of improvement (ii) comparison, when possible, of tools on which numerical methods have been implemented

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	EURAD Kick-off meeting (General Assembly n°1)	1 - ANDRA	1	EURAD Kick-off meeting (General Assembly n°1)
MS3	DONUT Kick off - WP Meeting 1	1 - ANDRA	1	DONUT Kick off - WP Meeting 1
MS12	EURAD EJP Newsletters	1 - ANDRA	3	EURAD EJP Newsletters (Due date : M3 and then every quarter)

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS30	EURAD General Assembly n°2	1 - ANDRA	7	EURAD General Assembly n°2
MS34	DONUT WP Meeting 2	1 - ANDRA	7	DONUT WP Meeting 2
MS42	EURAD Annual Work Plan 2	1 - ANDRA	9	EURAD Annual Work Plan 2
MS81	EURAD General Assembly n°3 + EURAD Annual Meeting 1	1 - ANDRA	13	EURAD General Assembly n°3 + EURAD Annual Meeting 1
MS85	EURAD Periodic Report 1	1 - ANDRA	14	EURAD Periodic Report 1
MS94	ACED - GAS - DONUT Joint Workshop - 1	32 - ONDRAF/NIRAS	16	ACED - GAS - DONUT Joint Workshop
MS103	EURAD General Assembly n°4	1 - ANDRA	19	EURAD General Assembly n°4
MS105	DONUT WP Meeting 3	1 - ANDRA	19	DONUT WP Meeting 3
MS112	EURAD Annual Work Plan 3	1 - ANDRA	21	EURAD Annual Work Plan 3
MS114	DONUT Intermediate report describing numerical method improvement and their transferability in numerical tools	1 - ANDRA	22	DONUT Intermediate report describing numerical method improvement and their transferability in numerical tools
MS115	DONUT Intermediate report describing numerical method improvement and their transferability in numerical tools.	1 - ANDRA	22	DONUT Intermediate report describing numerical method improvement and their transferability in numerical Tools.
MS116	DONUT Intermediate report describing improvement and implementation of scale transition methods improvement and their application for multiscale simulations	1 - ANDRA	22	DONUT Intermediate report describing improvement and implementation of scale transition methods improvement and their application for multiscale simulations
MS117	DONUT Intermediate report describing numerical developments realized to treat uncertainty	1 - ANDRA	22	DONUT Intermediate report describing numerical developments realized to treat uncertainty
MS130	HITEC Task 3.3 -Modelling benchmarks – description (Description of calibration case, verification cases and benchmarks selected for T3.3 in cooperation with DONUT	50 - VTT	24	HITEC Task 3.3 -Modelling benchmarks – description (Description of calibration case, verification cases and benchmarks selected for T3.3 in cooperation with DONUT
MS136	EURAD General Assembly n°5 + EURAD Annual Meeting 2	1 - ANDRA	25	EURAD General Assembly n°5 + EURAD Annual Meeting 2

Schedule of relevant Milestones

Milestone number¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS140	EURAD Periodic Report 2	1 - ANDRA	26	EURAD Periodic Report 2
MS153	EURAD General Assembly n°6	1 - ANDRA	31	EURAD General Assembly n°6
MS156	DONUT WP Meeting 4	1 - ANDRA	31	DONUT WP Meeting 4
MS162	EURAD Annual Work Plan 4	1 - ANDRA	33	EURAD Annual Work Plan 4
MS165	ACED - GAS - DONUT Joint Workshop	32 - ONDRAF/NIRAS	33	ACED - GAS - DONUT Joint Workshop
MS185	EURAD General Assembly n°7 + EURAD Annual Meeting 3	1 - ANDRA	37	EURAD General Assembly n°7 + EURAD Annual Meeting 3
MS189	EURAD Periodic Report 3	1 - ANDRA	38	EURAD Periodic Report 3
MS199	EURAD General Assembly n°8	1 - ANDRA	43	EURAD General Assembly n°8
MS201	DONUT WP Meeting 5	1 - ANDRA	43	DONUT WP Meeting 5
MS206	EURAD Annual Work Plan 5	1 - ANDRA	45	EURAD Annual Work Plan 5
MS222	EURAD General Assembly n°9 + EURAD Annual Meeting 4	1 - ANDRA	49	EURAD General Assembly n°9 + EURAD Annual Meeting 4
MS224	EURAD Periodic Report 4	1 - ANDRA	50	EURAD Periodic Report 4
MS234	EURAD General Assembly n°10	1 - ANDRA	55	EURAD General Assembly n°10
MS240	EURAD General Assembly n°11 + EURAD Annual Meeting 5	1 - ANDRA	60	EURAD General Assembly n°11 + EURAD Annual Meeting 5
MS241	EURAD Periodic Report 5	1 - ANDRA	60	EURAD Periodic Report 5 (Due date: 60+2)

Work package number ⁹	WP5	Lead beneficiary ¹⁰	15 - JUELICH
Work package title	Fundamental understanding of radionuclide retention (FUTuRE)		
Start month	1	End month	48

Objectives

Objectives

- Fundamental insights into the impact of chemical boundary conditions and the role of microstructures on radionuclide speciation and mobility in “real” clay rocks as well as crystalline rocks
- Enhance the quantitative and mechanistic understanding of the impact of (i) specific surface properties of materials (diffusive double layer, surface potential), (ii) the role of grain boundaries, (iii) the effect of water saturation, content and chemistry (pH, ionic strength) as well as (iv) the impact of pore size variability and heterogeneity on the mobility of chemical species
- Refined understanding of the relation between fracture/ pore structures and transport as well as the feedback of mineral reactions (dissolution/precipitation, clogging) on pore structure and connectivity
- Closing knowledge gaps regarding sorption reversibility, uptake mechanisms (adsorption vs. incorporation, precipitation), sorption competition and surface diffusion which have not been addressed sufficiently in previous European projects (e.g. FUNMIG, SKIN).
- Fundamental understanding and thus reducing uncertainties of surface induced (heterogeneous) redox processes with regard to coupled sorption and electron transfer interface reactions governing the retention of redox-sensitive radionuclides at Fe(II)/Fe(III) bearing minerals surfaces – going beyond previous European projects (e.g. RECOZY).

Expected impacts

- Regarding RWM implementation needs

The WP will provide the scientific basis needed to bound the applicability range and to estimate uncertainties in the simplistic concepts used in the current safety assessment (SA) studies. The development of multicomponent mechanistic sorption models and pore scale simulations of radionuclides transport will allow validation of the concepts used in SA and ensure that all relevant processes are sufficiently understood and are taken in to account in SA at an appropriate level, e.g. surface diffusion, sorption mechanisms, competition and reversibility in clay rocks. Moreover, the proposed research will contribute to the understanding of transport of radionuclides in the crystalline rock environment by properly identifying relevant properties and species involved in sorption and transport processes, altogether with description of fractured rock environment. The combined analysis of reactivity, structure, flow field, and RN mobility/ retention would provide a unique dataset that would enable to include local boundary driven transport processes into safety assessment models.

The R&D in this work package covers a substantial fraction of the sub-domains addressed in domain 1.6 Radionuclide and Chemical Species Migration of the SRA regarding knowledge gaps related to sorption process, heterogeneous redox processes and in particular overall radionuclide mobility in “real” systems.

The WP is linked to the Roadmap Theme 4 (geoscience to understand rock properties, radionuclide transport and long-term geological evolution) phases 2-4,

- Regarding safety

Improvement of the scientific basis for the safety case of deep geological disposal in clay rock and crystalline rock. Reduction of uncertainties and potential reduction of conservatisms in more realistic descriptions of repository system evolution.

Description of work and role of partners

WP5 - Fundamental understanding of radionuclide retention (FUTuRE) [Months: 1-48]

JUELICH, ANDRA, CEA, CIEMAT, CNRS, GRS, KIT, MTA EK, PSI, RATEN, SCK•CEN, SÚRAO, TNO, UHelsinki

Description of work (where appropriate, broken down into tasks), lead partner and role of participants

Task 1 – S/T coordination, State-of-the-art and training material

Start: Month 1 – End: Month 48 - Task Leader: [JUELICH]

Task contributors: [Andra] [CEA] [JUELICH] [PSI] [SCK•CEN] [TNO]

Total PM: 8,3

Subtask 1.1 – S/T coordination

Start: Month 1 – End: Month 48 Subtask Leader: [JUELICH]

Subtask Contributors: [Andra] [JUELICH]

Total PM: 3

The scientific and technical coordination of WP5-FUTuRE will be performed by the WP Leader [JUELICH]. The WP Leader will be supported by the Task leaders and co-leaders: [PSI] [SÚRAO (UJV)] [JUELICH (HZDR)] [SCK•CEN] [Andra (BRGM)] which together with [JUELICH] constitute the WP Board of FUTuRE. The WP Leader will make sure that EURAD rules are followed by all partners, that the scientific milestones and deliverables are reached timely, and that the results are disseminated efficiently inside and outside the project. The WP Leader will ensure the interface between the WP Board, between the participants of WP5-FUTuRE, and with the Programme Management Office and the other EURAD WPs.

This subtask consists of ensuring information transfer between different (sub)tasks. This is accomplished by one WP meeting (WPM) per year involving Task 2 and 3, in addition to the kick-off meeting (WPM1).

Subtask 1.2 – State-of-the-art

Start: Month 1 – End: Month 48 Subtask Leader: [SCK•CEN]

Subtask Contributors: [CEA] [PSI] [SCK•CEN] [TNO]

Total PM: 4,3

In order to set a “baseline” and also as input to WP11-KM SoK, a state-of-the-art report will be drafted at the start of the project (Month 6) with the aim to provide a comprehensive overview of the available knowledge on the understanding of radionuclide retention in clay and crystalline rocks (D5.1). Emphasis will be on the current available knowledge with respect to i) transferability of sorption phenomena to compacted/realistic systems and sorption reversibility and, ii) surface induced (heterogeneous) redox processes.

At the end of the project (Month 48), this report will be updated incorporating the newly acquired knowledge (D5.2). A team of 4 research groups will compile these status report [SCK•CEN] [TNO] [PSI] and [CEA] at month 6 and month 48.

Subtask 1.3 – Training Materials

Start: Month 24 – End: Month 48 Subtask Leader: [JUELICH]

Subtask Contributor: [JUELICH]

Total PM: 1

Learning materials will be generated in order to:

- Provide the possibility for independent checks of an interested person that the SoK is well understood, and
- Request trainees for face-to-face training at the corresponding training modules of the “EURATOM RWM school” to prepare for the lectures so that a high level can be kept with the expected prominent training outcome.

The details of such material will be developed together with the WP13- KM Training/Mobility in view of different levels of learning ambition for different communities. As the training programme develops, amongst others questions on learning outcome from previously held training sessions and videos of such lectures can be added. The training materials developed within this subtask will be delivered under D5.3.

Task 2 - Mobility

Start: Month 1 – End: Month 48 - Task Leader: [PSI] – Co-Leaders: [JUELICH (HZDR)] and [SCK•CEN]

Task Contributors: [Andra (BRGM)] [CEA] [CIEMAT] [CNRS-SUBATECH/IC2MP/IPHC (UPoitiers)] [JUELICH]

Total PM: 349,7

Task objectives:

- Experimental studies on RN mobility in compacted clay with strongly sorbing RN: actinides, intermediate sorbing RN: Fe, Ra, weakly sorbing RN: I/Se) and a limited number of clay systems: pure clay systems (illite, montmorillonite) and clay rocks (in particular Opalinus clay and COx)
- Experimental studies on RN mobility in crystalline rock with strongly sorbing RNs: actinides, intermediate sorbing RNs: Ra, weakly sorbing: I/Se): Identification of the impact of structure (connected pore network and surface topography of fractured crystalline rock samples and mineral infills) on RN mobility; impact of flow velocity; providing an interface to the WP4-DONUT (smart Kd approach) by using the quantitative information about parameter variability (surface charge, nanotopography, flow velocity anisotropy) that reflect the complexity of natural materials.
- Sorption studies (excluding redox processes) with a focus on reversibility to close specific knowledge gaps with Ni and Ra in support of mobility studies

Subtask 2.1 - Mobility of radionuclides in compacted clay

Start: Month 1 – End: Month 48 - Task Leader: [PSI]

Subtask contributors: [Andra] [CEA] [CIEMAT] [CNRS-IC2MP/SUBATECH/IPHC (UPoitiers)]

[KIT (JGU)] [JUELICH] [MTA EK] [PSI] [SCK•CEN]

Total PM: 174,7

Diffusion studies on well-defined clay systems [SCK•CEN] [PSI] [CIEMAT] and on intact clay rocks [PSI] [CIEMAT] [JUELICH] [KIT (JGU)] [MTA EK] will be performed and the tracer profiles analysed with state-of-the art analytical tools such as Mass Accelerated Spectroscopy, Attenuated Total Reflection Fourier Transform Infrared Spectroscopy, micro-XAS and laser ablation with HR-ICP-MS in order to get better information on the speciation of the different nuclides on the surface of the solid phase. The diffusion profiles will be described with reactive transport codes containing state-of-the art adsorption and solid solution models as well as state-of-the art surface mobility models [PSI] [SCK•CEN] [KIT (JGU)] [JUELICH] [CNRS-SUBATECH]. This will give indication on whether the models derived from batch sorption experiments can be applied to compact systems. Pure clay samples of illite and kaolinite with well-defined characteristics such as porosity, clay particle size distribution and particle orientation will be provided by IC2MP for diffusion studies [CNRS-IC2MP] [CEA] [PSI]. Complementary to the diffusion studies, also batch sorption studies on compact clay systems will be performed [CNRS-SUBATECH], [CIEMAT].

The radiotracers that will be used in the diffusion and sorption studies are i) moderately sorbing tracers such as Fe, Mn, Zn, Ni, Ra [CIEMAT] [JUELICH] [SCK•CEN] [MTA EK] [CNRS-SUBATECH] and ii) strongly sorbing tracers such as Eu, Np, Pu, U and other actinides [KIT (JGU)] [CNRS-SUBATECH] [PSI] [CNRS-IPHC] [MTA EK]. Also a few weakly sorbing anionic tracers such as I and Se will be studied [SCK•CEN] [MTA EK] [CIEMAT] to decipher how simultaneous anion exclusion, sorption and surface induced mobility can be consistently described.

The results and outputs of Task 2.1, including statements on future research needs, will be compiled in a final report (D5.4).

Subtask 2.2 - Mobility of radionuclides in crystalline rock

Start: Month 1 – End: Month 48 - Task Leader: [JUELICH (HZDR)]

Subtask contributors: [JUELICH (HZDR)] [GRS] [KIT] [POSIVA] [SÚRAO (UJV)] [UHelsinki]

Total PM: 73,9

The work will be performed by a team out of [GRS] [JUELICH (HZDR)] [KIT] [UHelsinki] UJV, [POSIVA] and [SÚRAO]. The connected pore network and surface topography of fractured crystalline rock samples and mineral infills (provided by [SÚRAO] and [POSIVA]) are analyzed using μ CT [UHelsinki] [JUELICH (HZDR)] and interferometry microscopy (HZDR) prior to flow, diffusion, and sorption experiments. After transport experiments, post mortem analyses are performed using C-14-PMMA autoradiography technique [UHelsinki] interferometry [JUELICH (HZDR)], and AFM [GRS]. Batch type and flow through sorption experiments utilize reference pore water of the specific host rock [GRS] [JUELICH (HZDR)] [SÚRAO (UJV)]. We analyze the impact of surface potential variability, the role of grain boundaries [JUELICH (HZDR)] the effect of water chemistry (Eh, pH, ionic strength: [GRS] [SÚRAO (UJV)] as well as the impact of pore size variability of fracture infills and intact rock (nanometer to micron scale) [GRS] [SÚRAO (UJV)] [UHelsinki] [JUELICH (HZDR)]. Additional objectives include the analysis of the fluid velocity field (diffusive vs. advective transport) in and close to fractures by using PET techniques [JUELICH (HZDR)]. We utilize flow-through tracer tests to analyse the mobility of non-sorbing, intermediate, and strongly sorbing radionuclides (HTO, I, Ba/Eu) within rock fractures that covered with mineral infills [SÚRAO (UJV)]. Strongly, intermediate, and weakly sorbing radionuclides (Eu, Ra, Ba, Sr, Se (IV), and I) are used for sorption experiments focusing on the impact of porosity heterogeneities at the micron scale [SÚRAO (UJV)] [GRS] [UHelsinki] [JUELICH (HZDR)]. The laboratory experiments will be complemented by results of quantification of speciation and transport of radionuclides (Se, Am, Pu, Np, U, Tc) under natural crystalline fracture conditions under natural shear zone in Grimsel Test site. The experimental and analytical results will provide a basis for rigorous uncertainty and sensitivity studies thus providing an interface to WP DONUT. Generally, the results contribute to a realistic view on radionuclide migration in complex systems in order to overcome the current over-conservative consideration of heterogeneities, such as fracture planes, mineral infills, and porosity networks. The activities will be performed under close cooperation of all participating institutions.

The results and outputs of Task 2.2, including statements on future research needs, will be compiled in a final report (D5.5).

Subtask 2.3 - Reversibility of sorption

Start: Month 1 – End: Month 48 - Task Leader:[PSI]

Subtask contributors: [Andra (BRGM)] [CIEMAT] [CNRS-IPHC] [JUELICH] [MTA EK] [PSI] [SCK•CEN]

Total PM: 101,1

The sorption of radionuclides on clay minerals in engineered and geological barrier systems is a key safety function in deep geological disposal of radioactive waste. Reliable sorption data (K_d -values) and a mechanistic understanding of adsorption processes are mandatory for a proper evaluation of this safety function. Current models used in SA assume reversibility of the sorption. There are strong experimental evidences that the adsorption process is not fully reversible for a number of radionuclides.

The main aim of this subtask is to address open questions with respect to the adsorption reversibility and the nature of mechanism controlling the retention in the long-term (e.g. adsorption vs incorporation (surface precipitation, neoformation)). The degree of adsorption/desorption (reversibility), will be investigated over a relevant range of

geochemical conditions (i.e., pH, I, nuclide concentration, competing nuclide or ligand, time scales) by macroscopic batch type experiments on (i) pure 2:1 type clay minerals [PSI] [Andra (BRGM)] [CNRS-IPHC] [CIEMAT] [JUELICH] [SCK•CEN] (ii) Fe mixed oxides [Andra (BRGM)] [CNRS-IPHC] and (iii) complex rock systems, primarily Opalinus Clay [JUELICH] [CNRS-IPHC] and Callovo-Oxfordian Clay [CNRS-IPHC] [CIEMAT] with a limited activity on Boda Claystone [MTA EK].

To obtain information on the molecular scale structure of the formed surface complexes, spectroscopic methods such as X-ray absorption spectroscopy [PSI] [CIEMAT] high resolution scanning transmission electron microscopy [Andra (BRGM)] Pair Distribution Function [Andra (BRGM)] transmission electron microscopy, micro-spectroscopy [MTA EK] and Attenuated Total Reflectance Fourier Transformed Infrared spectroscopy [CNRS-IPHC] will be applied.

Raman microscopy will be used to monitor the uptake of Ra during (Ba,Ra)SO₄ co-precipitation. It is the intention to implement the existing thermodynamic models to account for surface precipitation [PSI] [MTA EK] or sulphate co-precipitation of Ra [JUELICH] [PSI]. Following radiotracers will be used: weakly sorbing Se [SCK•CEN] [CIEMAT] [MTA EK] and moderately sorbing Ni [PSI] [Andra (BRGM)] [CIEMAT] [SCK], Ra [JUELICH] [CIEMAT] [MTA EK] and U(VI) [CNRS-IPHC]. The partners [PSI] [CNRS-IPHC] [CIEMAT] [JUELICH] [SCK•CEN] and [MTA EK] are also participating in subtask 2.1 where the aim is to evaluate whether adsorption processes and adsorption models developed on clays and clay rocks in diluted systems can be transferred as such to the real, compacted clays and clay rocks.

The results and outputs of Task 2.3, including statements on future research needs, will be compiled in a final report (D5.6).

Task 3 - Redox reactivity of radionuclides on mineral surfaces

Start: Month 1 – End: Month 48 - Task Leader: BRGM

Task Contributors: [Andra (BRGM)] [CEA] [CIEMAT] [CNRS (UGrenoble)] [JUELICH (HZDR)] [KIT] [PSI] [RATEN] [TNO]

Total PM: 237,2

Task objectives:

The overarching goal of task 3 “Redox” is to contribute to a better understanding of the coupled sorption and electron transfer interface reactions governing the retention of redox-sensitive radionuclides on Fe(II)/Fe(III) bearing minerals so as to improve our capacity to model, and thus predict, the fate of these elements within the safety assessment of radioactive waste storage. To address this issue, the interaction between different redox-sensitive radionuclides (or their non-radioactive analogues), including U, Pu, Tc, Np and Se, and purified relevant Fe-containing minerals and, to a minor extent, with rock envisioned as potential host-rocks (e.g., Callovian-Oxfordian) will be systematically investigated. Mineral properties with respect to its redox reactive iron content (structural/adsorbed) (i.e. abundance, location in the crystal structure, and oxidation state(s)) will be correlated to the degree of radionuclides retention (K_d) and molecular scale surface speciation. The transferability of the knowledge gained on dispersed pure phases (batch experiments) to the description and understanding of diffusion processes of radionuclides in compacted systems will be verified.

In a first part, pure clays and iron oxides (including magnetite) and, to a minor extent, argillaceous rocks (e.g., Callovian-Oxfordian rock or red clay), will be prepared and characterized for subsequent use in the different experiments [Andra (BRGM)] [PSI] [JUELICH (HZDR)] [CIEMAT] [TNO] [Andra] [RATEN]. HZDR will prepare magnetite samples with varying characteristics (i.e. Fe(II)/Fe(III), dopants, SSA, structural defects). Clay minerals with different Fe(II)/Fe(III) ratios will be prepared by reducing to different degrees the structural Fe(III) or by sorbing Fe(II) [Andra (BRGM)] [TNO] [PSI].

Complementary techniques (wet chemistry, Mossbauer spectrometry, electrochemistry, microscopy, and synchrotron-based X-ray techniques) will be employed to characterize the samples and the contacting solutions [RATEN] [Andra (BRGM)] [PSI] [JUELICH (HZDR)] [CIEMAT]. The iron oxides and clay samples obtained in this way will differ in their Fe characteristics (i.e., content, speciation and structural location), thus allowing to investigate the impact of each of these parameters on the extent and type of the redox interaction between minerals and radionuclides.

The second part of this task will focus on the understanding of the retention mechanisms of redox-sensitive radionuclides (e.g., U, Pu, Tc, Np, Se) on/in these Fe(II)/Fe(III) bearing minerals and of the associated electron transfer reactions [RATEN] [KIT] [PSI] [TNO] [CIEMAT] [JUELICH (HZDR)] [CNRS (UGrenoble)] [CEA]. Batch-type sorption experiments under different experimental conditions (e.g., pH, Eh, [RNs] dopants, solid concentration, time, presence of organics or H₂, etc.) and under controlled atmosphere will be carried out to quantify the retention and type of surface reaction (adsorption, reduction, oxidation, (co)-precipitation etc.). Competitive sorption experiments and reversibility tests will also be carried out. These experiments will guide the choice in the samples dedicated to structural speciation measurements and provide sufficient experimental data to develop reliable surface reactivity models able to describe the retention of the chosen radionuclides under a relatively large range of conditions.

Molecular scale speciation techniques (e.g., XANES, EXAFS) and microscopy will be employed to identify the oxidation state(s) as well as the structural environment (adsorption, precipitation - e.g. nanoparticles, location of the

surface complex - e.g. association with Fe) of the chosen radionuclides in the presence of above-mentioned mineral samples.

Additional experiments carried out with samples representative of host-rocks (compacted and intact argillaceous rocks), and in particular diffusion experiments, will enable to transfer the knowledge gained on isolated minerals to the characterization of the properties of actual materials present in radioactive waste repositories (including the mobility of the elements of interest in these materials).

The results and outputs of Task 3, including statements on future research needs, will be compiled in a final report (D5.7).

Participation per Partner

Partner number and short name	WP5 effort
1 - ANDRA	2.00
BRGM	30.50
5 - CEA	23.00
6 - CIEMAT	53.00
8 - CNRS	86.00
UGrenoble	31.00
UPoitiers	7.00
15 - JUELICH	31.00
HZDR	48.00
16 - GRS	10.40
24 - KIT	47.00
Uni Mainz	25.00
26 - MTA EK	21.00
34 - PSI	81.95
36 - RATEN	22.00
38 - SCK•CEN	12.25
42 - SÚRAO	1.00
ÚJV	31.00
44 - TNO	14.00
48 - UHelsinki	18.00
Total	595.10

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D5.1	FUTuRE - Initial State-of-the-art report on the understanding of	38 - SCK•CEN	Report	Public	6

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
	radionuclide retention in clay and crystalline rocks				
D5.2	FUTuRE - Updated State-of-the-art on the understanding of radionuclide retention in clay and crystalline rocks	38 - SCK•CEN	Report	Public	48
D5.3	FUTuRE - Related deliverable: D5.4 Training materials	15 - JUELICH	Report	Public	36
D5.4	FUTuRE - Final technical report on radionuclide mobility in compacted clay systems	34 - PSI	Report	Public	48
D5.5	FUTuRE - Final technical report on radionuclide mobility in crystalline systems	15 - JUELICH	Report	Public	48
D5.6	FUTuRE - Final report on reversibility of sorption	34 - PSI	Report	Public	48
D5.7	FUTuRE - Final technical report on redox reactivity of radionuclides on mineral surfaces	1 - ANDRA	Report	Public	48

Description of deliverables

D5.1 State-of-the-art report on the understanding of radionuclide retention in clay and crystalline rocks. Emphasis will be on the current available knowledge with respect to i) transferability of sorption phenomena to compacted/ realistic systems and sorption reversibility and, ii) surface induced (heterogeneous) redox processes. Lead: [SCK•CEN] Month 6

D5.2 State-of-the-art report on the understanding of radionuclide retention in clay and crystalline rocks. Emphasis will be on the current available knowledge with respect to i) transferability of sorption phenomena to compacted/ realistic systems and sorption reversibility and, ii) surface induced (heterogeneous) redox processes. Lead: [SCK•CEN] Month 48

D5.3 Training materials Lead: [JUELICH] Month 36)

D5.4 WP5-FUTuRE Final technical report on radionuclide mobility in compacted clay systems This deliverable will describe results and outputs of Task 2.1, including statements on future research needs Lead: [PSI] Month 48.

D5.5 WP5-FUTuRE Final technical report on radionuclide mobility in crystalline systems - This deliverable will describe results and outputs of Task 2.2, including statements on future research needs Lead: [JUELICH (HZDR)] Month 48

D5.6 WP5-FUTuRE Final report on reversibility of sorption - This deliverable will describe results and outputs of Task 2.3, including statements on future research needs Lead: [PSI] Month 48.

D5.7 WP5-FUTuRE Final technical report on redox reactivity of radionuclides on mineral surfaces - This deliverable will describe results and outputs of Task 3, including statements on future research needs Lead: [Andra (BRGM)] Month 48

D5.1 : FUTuRE - Initial State-of-the-art report on the understanding of radionuclide retention in clay and crystalline rocks [6]
 FUTuRE - Initial State-of-the-art report on the understanding of radionuclide retention in clay and crystalline rocks
 D5.2 : FUTuRE - Updated State-of-the-art on the understanding of radionuclide retention in clay and crystalline rocks [48]
 FUTuRE - Updated State-of-the-art on the understanding of radionuclide retention in clay and crystalline rocks
 D5.3 : FUTuRE - Related deliverable: D5.4 Training materials [36]
 FUTuRE - Related deliverable: D5.4 Training materials
 D5.4 : FUTuRE - Final technical report on radionuclide mobility in compacted clay systems [48]
 FUTuRE - Final technical report on radionuclide mobility in compacted clay systems
 D5.5 : FUTuRE - Final technical report on radionuclide mobility in crystalline systems [48]
 FUTuRE - Final technical report on radionuclide mobility in crystalline systems
 D5.6 : FUTuRE - Final report on reversibility of sorption [48]
 FUTuRE - Final report on reversibility of sorption
 D5.7 : FUTuRE - Final technical report on redox reactivity of radionuclides on mineral surfaces [48]
 FUTuRE - Final technical report on redox reactivity of radionuclides on mineral surfaces

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	EURAD Kick-off meeting (General Assembly n°1)	1 - ANDRA	1	EURAD Kick-off meeting (General Assembly n°1)
MS4	FUTuRE Kick-off meeting (WPM1)	15 - JUELICH	1	FUTuRE Kick-off meeting (WPM1)
MS12	EURAD EJP Newsletters	1 - ANDRA	3	EURAD EJP Newsletters (Due date : M3 and then every quarter)
MS27	SOTA from RD&D FUTuRE WP as input to UMAN T3.3	15 - JUELICH	6	SOTA from RD&D FUTuRE WP as input to UMAN T3.3
MS30	EURAD General Assembly n°2	1 - ANDRA	7	EURAD General Assembly n°2
MS42	EURAD Annual Work Plan 2	1 - ANDRA	9	EURAD Annual Work Plan 2
MS50	FUTuRE Report on set-up of experiments – Task 2.1	15 - JUELICH	10	FUTuRE Report on set-up of experiments – Task 2.1
MS51	FUTuRE Report on set-up of experiments – Task 2.2	15 - JUELICH	10	FUTuRE Report on set-up of experiments – Task 2.2
MS52	FUTuRE Report on set-up of experiments – Task 2.3	15 - JUELICH	10	FUTuRE Report on set-up of experiments – Task 2.3
MS53	FUTuRE Report on set-up of experiments – Task 3	15 - JUELICH	10	FUTuRE Report on set-up of experiments – Task 3
MS73	FUTuRE WPM2	15 - JUELICH	13	FUTuRE WPM2

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS81	EURAD General Assembly n°3 + EURAD Annual Meeting 1	1 - ANDRA	13	EURAD General Assembly n°3 + EURAD Annual Meeting 1
MS85	EURAD Periodic Report 1	1 - ANDRA	14	EURAD Periodic Report 1
MS103	EURAD General Assembly n°4	1 - ANDRA	19	EURAD General Assembly n°4
MS112	EURAD Annual Work Plan 3	1 - ANDRA	21	EURAD Annual Work Plan 3
MS131	FUTuRE WPM3	15 - JUELICH	25	FUTuRE WPM3
MS136	EURAD General Assembly n°5 + EURAD Annual Meeting 2	1 - ANDRA	25	EURAD General Assembly n°5 + EURAD Annual Meeting 2
MS140	EURAD Periodic Report 2	1 - ANDRA	26	EURAD Periodic Report 2
MS153	EURAD General Assembly n°6	1 - ANDRA	31	EURAD General Assembly n°6
MS162	EURAD Annual Work Plan 4	1 - ANDRA	33	EURAD Annual Work Plan 4
MS181	FUTuRE WPM4	15 - JUELICH	37	FUTuRE WPM4
MS185	EURAD General Assembly n°7 + EURAD Annual Meeting 3	1 - ANDRA	37	EURAD General Assembly n°7 + EURAD Annual Meeting 3
MS189	EURAD Periodic Report 3	1 - ANDRA	38	EURAD Periodic Report 3
MS199	EURAD General Assembly n°8	1 - ANDRA	43	EURAD General Assembly n°8
MS206	EURAD Annual Work Plan 5	1 - ANDRA	45	EURAD Annual Work Plan 5
MS215	FUTuRE WPM5	24 - KIT	48	FUTuRE WPM5
MS222	EURAD General Assembly n°9 + EURAD Annual Meeting 4	1 - ANDRA	49	EURAD General Assembly n°9 + EURAD Annual Meeting 4
MS224	EURAD Periodic Report 4	1 - ANDRA	50	EURAD Periodic Report 4
MS234	EURAD General Assembly n°10	1 - ANDRA	55	EURAD General Assembly n°10
MS240	EURAD General Assembly n°11 + EURAD Annual Meeting 5	1 - ANDRA	60	EURAD General Assembly n°11 + EURAD Annual Meeting 5
MS241	EURAD Periodic Report 5	1 - ANDRA	60	EURAD Periodic Report 5 (Due date: 60+2)

Work package number ⁹	WP6	Lead beneficiary ¹⁰	32 - ONDRAF/NIRAS
Work package title	Mechanistic understanding of gas transport in clay materials (GAS)		
Start month	1	End month	60

Objectives

Objectives

The main objectives of this WP are:

- To improve the mechanistic understanding of gas transport processes in natural and engineered clay materials, their couplings with the mechanical behaviour and their impact on the properties of these materials;
- To evaluate the gas transport regimes that can be active at the scale of a geological disposal system and their potential impact on barrier integrity and repository performance.

The programme of work will aim to provide results that are applicable to a wide range of National Programmes. This is possible because the results of previous efforts on the identification and characterisation of the possible gas transport processes suggest that the mechanisms at play in different clays are generally similar, while the conditions (gas pressure, stresses/deformations, saturation, ...) for the transition from one transport regime (diffusion, two-phase flow, pathway dilation and fracturing) to another strongly depend on the specific properties of a given clay material.

This WP will also aim to transfer knowledge gained from lab and in situ experiments to configurations that are commonly found in current repository designs, to address key questions from the end-users:

- How could gas migrate within the repository and which water soluble and volatile radionuclide transport could be associated with it?
- How and to what extent could the hydro-mechanical perturbations induced by gas effect barrier integrity and long-term repository performance?

This WP will build up heavily on the experience feedback and conclusions from the previous EC Project FORGE. The experimental investigation of gas transport in FORGE sometimes revealed complex mechanisms (e.g. such as the development of discrete, unstable pathways controlled by the mechanical behaviour of the porous media). However, it was also suggested that this complexity can be addressed as long as one can bound the effects of these mechanisms using simpler and robust descriptions for evaluation purposes. This WP will then aim at increasing the confidence in the overall understanding of gas behaviour in clay materials gained from the FORGE EC project and improving its integration in the conceptualisation process for the different components of a repository system. This should in turn support and justify the use of robust evaluation approaches and confirm the expert judgement at the end of FORGE that gas is not a show stopper for geological disposal but a question of managing uncertainties.

The WP is linked to EURAD Roadmap Theme 4 - Geoscience to understand rock properties, radionuclide transport and long-term geological evolution - phases 1-2.

Expected impacts

Regarding RWM implementation needs

- Provide input to implementers that may inspire design measures that further reduce the gas impact or the uncertainties associated with gas flow through geological disposal systems.
- Other impacts mentioned below also answer directly or indirectly RWM implementation needs.

Regarding safety

- Testing of various approaches for the treatment of gas in the safety case, identifying the inherent strengths and limitations of each approach and assessing its suitability in different contexts, as this may depend on the system that is being evaluated (host rock/design) or even the advancement of the (national) programme. Similarities of approaches between National Programmes will be identified and the rationale behind possible differences explained.
- Address the key questions that are common to all end-users, as per the second WP objective and confirm the insight from FORGE that gas is not a show-stopper for the Safety Case but a question of managing uncertainties.

Regarding increasing scientific and technical knowledge (beyond state-of-the-art) in the field of RWM

- Bridging the gap between experimentalists and modellers. Building on the lessons learned from FORGE, we do not propose a separate "modelling" (sub-)task. Modellers will be embedded with the experimentalists in subtasks of tasks 2 and 3 to encourage dialogue in the design of experiments and the development of shared conceptualisations of the observed behaviour.

- Building confidence in and extending the scientific bases on the fundamentals of gas transport in clay materials. Previous work suggests that the fundamental gas transport mechanisms that can develop in different clays are similar. Because a wide enough, but realistic, range of conditions will be explored for representative clay materials, this WP will provide data which will be of relevance for all disposal concepts that include clay barriers. Testing over a range

of conditions spanning low (diffusion) to high (advection) gas generation rates we will obtain a better understanding of processes which then has broader end-user appeal.

- Foster the transfer of knowledge between the scientific community (RE's) and the end-users (WMO's and TSO's), through the strong interactions between the three main tasks of this WP. Guidance by end-users will ensure that the experimental and model development work programme in tasks 2 and 3 remains focussed on materials and conditions that are of relevance. Scientists (RE's) will be asked to review the work performed in Task 4 to ensure that the evaluation of gas transport migration, its consequences and the treatment of residual uncertainties are consistent with the body of scientific knowledge.

Description of work and role of partners

WP6 - Mechanistic understanding of gas transport in clay materials (GAS) [Months: 1-60]

ONDRAF/NIRAS, ANDRA, BGE, CEA, CIEMAT, CNRS, COVRA, JUELICH, GRS, IRSN, KIT, LEI, NAGRA, PSI, RWM, SCK•CEN, SÚRAO, UHelsinki, UKRI

Description of work

Task 1 – S/T coordination, State-of-the-art and training material

Start: Month 1 – End: Month 60 - Task Leader: [ONDRAF/NIRAS]

Task Contributors: [IRSN] [NAGRA] [ONDRAF/NIRAS (ULiege)] [SCK•CEN] [UKRI-BGS]

Total PM: 10

Subtask 1.1 - S/T coordination

Start: Month 1 – End: Month 60 - Subtask Leader: [ONDRAF/NIRAS]

Total PM: 2

Given the objective of strong integration within this WP and the multiple interactions foreseen throughout the work programme defined in Tasks 2, 3 and 4, a scientific and technical coordinator [ONDRAF/NIRAS] will ensure that the R&D programme is going according to the plan, check coherency between actions and foster interactions between partners active in the different tasks. To facilitate a broad information exchange between tasks, the S/T coordinators and Task Leaders will organise 2 WP meetings (in workshop format) per year involving tasks 2, 3 and 4 together. Once a year, one of these meeting will be organised jointly with the WP HITEC, aligned with EURAD Annual meeting to minimise travel costs (i.e. Kick-off meeting month 1 + annual meeting months 13, 25, 37, 49, 60). The intermediate annual meeting, specific to the WP GAS, will be organised on months 8, 20, 32, 44, 56.

This scientific and technical WP Leader will then ensure interactions with other WPs among which HITEC, ACED, DONUT, UMAN and KM WPs, as well as the coordination of the production, cross-reviewing and edition of the GAS WP deliverables with the support of (sub)task leaders. These deliverables are:

- the initial (D6.1) and updated state of the art, SOTAs (D6.2) see subtask 1.2 below;
- three thematic technical reports, on gas transport and retention (D6.7), barrier integrity and conceptualisation (D6.8) and evaluation at the repository scale respectively (D6.9). The thematic reports will be drafted within the corresponding R&D tasks of the WP;
- a general introduction and conclusion will complement the three thematic reports so that these can be disseminated together at the end of the project as a coherent set of documents (D6.6).

The work performed in this WP and the results will be summarized in the three thematic reports that follow the same logic than WP organisation (respectively D6.2 related to Task 2, D6.3 related to Task 3 and D6.4 related to Task 4). Each thematic report will be coordinated by task and subtask leaders. Together with the peer-reviewed scientific papers that are expected be produced by (groups of) organisations involved in this WP, these thematic reports aim at providing reliable scientific/technical references about the knowledge produced in the GAS WP that can be of use to early stage and advanced programmes alike. The S/T WP Leader will also make sure that this collection of reports will be written so that it can be of use to the scientific community interested in gas transport through low-permeability geomaterials beyond the field of RWM.

At the end of the WP, a general workshop on “Mechanistic understanding of gas transport in clay-based materials” will be planned to facilitate the release of main findings of this WP within the whole scientific community and the end-user Lead organisation: [ONDRAF/NIRAS] month 56) (D6.5).

This subtask also includes the follow-up of interactions with other RD&D WPs and the KM WP.

List of WP meetings and Workshops:

Kick-off GAS WP Meeting (WPM1) month 1

GAS WP Meeting (WPM 2) month 7

GAS WP Meeting (WPM 3) jointly organised with the WP HITEC month 13

ACED - GAS - DONUT Joint Workshop month 13 - 18

GAS WP Meeting (WPM 4) month 19

GAS WP Meeting (WPM 5) jointly organised with the WP HITEC month 25

GAS WP Meeting (WPM6) month 31

ACED - GAS - DONUT Joint Workshop month 30 -37

GAS WP Meeting (WPM 7) jointly organised with the WP HITEC month 37

GAS WP Meeting (WPM 8) month 43

GAS WP Meeting (WPM 9) month 49

GAS WP Meeting (WPM 10) month 56

Workshop on “Mechanistic understanding of gas transport in clay-based materials” (Month 56)

Subtask 1.2 - State-of-the-art reporting

Start: Month 1 – End: Month 60 - Subtask Leader: [ONDRAF/NIRAS]

Subtask contributors: [UKRI-BGS] [SCK•CEN] [NAGRA] [IRSN] [ONDRAF/NIRAS]

Total PM: 6

In the early stage of the WP, a state-of-the-art (SOTA) report on gas transport through clay materials (D6.1) will be produced including:

- a synthesis of the state of knowledge on gas transport through clay materials based mainly on current descriptions of diffusive and advective gas transports through clay materials as well as current descriptions of gas-induced impacts on barrier integrity (including self-sealing processes);
- An overview of the current conceptualisations of gas migration through geological disposal systems and related processes and an overview of the current modelling approaches, as used in the context of the safety case.

Not only current knowledge, but also key uncertainties and how these are currently treated will be presented. The reference material for drafting this overview document will come from National Programmes, previous EC projects (FORGE EC project in particular), other international projects (NEA, IAEA) and general scientific references (not limited to the world of RWM).

The aim of this initial SOTA is to give a general overview of the state-of-knowledge with respect to main WP R&D topics, with sufficient context so that it can be of use to a lay audience (with limited technical background), early stage programmes and R&D managers. The SOTA will also provide a baseline against which WP progress can be measured. This requires the pursuit of consensus from all partners (or identification of divergences) about the(ir) current understanding(s) of the key issues and may require some time for internal review (e.g., to make sure that key scientific issues and aspects of the treatment of gas in a Safety Case are unequivocally understood in the same way by all, or to record and explain differences of views, if any). This is why the proposed target date for delivery of the reviewed deliverable is month 18.

In the final stage of the WP, the state-of-the-art report (D6.2) will be updated integrating the key findings of the R&D tasks in this WP and relevant finding from other WP's. The main objective will be to put in evidence the significance of the findings of tasks 2 and 3 on the phenomenological descriptions of gas transport in clay materials and at repository scale and evaluate the consequences of these findings on the conceptualisation of gas migration through geological disposal systems (task 4).

Subtask 1.3 – Training materials

Start: Month 1 – End: Month 60 - Subtask Leader: [SCK•CEN] and [ONDRAF/NIRAS (ULiège)]

Subtask contributors: [SCK•CEN] and [ONDRAF/NIRAS (ULiège)]

Total PM: 2

Two training workshops (in the format of a doctoral schools) will be organised jointly with the WP on “Influence of temperature on clay-based material behaviour” (HITEC), as the target audiences are similar and the lecturers are likely to be involved in both WP's (D6.3 and D6.4). WP's will propose lectures and tutors on geomechanics and multi-physical coupling. Courses will integrate main WP's results on thermo-hydromechanical behaviour of clayey materials and on gas transport through clayey materials at this stage of the WP. The courses will highlight the consequences of thermal and gas-induced hydro-mechanical perturbations on barrier integrity and long-term performance.

More practically, the 1st school will be organised at the beginning of the WP (Lead organisation: [ONDRAF/NIRAS (ULiège)] month 6) in close link with Training/Mobility KM WP. The topic will be on multi-physical coupling in geomechanics (especially THM and Gas coupling issues). The objective will be to draw a state-of-knowledge on the fundamentals of these couplings at the beginning of the WP. The 2nd school will be organised at the end of the HITEC WP (during the 4th year). The objective will be to highlight the main results of EURAD-1 on THM and Gas issues with respect to the knowledge on multi-physical coupling in geomechanics and their applications.

Task 2 - Transport Mechanisms

Start: Month 1 – End: Month 60 - Task Leader: [SCK•CEN]

Task Contributors: [BGE] [CIEMAT (UPC)] [CNRS-SUBATECH (UGrenoble) (ULorraine) (UPoitiers)] [COVRA (TU Delft)] [IRSN] [KIT (BGR)] [ONDRAF/NIRAS (ULiege)] [PSI] [SÚRAO (CTU) (UJV)] [SCK•CEN] [UKRI-BGS]
Total PM : 364,5

Task Objectives:

Task 2 “Transport mechanisms” focusses on the main gas transport mechanisms which will take place in a disposal system in the post-closure phase. Different mechanisms are generally expected to be of importance in a geological repository:

- Gas produced within the system can dissolve in the pore water and can then be transported by diffusion. The diffusion of dissolved gas may be retarded by physio-sorption on the solid phase. Improving the mechanistic understanding of diffusive transport of dissolved gas and retention mechanisms will be the general objective of Subtask 2.1 “Gas diffusion and retardation processes at high level of water saturation”.
- If the gas production rate exceeds the rate at which gas can be dissolved and evacuated by diffusion, a free gas phase will develop. As gas pressure increases, advective transport will occur. Two primary modes for advective gas transport are proposed; (i) visco-capillary flow and (ii) the formation of discrete gas-filled pathways. Exploring which transport mechanisms prevail under which range of conditions and understanding how the coupling between pressure in the liquid and gas phase are the stresses in the solid phase control gas transport will be a general objective of Subtask 2.2 “Advection (displacement vs. dilation)”.

Specific objectives of Subtask 2.1 “Gas diffusion and retardation processes at high level of water saturation”: in order to compare the rates of gas generation and gas evacuation by dissolution and diffusion, knowledge of the diffusion parameters of dissolved gas through the used materials is essential. Up to now, diffusion parameters are available essentially in water saturated systems. As partial desaturation might occur at some point during the repository evolution, this WP will extend the available experimental data for gas diffusion to partially desaturated conditions. In line with the general objective to improve mechanistic understanding, interpretation of the experimental results will be supported by pore network modelling. The experimental and modelling work programme aims in particular to investigate how petrophysical parameters (e.g. mineralogy and density) and the stress state influence the diffusion parameters.

While diffusing through the pore water, dissolved gas might also interact with the barrier materials. Up to now, interactions (mainly gas sorption) have only been studied under dry conditions. In particular, hydrogen uptake due to sorption processes has only been studied under dry condition. One objective of this subtask is to determine if gas sorption could be a relevant retardation mechanism for diffusive transport under repository conditions, in clays that are partially or fully saturated with pore water. Again, the impacts of the pore network morphologies and the nature of the mineral assemblages on the gas sorption mechanisms will be investigated.

Key objectives of sub-task 2.1 are thus:

- 1) to determine gas diffusion parameters on different clayey materials at different degrees of water saturation and support experimental data interpretation by pore network modelling, and
- 2) to understand gas physisorption mechanisms in microporous systems.

The gas of interest in this task is chiefly H₂, but other apolar gases such as CH₄ (by-product of bacterial activity), He, Ar (naturally occurring noble gases) and Ne (H₂ proxy) will be also investigated in order to i) avoid artefacts related to bacterial activity triggered by H₂, ii) overcome safety problem especially in underground laboratories, and iii) probe the effect of polarizability and kinetic diameter on apolar gases mobility in porous networks.

Specific objectives of Subtask 2.2 “Advection (displacement vs. dilation)”: From previous work (including work done in the previous EC project FORGE), two primary modes for advective gas transport through natural mudrocks are proposed; (i) visco-capillary flow, where capillary forces must be overridden in order to allow displacement of the wetting phase, by migrating gas and (ii) the formation of discrete gas-filled pathways, by localised consolidation of the clay matrix. The potential for one specific mechanism to prevail is dependent on a range of factors, including the saturation state of the clay and the ratio of the clay to sand fraction. Natural heterogeneity within clay-hosted repositories may also play an important role in the migration of gas and the mitigation of peak gas pressure. For fully-saturated, pure clay bentonite materials, such as those used in engineered barriers, experimental evidence indicates that gas flow by pathway dilation is the preferred mode of transport. In such cases, significant hydromechanical coupling is observed, which cannot be satisfactorily explained by visco-capillary flow processes. This hydromechanical coupling between the immiscible phase, the interstitial fluid, and the total stress, remains unclear. Understanding these relationships, how they vary from one formation to another, and what impact, if any, they have on the integrity of the host rock, is now a priority research issue.

Through new experimental studies, this subtask aims to:

1) Provide reference data for various natural and engineered clay materials under a sufficiently broad range of conditions, which will make it possible to investigate in a more systematic way how petrophysical parameters, like mineralogy or density, and conditions such as the stress state influence free gas transport.

2) Improve understanding of the observed gas transport modes and identifying their main controls, through interpretation of the experimental results by models in which the representation of crack propagation and pathway dilatancy is implemented at a process level.

3) Conceptualisations of the transport mechanisms limited to the macro-scale (continuum representation + discrete conducting features) such as those developed, for instance, in the FORGE EC project will be compared to conceptualisations in which the micro-scale is also represented to better improve understanding of how micro-level heterogeneities and deformations affect macro properties.

The experimental and modelling programmes of the subtask 2.2 aim at characterising and understanding advective gas transport in fully saturated (or close to saturation) clayey materials. For bentonite, it will benefit from the results of the BEACON EC project that characterises the hydro-mechanical coupling of swelling clay materials during resaturation phase. For bentonite barriers, BEACON EC project, this WP and the HITEC WP are complementary as these together support the global description of hydro-mechanical processes from the installation of materials to their evolution over the long term (including the thermal phase in the case of heat-emitting waste) and the consequences of gas flow. The integration of knowledge will be facilitated by involvement in this subtask of the GAS WP of some BEACON and HITEC WP partners.

Subtask 2.1 – Diffusion and retardation

Start: Month 1 – End: Month 60 - Subtask Leader: [CNRS-SUBATECH (UGrenoble)]

Subtask contributors: [SCK•CEN] [PSI] [UKRI-BGS] [IRSN] [CNRS-SUBATECH (UGrenoble)]

Total PM: 137,1

Subtask 2.1 will focus on diffusion and gas adsorption experiments. Both will be supported by modelling activities.

- [SCK•CEN] and [PSI] will perform diffusion experiments on Boom Clay, Opalinus Clay and sand/bentonite mixtures and the experimental results will be supported by pore network modelling. Experiments will be carried out at different degrees of saturation, with different gases. This will allow determining how the effective diffusion coefficient is influenced by desaturation. By using lattice-Boltzmann modelling, the gas partitioning in pores of different sizes will be estimated. The proposed work plan is complementary to that of IRSN and collaboration will be considered.

- [UKRI-BGS] will perform and model experiments on clay simulants to investigate the impact of mineralogy on the diffusion coefficient. A series of tests will be performed providing reference values for different mineral combinations, yielding data of interest to multiple end-users.

- [IRSN] will use various techniques (gas absorption, micro, nano tomo RX, FIB) to characterize the pore network of different clay materials (Toarcian, Callovo-Oxfordian argillite, Opalinus Clay) and use this data to build synthetic pore network models that will allow to theoretically determine the effective diffusion coefficients as function of the water saturation. These values can be tested against those determined in the diffusion experiments by [SCK•CEN] [PSI] and [BGS].

- [CNRS-SUBATECH (UGrenoble)] will study hydrogen uptake in microporous systems (pure clay phases and various claystones). [CNRS-SUBATECH (UGrenoble)] will perform H₂ sorption isotherms over a wide range of pressure to study retention mechanisms and fundamental thermodynamic properties of the retention process and will also study the desorption processes to clearly evaluate hydrogen mobility and retardation mechanisms in clay-rich porous media. [CNRS-SUBATECH] will perform computational atomistic modelling to investigate the molecular mechanisms of gas sorption in clay-based materials with further extension to a mesoscale and multiscale modelling. [CNRS-SUBATECH (UGrenoble)] will work cooperatively to characterize the nanoporous structure properties and its effect on H₂ sorption (IR/Raman spectroscopy, X-Ray diffraction, QENS, etc.).

- In addition, [SCK•CEN] will perform an in-situ diffusion experiment in the Boom Clay. Results that will be available during the time span of this WP will be communicated to the organisations involved in this subtask. This is a contribution in kind.

Subtask 2.2 – Advection (displacement versus dilatant gas flow)

Start: Month 1 – End: Month 60 – Subtask Leader: [UKRI-BGS]

Subtask contributors: [CNRS (ULorraine) (UPoitiers)] [SÚRAO (CTU) (UJV)] [ONDRAF/NIRAS (ULiège)] [IRSN] [COVRA (TU Delft)] [CIEMAT (UPC)] [BGE] [JUELICH (UFZ)] [KIT (BGR)] [UKRI-BGS] [SCK•CEN]

Total PM: 227,4

The focus of this subtask is to determine if visco-capillary, dilatant flow or a combination of the two apply in clay-rich materials. The subtask is split into integrated components (laboratory/field and numeric) for which new experimental studies provide reference data to guide and validate numerical modelling.

Laboratory and field activities:

- [UKRI-BGS] will perform experiments to help identify the governing processes (displacement or dilation) for natural and engineered materials of interest to different European programmes. Additional tests will be performed on simulant materials to explore the dependency of transport mechanisms to petro-physical properties, which are of interest to Member-States that have not selected a particular clay-based host rock or EBS material. Pathway imaging techniques will also be used. Finally, observations will also be up-scaled to include in-situ measurements of gas migration at a repository-relevant scale using the Lasgit facility at the Äspö URL managed by SKB.
- [CNRS (UPoitiers)] will characterise gas propagation through Callovo-Oxfordian claystone using X-ray tomography at macro-scale and TEM on MMA-impregnated post-mortem samples for the micro-scale. Tests will cover range of gas injection pressures corresponding to the different stages of gas migration. 2D maps of the sample microstructure at several stages will allow exhibiting the changes of micro-structure of the claystone upon gas migration. The role of mineralogical heterogeneities (e.g., pyritic filaments and/or thin bedding laminations of non-clay minerals in clay rocks) will be also investigated.
- [CIEMAT] will focus on gas migration testing of EBS buffer material. The range of actual conditions (gas pressure, stress/deformation, saturation) at which each gas transport regime occurs will be determined for the Spanish EBS material, used as a representative reference material. This is expected to yield new knowledge about the mechanisms that control these transport regimes in engineered but also natural clay materials at low suctions (close to saturation, representative of long term conditions).
- [SÚRAO (CTU) (UJV)] will directly measure hydrogen migration at slow pressurization rates in the Czech Ca-Mg bentonite, complementing work by other Teams.

In addition, [SCK•CEN] will perform long-term, slow gas injection tests in the lab under well-controlled mechanical conditions to investigate the transition from the diffusive to the advective transport regimes. This is a contribution in kind. The proposed setup will be communicated to organisations active in Task 2 for review and the results will be made available to this WP.

Numerical modelling activities:

- [ONDRAF/NIRAS (ULiège)] will develop a Micro-Macro model (FE² method, Finite Element Method combining macro and micro-scale models) to take explicitly into account the presence of bedding planes and pore network morphologies at the micro-level. The objective is to predict at micro-level the deformations of these heterogeneities and to evaluate the impact on macro properties.
- [CNRS (ULorraine)] and [IRSN] will conduct numerical simulations of multiphase fluid transport through deformable nanoporous geomaterials. CNRS-Georessources will follow a digital rock physics approach based on FIB-SEM images of actual material, using a lattice-Boltzmann model. Numerical results will be used to upscale effective properties (deformation-dependent saturation curve, relative permeability). [IRSN] will extend its SPH code capable of simulating dilatancy flow by adding an appropriate damage model and improving the representation of water transfer via the gas phase (evaporation, vapour diffusion).
- [COVRA (TU Delft)] [CIEMAT (UPC)] [KIT (BGR)] [BGE] [JUELICH (UFZ)] will test conceptual models at the macro-scale against results from selected laboratory and field experiments. [COVRA (TU Delft)] and [CIEMAT (UPC)] will numerically investigate the effects of natural heterogeneities of material parameters and uncertainties on these parameters through the use of random and auto-correlated spatial distributions of certain material properties or model parameters. [KIT (BGR)] will collaborate with [BGE] & [JUELICH (UFZ)] and will test different continuum model approaches to describe the induced permeability change benchmarked against data from in situ gas injection experiments in saturated claystone (Mont Terri Rock Laboratory) and compacted bentonite Mx-80 (DECOVALEX) under high gas injection pressure.

Task 3 - Barrier Integrity

Start: Month 1 – End: Month 60 - Task Leader: [NAGRA]

Task Contributors: [Andra] [BGE] [CEA (EDF)] [CIEMAT (UPC)] [CNRS (ULorraine) (Upoitiers)] [COVRA (TU Delft)] [JUELICH (UFZ)] [GRS] [IRSN] [KIT (BGR)] [NAGRA (CIMNE) (EPFL) (ZHAW)] [ONDRAF/NIRAS (ULiège)] [SÚRAO (CTU)] [UKRI-BGS]

Total PM: 236,8

Task Objectives

Accumulation of gas in the back-filled structures of a deep geological repository associated with the build-up of excessive gas pressures may impair the long-term safety functions of the repository's multi-barrier system, namely the radionuclide retention and attenuation capacity of the engineered barrier system (EBS) and the geological barriers. Clay-rich rocks and clay-based EBS are particularly prone to failure due to their low mechanical strength. On the other hand, it is well known that clays exhibit the favourable feature to self-seal after sustaining mechanical failure. Task 3 is aimed at gaining a mechanistic understanding of the hydro-mechanical phenomena and processes, associated with:

- the gas-induced failure of clay barriers, i.e. within the engineered barrier system (EBS), within the Excavation Damage Zone (EDZ) and within the host rock (Subtask 3.1);
- the effectiveness of self-sealing processes along gas-induced pathways in the clay barriers of a geological repository (Subtask 3.2).

The evaluation of achievements is accomplished by model-supported data analyses, predictive modelling and the application of the newly developed modelling tool on in-situ experiments (Subtask 3.3).

As mentioned in Task 2, after the FORGE EC project, the hydromechanical coupling between the gas phase, the interstitial fluid, and the total stress, are still a priority research issue. For bentonite barriers the task will benefit from the BEACON EC project that characterises the hydro-mechanical coupling of swelling clay materials during the resaturation phase. This transfer of knowledge will be facilitated by involvement in this task of some BEACON partners.

Subtask 3.1 - Gas-induced impacts on barrier integrity

Start: Month 1 – End: Month 60 – Subtask Leader: [NAGRA]

Subtask contributors: [Andra] [CNRS (ULorraine) (Upoitiers)] [GRS] [IRSN] [NAGRA (CIMNE) (EPFL) (ZHAW)] [SÚRAO (CTU)] [UKRI-BGS]

Total PM: 84,4

Laboratory experiments will be designed and executed, aimed at investigating the evolution of damage in clay-rich geomaterials when subjected to excessive water / gas pressures. Different test set-ups and different test procedures will be required for the investigation of argillaceous rock and EBS material, respectively.

Host rock material (including Boom Clay, Callovo-Oxfordian argillite, Opalinus Clay, Lower Cretaceous Marls of Northern Germany)

Fracture initiation and fracture propagation processes in the intact host rock and fracture reactivation in the Excavation Damaged Zone (EDZ) as well as the reactivation of tectonic features depend on the rock fabric and on the prevailing in situ conditions (pore pressure and stress). Fracture opening and fracture sliding mechanisms will be investigated along typical stress paths, which are representative for real repository conditions.

- [NAGRA (CIMNE)] and [GRS] will perform hydro-mechanical laboratory experiments on rock samples, covering the above mentioned classes of host rocks. The test set-ups ensure the precise control of water/gas flow, pore pressure / total suction, stress state and strains during all test stages (isostatic/triaxial cells). The impact of texture and tectonic overprint on gas-induced damage evolution will be addressed by testing the rock samples parallel, perpendicular and at oblique angles to the principal orientations of micro-fabric, respectively.

- Further phenomenological experiments will be conducted by [UKRI-BGS] and [CNRS (UPoitiers) (ULorraine)]. [UKRI-BGS] will use a direct shear rig for water/gas injection experiments. Shear fractures will be created within the apparatus while tensile fractures will be created externally. Quantitative textural information of all fracture surfaces will be determined prior, and after, detailed gas testing. [CNRS (ULorraine)] will visualise gas transport processes in a permeameter cell which is transparent to X-rays. Thus, it is possible to follow the evolution of damage and self-sealing processes in the sample during gas injection and after shut-in using a high-resolution X-ray CT scanner. [CNRS (UPoitiers)] will provide additional capacities for microstructural analyses, including post-mortem TEM on MMA resin impregnated samples.

Buffer materials (including compacted granular bentonite, bentonite blocks, sand/bentonite mixtures)

[NAGRA (EPFL)] [IRSN] and [SÚRAO (CTU)] will conduct long-term water/gas injection tests in oedometric/isostatic cells to investigate pathway dilation and particle mobilization. The laboratory experiments shall reveal the impact of the as-compacted state (e.g., dry density, grain size distribution, initial water content) and the hydration process (e.g., imbibition process, water chemistry) on the gas breakthrough pressure of the hydrated material and on the fraction of mobilized bentonite.

Microstructural analyses of the investigated geomaterials (damaged or intact host rocks and EBS materials, respectively) before and after gas injection will be conducted with the support of [NAGRA (ZHAW)] to get insight in the prevailing failure mechanisms. This includes the evaluation of apertures, extensions and surface roughness of the induced fractures and statistical descriptions of the pore networks of the intact and of the damaged material.

Complementary activities by [NAGRA] and [Andra] in Task 3.1 comprise desk studies and the compilation of experimental data bases on gas induced rock failure from in-situ experiments in URLs (Bure, Mont Terri). Thus, a review of gas-related FEPs will be conducted as an initial action in the context of the State-of-the-art report (see Task 3.3) to address further detrimental effects associated with gas transport. The outcome of the FEP screening may lead to complementary experimental investigations in the later stages of the WP.

Subtask 3.2 – Pathway closure and sealing processes

Start: Month 1 – End: Month 60 - Subtask Leader: [Andra]

Subtask contributors: [Andra] [CNRS (ULorraine)] [GRS] [NAGRA (CIMNE) (ZHAW) (EPFL)] [SÚRAO (CTU)] [UKRI-BGS]

Total PM: 72

From a mechanistic point of view, the self-sealing capacity of clay-bearing materials is associated with various (thermo-)hydro-mechanical and –chemical processes and controlled by the prevailing state conditions. Mechanical closure of fractures (e.g., crack closure, fracture sliding), hydro-chemical interactions of the pore water with the clay-bearing solid phase of the geomaterial (e.g., swelling, dis-aggregation) and colloidal transport processes (e.g. sedimentation, clogging) have been identified as typical self-sealing mechanisms in clay-rich materials. In this context, it is important to consider also phenomena and processes that could prevent fracture closure, such as mineral transformations and hydromechanical reorganizations of the rock fabric caused by gas seepage through the clay barriers over long time periods of several 10'000 years.

- [NAGRA (CIMNE) (EPFL)] [GRS] [SÚRAO (CTU)] will investigate the self-sealing capacity of the tested geomaterials essentially with the same test configurations as used for the gas injection experiments. After termination of the gas injection experiments, the test specimen will be subjected to different pressure recovery conditions including re-saturation with different water compositions and different total stress scenarios. Subsequently, final water permeability testing will be conducted to qualify the loss of hydraulic barrier function of the test specimen. Different host rocks and different fracture modes will be addressed. Visualisation techniques such as micro-CT, SEM, and possibly others provided with the support of [NAGRA (ZHAW)] will allow revealing the microstructural changes of the investigated test samples at the end of the self-sealing stage.
- The phenomenological gas injection experiments by [UKRI-BGS] and [CNRS (UPoitiers) (ULorraine)] will also be extended beyond the shut-in phase to visualise at pore scale the complex HM-C interactions, which are associated with the self-sealing process.
- [Andra] and [NAGRA] will take responsibility for the desk studies (review of gas related FEPs, SOTA report) and the compilation of experimental data bases on large-scale self-sealing experiments in URLs (Bure: CDZ, GER; Mont Terri: FS-C).

The self-sealing studies of this subtask are closely connected to the ones planned in the subtask 2.1 of the HITEC WP ("Clay host rock" task – "Experiment near field with EDZ" subtask). The aim of these tasks in these two WPs will be to characterise (T)HM(-C)(+gas) processes associated to self-sealing mechanisms in clays. Hence, tests will be performed jointly during the duration of the WP under various thermal and chemical conditions to provide a complete characterisation of self-sealing processes in clays. To facilitate a broad information exchange between the two WPs on these aspects, joint workshops will be organised each year until the end of the HITEC WP (months 13, 25, 37).

Subtask 3.3 – Model-based interpretation and synthesis of results

Start: Month 1 – End: Month 60 - Sub-task Leader: [JUELICH (UFZ)]

Subtask contributors: [NAGRA (CIMNE) (EPFL)] [CIEMAT (UPC)] [CNRS (UPoitiers)] [CEA (EDF)] [ONDRAF/NIRAS (ULiège)] [COVRA (TU Delft)] [BGE] [KIT (BGR)] [Andra] [JUELICH (UFZ)]

Total PM: 80,3

Subtask 3.3 is dedicated to the interpretation of the experimental results and the synthesis of the scientific achievements (development of process models for pathway dilation and self-sealing). Furthermore, the scientific coordination of the subtasks and the exchange with Tasks 2 and 4 will be accomplished with the support of the S/T WP Leader.

[JUELICH (UFZ)] [Andra] and [NAGRA] will survey the state of knowledge by participating to the state-of-the-art report and the compilation of comprehensive experimental databases from previous research programmes (e.g.; NEA/ Clay Club Initiatives on "Gas" and on "Self-sealing"; EU FP7-FORGE). Drawing on the input from Tasks 3.1 & 3.2, UFZ will coordinate the elaboration of an experimental design report, which includes a detailed description of the experimental set-ups and test procedures and a revised version of the detailed work programme of Tasks 3.1, 3.2 and 3.3. The modelling teams [NAGRA (CIMNE) (EPFL)] [CIEMAT (UPC)] [COVRA (TU Delft)] [ONDRAF/NIRAS (ULiège)] [CNRS (UPoitiers)] [CEA (EDF)] and [BGE] [KIT (BGR)] and [JUELICH (UFZ)] will contribute to the experimental design of the laboratory experiments and the model-based interpretation of the acquired experimental results. Back analysis of the experiments will feed in the development of conceptual process models of gas-induced damage evolution and self-sealing processes for damaged or intact host rocks and EBS materials, respectively. Validation of these models will take place in a series of prediction-evaluation exercises, covering different loading paths in different geometric configurations (host rocks: isostatic / triaxial; EBS material: oedometric / isostatic). Eventually, the validated process models will be applied for the back-analysis of selected in-situ experiments in URLs.

In the final stage of the WP, a synthesis of the experimental achievements will be accomplished as part of the final task reporting. The execution of the 3 subtasks will be conducted in close cooperation with Tasks 2 and 4. This will ensure a consistent and balanced appraisal, which is in line with the overall objectives of the WP.

Task 4 - Repository performance aspects

Start: Month 1 – End: Month 60 - Task Leader: [Andra]

Task Contributors: [Andra] [CEA (EDF)] [COVRA (TU Delft)] [IRSN] [KIT (BGR)] [LEI] [NAGRA] [ONDRAF/NIRAS (ULiege)] [RWM] [SCK•CEN] [UHelsinki (Aalto University)]

PM : 70,5

Task objectives

This task aims at fulfilling the second high-level objective of the WP, which is to evaluate the gas transport regimes that can be active at the scale of a geological disposal system and their potential impact on repository performance. It is dedicated in particular to end-users questions concerning:

- the effects of the presence of gas and its transport on the transfer of soluble and volatile radionuclides;
- the consequences of gas-induced hydro-mechanical perturbations on barrier integrity and long-term performance.

From past evaluations it is known that gas generated by corrosion and/or radiolysis in large quantities may result in the development of a gas phase within the existing porosity of the engineered barrier system (EBS), within the Excavation Damaged Zone (EDZ) and, to some extent, within the host rock. Experimental evidence suggests that discrete, transient, gas-specific pathways may also form through (or between) EBS materials, the EDZ and the host rock in the form of sub-critical (pathway dilation) or supercritical (fracturing) cracks. The transient nature of such phenomena is to be emphasized. Desaturation can have a significant effect on soluble radionuclide migration: it may limit the extent of diffusion of soluble radionuclides but may also result in advective transport of radionuclides, if groundwater is displaced one way or another by gas as a consequence of pressurization or suction. High levels of desaturation may even affect the gas source term by decreasing the availability of water for gas production processes. Continuous gas pathways, possibly evolving and unstable, may form from the deposition zones to the repository access. These would affect the migration of volatile radionuclides. Finally, high gas pressures may possibly result in mechanical damage to the engineered and natural barriers, including the host rock, and could affect the global functioning of the repository. It is important to assess if this could occur in practice and if such damage would be transient only or would have a lasting effect and how this would affect (or not) the outcome of a safety case.

Task 4 will build and improve from the EC project FORGE, which ran from 2008-2013, in several ways, by:

- including in the analysis hydro-mechanical couplings;
- including in the analysis the transfer of soluble and volatile radionuclides;
- promoting the use of multiple assessment approaches, supported by different numerical modelling tools;
- being driven from an end-user perspective of gas induced effects.

This task will also benefit from recent advances in phenomenological understanding from the CAST (CARbon-14 source term and fate) and BEACON (bentonite mechanical evolution) EC projects allowing respectively (i) a better understanding of potential release mechanisms of carbon-14 (in the form of methane for instance) from radioactive waste materials under conditions relevant to geological disposal facilities and (ii) a better characterisation of hydro-mechanical coupling in swelling clayey materials (from the installation of materials to their evolution over the long term).

Task 4 will be mainly end-users oriented. Based on the input from tasks 2 and 3 of this WP and relevant input from other WPs in EURAD-1, the objective of subtask 4.1 will be to assemble phenomenological descriptions of gas transport and its likely consequences on barrier integrity and radionuclide transfer at repository relevant scale, in the form of storyboards. The resulting conceptualisations of gas transport and of its possible consequences for typical repository configurations in clayey host rocks will be passed on to subtask 4.2, which will be dedicated to the assessment of different approaches and tools (e.g. numerical modelling) that can be used for evaluating the effect of gas on repository performance.

To ensure seamless communication between the conceptualization group (subtask 4.1) and the evaluation/modelling group (subtask 4.2), the task 4 leader and the two subtask leaders will be jointly responsible for the coordination of actions and the synthesis of the results.

Subtask 4.1 – Conceptualization of gas migration at repository scale

Start: Month 1 – End: Month 60 - Subtask Leader: [RWM]

Subtask contributors: [Andra] [COVRA] [IRSN] [NAGRA] [ONDRAF/NIRAS] [RWM]

Total PM: 18,3

Sub-task 4.1 will be system oriented and will be carried out by end-users (i.e. WMO and TSO). REs will be involved through reviews of this work in Tasks 2 and 3 to ensure that good use is made of available scientific knowledge.

Current conceptualizations of gas migration through clay-rich host rock geological disposal systems and tools used for describing gas transport and its consequences at repository scale (e.g. numerical modelling) will be compiled and compared by the end-users partners involved [RWM] [Andra] [COVRA] [IRSN] [NAGRA] [ONDRAF/NIRAS] to highlight in particular:

- the gas transport processes and related processes considered as relevant at repository scale by each organization, shedding light on the similarities and differences between National Programmes;

- the key properties and conditions assumed to control these processes;
- the expected effects of gas on host rock, groundwater, radionuclide transfer and barrier integrity;
- the different modelling approaches that can be used to evaluate gas transport and related aspects (e.g. fully coupled at repository scale, lumping/homogenization, compartment modelling, ...), how these are related to the storyboards and the rationale for using one or another approach.

The storyboards/conceptualizations describing gas transport through typical repositories and its impact on system components will be phenomenologically-based. Special attention will be given to explain how the conceptualizations have been derived from the available scientific bases (references to experimental data, prioritization of processes for instance). First conceptualizations will be produced early on in the course of the WP (by Month 12) and will be reviewed by the participants to Tasks 2 and 3 to (i) check that repository-scale concepts are consistent with the scientific bases and, (ii) to inform the experimentalists / process-level modellers about the configurations and ranges of conditions that are relevant for repositories. An interaction will be organised at this stage (around Months 13 - 18) with the WP ACED, which also develops storyboards (of the chemical evolution of a disposal cell) to exchange information and ensure consistency.

This first conceptualization phase will be completed (by Month 12) by the definition of (i) a generic repository configuration and sets of properties and conditions on which sub-task 4.2 will test various evaluation approaches and (ii) a proposal for a set of indicators, covering the range of needs of various end-user in Europe for clay-based host rock repository, representative of the processes to be evaluated (transfer of RN, volatile and soluble, barrier integrity for instance). An interaction will also be organised at this stage with WP DONUT (between Months 13 – 18) to identify possible benchmark studies for DONUT and to exchange on numerical challenges and abstraction methodologies.

In a second phase, the focus will shift to the integration and understanding of the significance of the findings of Task 2 “Transport Mechanisms” and Task 3 “Barrier integrity” during the course of the WP. The phenomenological description improvements will be evaluated for transfer to the repository scale via updates to the storyboards. Uncertainties about which gas transport modes will effectively be active or about other gas-related aspects of the evolution of the system will be identified and evaluated in terms of possible scenarios to be investigated. Additional indicators may be proposed. These conceptualisation updates and alternative scenarios will be passed on to subtask 4.2 as input for the assessment of gas induced effects.

This integration task will imply strong interactions between the Task 4 and other tasks of the WP to ease the transfer of concepts from laboratory experiments and process-level models to the relevant configurations and scales. Interactions will also be organized again with other WP’s in order to take into account or provide input that can be relevant and/or appropriate (e.g. with the modelling WP DONUT and the chemical evolution assessment WPACED around Month 30 - 37, via a joint workshop focused on intermediate results of benchmark studies, numerical developments, and the application of abstraction methodologies). Along the course of this subtask, interactions will also be organised with the UMAN Strategic Study on understanding of uncertainty, risk and safety on the basis of the contribution of this subtask to the SOTAs (see below). These interactions will focus on the identification, characterization, potential significance and treatment of uncertainties in the abstraction process for gas transport (e.g. propagation of parameter uncertainties, scenario uncertainties...) and the evaluation of their consequences.

Subtask 4.2 – Model assisted assessment of gas induced effects

Start: Month 9– End: Month 60 - Subtask Leader: [IRSN]

Subtask contributors: [Andra] [CEA (EDF)] [COVRA (TU Delft)] [IRSN] [KIT (BGR)] [LEI] [ONDRAF/NIRAS (ULiège)] [SCK•CEN] [UHelsinki (Aalto University)]

Total PM: 52,2

Building on the storyboards, the definition of a generic repository and sets of properties and conditions, indicators and scenarios proposed in subtask 4.1, different approaches will be assessed to numerically describe disposal system behaviour in response to gas accumulation and pressure build-up. This assessment will compare:

- the use of coupled high-resolution models taking into account the full complexity at repository scale of gas related process understanding towards total system performance;
- the application of traceable, component-based model upscaling techniques, i.e. establishing detailed models of components, accounting for the complexity of the mechanistic understanding embodied in the process level models, then simplifying the representation of the components in the total system performance models.

To assess the relevancy of these different levels of complexity, several modelling teams [IRSN]

[UHelsinki (Aalto University)] [Andra] [BGR] [CEA (EDF)] [LEI] [SCK•CEN] [COVRA (TU Delft)] [ONDRAF/NIRAS (ULiège)] will apply various numerical approaches to a generic repository configuration with different sets of properties and conditions and with the scenarios defined in subtask 4.1. As the generic repository and the specificities of models will directly depend on the conceptualization subtask 4.1, these will be examined in detail during a working meeting organized around month 9.

The main objective of subtask 4.2 is not to perform a formal performance assessment or a code benchmarking exercise, but to highlight the inherent strengths and limitations of each approach and assessing its suitability in different contexts depending on which system is being evaluated (host rock/design) or what is the quality of available data/what is the magnitude of uncertainties. The analysis of the results of numerical evaluations will focus on gas-oriented indicators, developed in cooperation with subtask 4.1, related to volatile and soluble radionuclides transfer and barrier integrity, which are of direct relevance to performance assessment.

Interactions will be organized with other WP's and especially the modelling WP DONUT to address the challenges of building and operating large (or multi-)scale coupled process models of a full disposal system and with the networking WP UMAN on understanding of uncertainty, risk and safety for aspects related to the treatment of uncertainties (e.g. propagation of parameter uncertainty) in the abstraction process (see also the description of interactions with UMAN in subtask 4.1).

Participation per Partner

Partner number and short name	WP6 effort
1 - ANDRA	15.00
4 - BGE	3.58
5 - CEA	0.00
EDF	9.50
6 - CIEMAT	26.00
UPC	19.00
8 - CNRS	15.30
ULorraine	50.70
UGrenoble	39.70
UPoitiers	35.20
9 - COVRA	2.75
TU Delft	17.50
15 - JUELICH	0.00
UFZ	12.00
16 - GRS	11.00
19 - IRSN	40.00
24 - KIT	0.00
BGR	13.00
25 - LEI	6.50
27 - NAGRA	9.00
ZHAW	12.00
EPFL	32.00
CIMNE	34.00
32 - ONDRAF/NIRAS	6.50
ULiège	45.80
34 - PSI	24.00
37 - RWM	3.50

Partner number and short name	WP6 effort
38 - SCK•CEN	31.40
42 - SÚRAO	4.50
CTU	36.00
ÚJV	12.50
48 - UHelsinki	0.00
Aalto	6.00
49 - UKRI	107.77
Total	681.70

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D6.1	GAS - Initial State-of-the-art (SOTA) report on gas transport through clay materials	32 - ONDRAF/NIRAS	Report	Public	18
D6.2	GAS - Updated State-of-the-art (SOTA) report on gas transport through clay materials	32 - ONDRAF/NIRAS	Report	Public	60
D6.3	GAS - Training materials of the 1st GAS/HITEC Joint training course (copy of the presentations of each doctoral school organised during the course of the project)	32 - ONDRAF/NIRAS	Report	Public	3
D6.4	GAS - Training materials of the 2nd GAS/HITEC Joint training course (copy of the presentations of each doctoral school organised during the course of the project)	32 - ONDRAF/NIRAS	Report	Public	48
D6.5	GAS - Book of proceedings of the final GAS workshop	32 - ONDRAF/NIRAS	Report	Public	60
D6.6	GAS - Technical report of the GAS WP	32 - ONDRAF/NIRAS	Report	Public	60
D6.7	GAS - Technical report Gas Transport Mechanisms including diffusion, retention and	49 - UKRI	Report	Public	57

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
	advective processes in clay				
D6.8	GAS - Technical report on barrier integrity	27 - NAGRA	Report	Public	57
D6.9	GAS - Technical report on conceptualisation and evaluation at the repository scale	1 - ANDRA	Report	Public	57

Description of deliverables

- D6.1 – Initial State-of-the-art (SOTA) report on gas transport through clay materials
The SOTA will give a general overview of the state-of-knowledge with respect to main WP R&D topics, with sufficient context so that it would be of use to a lay audience (with limited technical background), early stage programmes and R&D managers. It will be based on state of knowledge before EURAD-1. The SOTA will also provide a baseline against which WP progress can be measured.
Delivery date: [Month 18] – Lead Beneficiary: [ONDRAF/NIRAS]
 - D6.2 – Updated State-of-the-art (SOTA) report on gas transport through clay materials
The SOTA report on gas transport through clay materials will be updated at the end of the WP in order to include EURAD-1 main findings.
Delivery date: [Month 60] – Lead Beneficiary: [ONDRAF/NIRAS]
 - D6.3 – Training materials of the 1st GAS/HITEC Joint training course course material (copy of the presentations of each doctoral school organised during the course of the project) Delivery date: [Month 6] – Lead beneficiary: [ONDRAF/NIRAS (ULiège)]
 - D6.4 – Training materials of the 2nd GAS/HITEC Joint training course course material (copy of the presentations of each doctoral school organised during the course of the project) Delivery date: [Month 48] – Lead beneficiary: [ONDRAF/NIRAS (ULiège)]
 - D6.5 – Book of proceedings of the workshop organised at the end of the WP. It will include a chapter on the advances in mechanistic understanding of gas transport from an end-user perspective.
Delivery date: [Month 60] – Lead beneficiary: [ONDRAF/NIRAS]
 - D6.6 – Technical report of the GAS WP This deliverable will be composed of a general introduction, three thematic technical reports of Dx2, D6.3 and D6.4. Together with the peer-reviewed scientific papers that are expected be produced by (groups of) organisations involved in this WP, this deliverable aims at providing reliable scientific/ technical references about the knowledge produced in the GAS WP. Delivery date: [Month 60] – Lead Beneficiary: [ONDRAF/NIRAS]
- D6.1 : GAS - Initial State-of-the-art (SOTA) report on gas transport through clay materials [18]
GAS - Initial State-of-the-art (SOTA) report on gas transport through clay materials
- D6.2 : GAS - Updated State-of-the-art (SOTA) report on gas transport through clay materials [60]
GAS - Updated State-of-the-art (SOTA) report on gas transport through clay materials
- D6.3 : GAS - Training materials of the 1st GAS/HITEC Joint training course (copy of the presentations of each doctoral school organised during the course of the project) [3]
GAS - Training materials of the 1st GAS/HITEC Joint training course (copy of the presentations of each doctoral school organised during the course of the project)
- D6.4 : GAS - Training materials of the 2nd GAS/HITEC Joint training course (copy of the presentations of each doctoral school organised during the course of the project) [48]
GAS - Training materials of the 2nd GAS/HITEC Joint training course (copy of the presentations of each doctoral school organised during the course of the project)
- D6.5 : GAS - Book of proceedings of the final GAS workshop [60]

GAS - Book of proceedings of the final GAS workshop

D6.6 : GAS - Technical report of the GAS WP [60]

GAS - Technical report of the GAS WP

D6.7 : GAS - Technical report Gas Transport Mechanisms including diffusion, retention and advective processes in clay [57]

GAS - Technical report Gas Transport Mechanisms including diffusion, retention and advective processes in clay

D6.8 : GAS - Technical report on barrier integrity [57]

GAS - Technical report on barrier integrity

D6.9 : GAS - Technical report on conceptualisation and evaluation at the repository scale [57]

GAS - Technical report on conceptualisation and evaluation at the repository scale

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	EURAD Kick-off meeting (General Assembly n°1)	1 - ANDRA	1	EURAD Kick-off meeting (General Assembly n°1)
MS5	Kick-off GAS WP Meeting 1	32 - ONDRAF/NIRAS	1	Kick-off GAS WP Meeting 1
MS12	EURAD EJP Newsletters	1 - ANDRA	3	EURAD EJP Newsletters (Due date : M3 and then every quarter)
MS20	GAS Task 2.2 Experimental set-ups, geometries and boundary conditions	32 - ONDRAF/NIRAS	6	GAS Task 2.2 Experimental set-ups, geometries and boundary conditions
MS28	HITEC/GAS training n°1 on multi-physical coupling in geomechanics (especially THM and Gas coupling issues)	50 - VTT	6	HITEC/GAS training n°1 on multi-physical coupling in geomechanics (especially THM and Gas coupling issues)
MS30	EURAD General Assembly n°2	1 - ANDRA	7	EURAD General Assembly n°2
MS35	GAS WP Meeting 2	32 - ONDRAF/NIRAS	7	GAS WP Meeting 2
MS42	EURAD Annual Work Plan 2	1 - ANDRA	9	EURAD Annual Work Plan 2
MS44	GAS State-of-the-art chapter on diffusion and gas sorption in clayey materials as an input to D6.1	32 - ONDRAF/NIRAS	9	GAS State-of-the-art chapter on diffusion and gas sorption in clayey materials as an input to D6.1
MS45	GAS State-of-the-art chapter on advective gas transport in clayey materials as an input to D6.1	32 - ONDRAF/NIRAS	9	GAS State-of-the-art chapter on advective gas transport in clayey materials as an input to D6.1
MS46	GAS State-of-the-art chapter on gas-induced impacts on barrier integrity including pathway closure and sealing processes as an input to D6.1	32 - ONDRAF/NIRAS	9	GAS State-of-the-art chapter on gas-induced impacts on barrier integrity including pathway closure and sealing processes as an input to D6.1

Schedule of relevant Milestones

Milestone number¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS58	GAS Task 3 – interim experimental design report comprising a revised detailed work programme of subtasks 3.1, 3.2 and 3.3	32 - ONDRAF/NIRAS	12	GAS Task 3 – interim experimental design report comprising a revised detailed work programme of subtasks 3.1, 3.2 and 3.3
MS59	GAS SOTA chapter on gas-induced impacts on model-based interpretation including a survey of previous research programmes and a screening of gas-related FEP lists as an input to D6.1	32 - ONDRAF/NIRAS	12	GAS State-of-the-art chapter on gas-induced impacts on model-based interpretation including a survey of previous research programmes and a screening of gas-related FEP lists as an input to D6.1
MS60	GAS SOTA chapter drawing an overview of the conceptualizations of gas migration through geological disposal systems and related processes, at the scale of a repository and how these can be translated into models	32 - ONDRAF/NIRAS	12	GAS State-of-the-art chapter drawing an overview of the conceptualizations of gas migration through geological disposal systems and related processes, at the scale of a repository and how these can be translated into models as an input to D6.1
MS61	GAS Technical Note defining a generic repository configuration, sets of parameters, conditions and relevant indicators	32 - ONDRAF/NIRAS	12	GAS Technical Note defining a generic repository configuration, sets of parameters, conditions and relevant indicators on which sub-task 4.2 will test various evaluation approaches
MS81	EURAD General Assembly n°3 + EURAD Annual Meeting 1	1 - ANDRA	13	EURAD General Assembly n°3 + EURAD Annual Meeting 1
MS83	GAS WP Meeting 3 jointly organised with the WP HITEC	32 - ONDRAF/NIRAS	13	GAS WP Meeting 3 jointly organised with the WP HITEC
MS84	HITEC WP Meeting 3 jointly organised with the WP GAS	50 - VTT	13	HITEC WP Meeting 3 jointly organised with the WP GAS
MS85	EURAD Periodic Report 1	1 - ANDRA	14	EURAD Periodic Report 1
MS94	ACED - GAS - DONUT Joint Workshop - 1	32 - ONDRAF/NIRAS	16	ACED - GAS - DONUT Joint Workshop
MS99	GAS - Task 2.1 Experimental progress report	32 - ONDRAF/NIRAS	18	GAS Task 2.1 Experimental progress report
MS100	GAS Task 2.2 - Experimental progress report	32 - ONDRAF/NIRAS	18	GAS Task 2.2 Experimental progress report
MS103	EURAD General Assembly n°4	1 - ANDRA	19	EURAD General Assembly n°4

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS106	GAS WP Meeting 4	32 - ONDRAF/NIRAS	19	GAS WP Meeting 4
MS112	EURAD Annual Work Plan 3	1 - ANDRA	21	EURAD Annual Work Plan 3
MS122	GAS Task 2.1 Modelling progress report.	32 - ONDRAF/NIRAS	24	GAS Task 2.1 Modelling progress report
MS123	GAS Task 2.2 Modelling progress report	32 - ONDRAF/NIRAS	24	GAS Task 2.2 Modelling progress report
MS124	GAS Tasks 3.1 and 3.2 experimental progress report	32 - ONDRAF/NIRAS	24	GAS Tasks 3.1 and 3.2 experimental progress report
MS125	GAS Task 3 – Progress report describing Modelling / concepts, codes and validation workflows	32 - ONDRAF/NIRAS	24	GAS Task 3 – Progress report describing Modelling / concepts, codes and validation workflows
MS136	EURAD General Assembly n°5 + EURAD Annual Meeting 2	1 - ANDRA	25	EURAD General Assembly n°5 + EURAD Annual Meeting 2
MS138	GAS WP Meeting 5 jointly organised with the WP HITEC	32 - ONDRAF/NIRAS	25	GAS WP Meeting 5 jointly organised with the WP HITEC
MS139	HITEC WP Meeting 5 jointly organised with the WP GAS	50 - VTT	25	HITEC WP Meeting 5 jointly organised with the WP GAS
MS140	EURAD Periodic Report 2	1 - ANDRA	26	EURAD Periodic Report 2
MS153	EURAD General Assembly n°6	1 - ANDRA	31	EURAD General Assembly n°6
MS157	GAS WP Meeting 6	32 - ONDRAF/NIRAS	31	GAS WP Meeting 6
MS162	EURAD Annual Work Plan 4	1 - ANDRA	33	EURAD Annual Work Plan 4
MS165	ACED - GAS - DONUT Joint Workshop	32 - ONDRAF/NIRAS	33	ACED - GAS - DONUT Joint Workshop
MS172	GAS Task 2.1 Experimental progress report	32 - ONDRAF/NIRAS	36	GAS Task 2.1 Experimental progress report
MS173	GAS Task 2.2 Experimental progress report	32 - ONDRAF/NIRAS	36	GAS Task 2.2 Experimental progress report
MS174	GAS Task 4.2 progress report on modelling and evaluation approaches applied to the generic repository derived from the conceptualizations of gas migration through geological disposal systems and related processes, at the scale of a repository	32 - ONDRAF/NIRAS	36	GAS Task 4.2 progress report on modelling and evaluation approaches applied to the generic repository derived from the conceptualizations of gas migration through geological disposal systems and related processes, at the scale of a repository
MS185	EURAD General Assembly n°7 + EURAD Annual Meeting 3	1 - ANDRA	37	EURAD General Assembly n°7 + EURAD Annual Meeting 3

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS187	GAS WP Meeting 7 jointly organised with the WP HITEC	32 - ONDRAF/NIRAS	37	GAS WP Meeting 7 jointly organised with the WP HITEC
MS188	HITEC WP Meeting 7 jointly organised with the WP GAS	50 - VTT	37	HITEC WP Meeting 7 jointly organised with the WP GAS
MS189	EURAD Periodic Report 3	1 - ANDRA	38	EURAD Periodic Report 3
MS199	EURAD General Assembly n°8	1 - ANDRA	43	EURAD General Assembly n°8
MS202	GAS WP Meeting 8	32 - ONDRAF/NIRAS	43	GAS WP Meeting 8
MS206	EURAD Annual Work Plan 5	1 - ANDRA	45	EURAD Annual Work Plan 5
MS209	HITEC/GAS training n°2 on multi-physical coupling in geomechanics (especially THM and Gas coupling issues)	50 - VTT	46	HITEC/GAS training n°2 on multi-physical coupling in geomechanics (especially THM and Gas coupling issues)
MS216	GAS Task 2.1 Modelling progress report	32 - ONDRAF/NIRAS	48	GAS Task 2.1 Modelling progress report
MS217	GAS Task 2.2 Modelling progress report.	32 - ONDRAF/NIRAS	48	GAS Task 2.2 Modelling progress report
MS220	GAS Chapter on pathway closure and sealing processes of the WP thematic report on barrier integrity as input to D6.8 (in common with HITEC WP)	32 - ONDRAF/NIRAS	48	GAS Chapter on pathway closure and sealing processes of the WP thematic report on barrier integrity as input to D6.8 (in common with HITEC WP)
MS221	GAS WP Meeting 9	32 - ONDRAF/NIRAS	49	GAS WP Meeting 9
MS222	EURAD General Assembly n°9 + EURAD Annual Meeting 4	1 - ANDRA	49	EURAD General Assembly n°9 + EURAD Annual Meeting 4
MS224	EURAD Periodic Report 4	1 - ANDRA	50	EURAD Periodic Report 4
MS225	GAS Update of the State-of-the-art chapter on diffusion and gas sorption in clayey materials as an input to D6.2	32 - ONDRAF/NIRAS	52	GAS Update of the State-of-the-art chapter on diffusion and gas sorption in clayey materials as an input to D6.2
MS226	GAS Update of the State-of-the-art chapter on advective gas transport in clayey materials as an input to D6.2	32 - ONDRAF/NIRAS	52	GAS Update of the State-of-the-art chapter on advective gas transport in clayey materials as an input to D6.2
MS227	GAS Chapter on diffusion and retention processes of the WP thematic report on gas transport mechanisms as input to D6.7	32 - ONDRAF/NIRAS	54	GAS Chapter on diffusion and retention processes of the WP thematic report on gas transport mechanisms as input to D6.7

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS228	GAS Chapter on advective gas transport of the WP thematic report on gas transport mechanisms as input to D6.7	32 - ONDRAF/NIRAS	54	GAS Chapter on advective gas transport of the WP thematic report on gas transport mechanisms as input to D6.7
MS229	GAS Chapter on gas induced impact of the WP thematic report on barrier integrity as input to D6.8	32 - ONDRAF/NIRAS	54	GAS Chapter on gas induced impact of the WP thematic report on barrier integrity as input to D6.8
MS230	GAS Chapter on model-based interpretation and synthesis of results of the WP thematic report on barrier integrity as input to D6.8	32 - ONDRAF/NIRAS	54	GAS Chapter on model-based interpretation and synthesis of results of the WP thematic report on barrier integrity as input to D6.8
MS231	GAS Update of the State-of-the-art chapter on model-based interpretation including a survey of previous research programmes and a screening of gas-related FEP lists as an input to D6.2	32 - ONDRAF/NIRAS	54	GAS Update of the State-of-the-art chapter on model-based interpretation including a survey of previous research programmes and a screening of gas-related FEP lists as an input to D6.2
MS232	GAS Chapter of the WP thematic report on conceptualisation and evaluation at repository scale	32 - ONDRAF/NIRAS	54	GAS Chapter of the WP thematic report on conceptualisation and evaluation at repository scale presenting the gas storyboards and the testing of various approaches for the evaluation of gas impact at repository scale in a performance assessment context (as an input to D6.9)
MS233	GAS Update of the State-of-the-art chapter drawing an overview on the conceptualizations of gas migration through geological disposal systems and related processes, at the scale of a repository	32 - ONDRAF/NIRAS	54	GAS Update of the State-of-the-art chapter drawing an overview on the conceptualizations of gas migration through geological disposal systems and related processes, at the scale of a repository and how these can be translated into models as an input to D6.2
MS234	EURAD General Assembly n°10	1 - ANDRA	55	EURAD General Assembly n°10
MS236	GAS WP Meeting 10	32 - ONDRAF/NIRAS	56	GAS WP Meeting 10
MS237	GAS Workshop on “Mechanistic understanding	32 - ONDRAF/NIRAS	56	GAS Workshop on “Mechanistic understanding

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
	of gas transport in clay-based materials”			of gas transport in clay-based materials”
MS238	GAS Chapter of the WP thematic report 4 on conceptualisation and evaluation at repository scale comparing modelling and evaluation approaches (as an input to D6.9)	32 - ONDRAF/NIRAS	57	GAS Chapter of the WP thematic report 4 on conceptualisation and evaluation at repository scale comparing modelling and evaluation approaches (as an input to D6.9)
MS240	EURAD General Assembly n°11 + EURAD Annual Meeting 5	1 - ANDRA	60	EURAD General Assembly n°11 + EURAD Annual Meeting 5
MS241	EURAD Periodic Report 5	1 - ANDRA	60	EURAD Periodic Report 5 (Due date: 60+2)

Work package number ⁹	WP7	Lead beneficiary ¹⁰	50 - VTT
Work package title	Influence of temperature on clay-based material behaviour (HITEC)		
Start month	1	End month	48

Objectives

Objectives

- The overall objective is to evaluate whether an increase of temperature is feasible and safe by applying existing and within the work package produced novel knowledge about the behaviour of clay materials at elevated temperatures:
 - to improve understanding of the THM behaviour of clay rock and engineered clay material (buffer) under high temperature and provide suitable THM models both for clay host rock and buffer,
 - to better assess effect of overpressures build up induced by the heat produced from the radioactive waste on the THM behaviour and properties of the clay host rock, and
 - to identify processes at high temperature and the impact of high temperature on the THM properties of the buffer material.
- Host clays formations: aim is to deploy knowledge to mechanics of clay in order to better evaluate and model possible damage evolution during the temperature transient phase, and better assess the consequences of a possible damage.
- Buffer bentonite: aim is to deploy knowledge to hydro-mechanical behaviour at high temperature. The temperature impact on important processes will be measured either while the clay is at the high temperature or after a high temperature exposure. Processes that may have a temperature dependence are swelling pressure, hydraulic conductivity, erosion properties, transport of solutes etc.
- The fourth objective is to document all the above to be utilised in Safety Cases studies
 - The safety functions include properties such as mechanical properties, swelling pressure, hydraulic conductivity, while the integrity of the clay may be evaluated as changes in mineralogy, chemical content or physical integrity of the compacted blocks.

The safety functions and the overall integrity of the bentonite and/or clay host rock will be evaluated after a high temperature exposure. The programme of work will aim to provide results that are applicable to a wide range of buffer material and clay host rock, which can be useful for different National Programmes.

Expected impacts

Regarding RWM implementation needs

For the disposal of HLW (vitrified waste and spent fuel in particular) it is important to assess the consequences of the heat produced by the radioactive decay during operation and in the post-closure phase. The heat pulse may affect the long-term performance (requirements set based on safety functions) of either the natural barriers and/or the engineered barriers. At this stage most of safety case considers a maximum temperature of 100°C in the buffer and in the host rock as an upper threshold. Being able to better accommodate higher temperatures while ensuring similar safety standards can have significant advantages with respect to disposing of higher enrichment/burn-up fuels, interim storage requirements, (re)packaging of the waste, reducing footprint of the disposal (optimizing tunnel spacing and canister spacing in the emplacement tunnels).

The WP is linked to the Roadmap Theme 4 (geoscience to understand rock properties, radionuclide transport and long-term geological evolution) phases 1-2.

Regarding safety case concerns

The second impact composes of knowledge about utilising higher temperatures, setting up limits of temperature and which kind of overall impacts higher temperatures causes to materials and systems.

Proving that temperatures higher than presently accepted are acceptable is very relevant even for current concepts. It increases safety margin and gives greater credibility to the design (e.g. if it is proven to work for 130°C then for 100°C it is definitely safe).

Regarding increasing scientific and technical Knowledge (beyond state-of-the-art) in the field of RWM

There is now only limited knowledge about the clay material behaviour at higher than 100°C. However, the existing knowledge shows that mineralogical alteration will on acceptable level up to 150°C. Therefore, the WP aims to increase scientific and technical knowledge mainly in mechanical behaviour of the clay materials.

Regarding radioactive waste management routes

The WP offers much support in thermal dimensioning of spent fuel repository, and has an effect to intermediate storage of spent fuel, because the storing time may be shortened. The programme of work will aim to provide results that are applicable to a wide range of clay host rock and buffer material, which can be useful for different National Programme.

Description of work and role of partners

WP7 - Influence of temperature on clay-based material behaviour (HITEC) [Months: 1-48]

VTT, ANDRA, BGE, CEA, CIEMAT, ChRDI, CNRS, ENRESA, KIT, LEI, NAGRA, ONDRAF/NIRAS, POSIVA, RWM, SKB, SÚRAO, UHelsinki, UKRI

Task 1 – S/T coordination, State-of-the-art and training material

Start: Month 1 – End: Month 48 - Task Leader: [VTT]

Task Contributors: [Andra] [BGE] [CIEMAT] [ENRESA] [NAGRA] [ONDRAF/NIRAS (EURIDICE)] [ULiege] [Posiva] [SÚRAO (CTU)] [RWM] [SKB] [VTT]

Total PM : 25,4

Subtask 1.1 – S/T coordination

Start: Month 1 – End: Month 48 Subtask Leader: [VTT]

Total PM: 2

The scientific and technical coordination of HITEC WP will be performed by the WP Leader [VTT]. The WP Leader will be supported by the Task leaders and co-leaders: [CNRS (ULorraine)] [SÚRAO (CTU)] [Andra] [SKB] [NAGRA] which together with [VTT] constitute the WP Board of HITEC. The WP Leader will make sure that EURAD rules are followed by all partners, that the scientific milestones and deliverables are reached timely, and that the results are disseminated efficiently inside and outside the project. The WP Leader will ensure the interface between the WP Board, between the participants of HITEC WP, and with the Programme Management Office and the other EURAD WPs.

This subtask consists of ensuring information transfer between different (sub)tasks. This is accomplished by 2 WP meetings per year (in workshop format) involving Task 2,3 and 4. Once a year, one of these meeting will be organised jointly with WP6-GAS aligned with the EURAD Annual conference to minimise travel costs. The intermediate annual meeting, specific to WP7-HITEC will be organised at month 6, 18, 42, 54.

Subtask 1.2 – State-of-the-art

Start: Month 1 – End: Month 48 - Subtask Leader: [CIEMAT]

Subtask contributors: [Andra] [BGE] [CIEMAT] [ENRESA] [ONDRAF-NIRAS (EURIDICE)] [NAGRA] [POSIVA] [RWM] [SKB] [SÚRAO]

Total PM : 16,3

The two main objectives are the state-of-the-art and existing data about clay materials at high temperature. Previous and ongoing national and Community-supported research programmes have led to the detailed understanding of the various key thermo-hydro-mechanical and chemical (THM-C) processes taking place in the buffer material up to 100°C (FEBEX, PROTOTYPE, BACCHUS, RESEAL, ECOCLAY, PEBS, DOPAS, BELBaR, Beacon, ...) and in host claystone (SELFRACTION, TIMODAZ, NF-PRO,...). Those data on THM on clay materials (buffer and clay host rock) at different temperature will be the starting point of the state of the art which will be produced in the early stage of the project, including:

- o a synthesis of the state of knowledge on the THM behaviour of different buffer materials at different temperatures. A focus has to be made on data obtained over 100°C;

- o a synthesis of the state of knowledge on the THM behaviour of host claystone (Boom clay, Opalinus Clay, Callovo Oxfordian claystone). The effect of temperature in near field on the EDZ (extension, permeability properties, self-sealing processes ...) and in far field on the thermal pressurization.

Task 1.2 will resume the state-of-the-art in terms of experimental procedure, processes, parameters and models available at low or high temperature for the different buffer material and host rock (D7.1). A focus will be made in identifying existing or ongoing large-scale in situ experiments which can be proposed in Tasks 2 and 3 as benchmark exercises.

In the final stage of the project, the state-of-the-art will be updated integrating the findings of all R&D tasks in this WP and relevant finding from other WP's (D7.2). The main objective will be to put in the evidence and the significance of the findings of Tasks 2 and 3 on the THM behaviour in clay materials at high temperature and at repository scale and evaluate the consequences of these findings on safety and optimization of geological disposal systems (Task 4).

Subtask 1.3 - Training materials

Start: Month 1 – End: Month 48 - Subtask Leader: [ONDRAF/NIRAS (ULiege)]

Subtask contributors : [SÚRAO (CTU)] [VTT] [ONDRAF/NIRAS (ULiege)]

Total PM : 7

Two training workshops (in the format of a doctoral schools) will be organised jointly with the WP on “Mechanistic understanding of gas transport (GAS)” as the target audiences are similar and the lecturers are likely to be involved in both WP's. WP's will propose lectures and tutors on geomechanics and multi-physical coupling. Courses will integrate main WP's results on thermo-hydromechanical behaviour of clayey materials and on gas transport through clayey materials at this stage of the project. The courses will highlight the consequences of thermal and gas-induced hydro-mechanical perturbations on barrier integrity and long-term performance.

More practically, the 1st school will be organised at the beginning of the project (Lead organisation: ULiège, month 6). The topic will be on multi-physical coupling in geomechanics (especially THM and Gas coupling issues). The objective will be to draw a state-of-knowledge at the beginning of the project. The 2nd school will be organised at the end of the HITEC project (during the 4th year). The topic will be to include the main results of EURAD-1 on THM and Gas issues to the knowledge on multi-physical coupling in geomechanics. The objective will be to highlight the contribution of EURAD-1 on the state-of-knowledge at the end of the project. (Combined deliverables with WP6-GAS D6.3 and D6.4)

Task 2 - Clay host rock <120°C

Start: Month 1 – End: Month 48 - Task Leader: [CNRS (ULorraine)]

Subtask contractors: [Andra] [BGE] [CEA (EDF)] [CIEMAT (UPC)] [CNRS-3SR (ULorraine)] [LEI] [NAGRA] [ONDRAF-NIRAS (EURIDICE) (ULiège)] [RWM] [UKRI-BGS]

Total PM: 263,1

Task objectives:

The heat generated by waste must not affect the favourable properties of the host rock, especially its transport properties, for containment. The overpressure generated by the difference between thermal expansion coefficient of pore water and the solid rock skeleton may have deleterious consequences. In far field, this could induce rock damage and reactivate fractures/faults. In the near field (i.e., in the vicinity of the cell) characterised by a fractured zone, this could induce fracture opening or propagation in this fractured zone, altering the permeability.

Thus, the main objective is to increase knowledge of the THM behaviour of clay host rock to help to optimise the repository design. More specifically, from experiments (for both near and far fields), modelling and benchmarking, the following questions will be addressed:

Do we sufficiently understand the processes leading to the observed overpressures and changes in the stress state? How can experiments be best designed to characterise the most sensitive parameters?

How good are the current THM models in representing the stress changes at repository-relevant conditions?

What are the THM criteria that can act as credible site-specific design criteria? The basic assumption is that no irreversible or long-term damage to the rock should occur. How can one best demonstrate that these design criteria can be met?

In the very unlikely case of damaging (fracturing) the rock, what will be the consequences and can we expect self-sealing in clay rich rock to occur as soon as the energy is released?

The characterisation of in-situ THM behaviour of the clay host rock is significant for the design of the underground nuclear waste disposal facility and to provide long-term safety. When temperature increases in a low-permeability medium, the pore water is compressed as a consequence of the difference between its thermal expansion coefficient and that of the solid skeleton of the rock, which leads to an overpressure.

In the near field (Subtask 2.1), the excavation of galleries or micro tunnels creates a fractured zone around them. The evolution of the effective stress field in the vicinity of the galleries due to the temperature rise can induce fracture opening or propagation of the excavation-induced fractured zone.

In far field (Subtask 2.2), the pore pressure induced by the temperature increase leads to a decrease of the effective vertical stress, which can reach the tensile strength of the rock and cause damage. Fracture or fault reactivation are also possible.

An improved knowledge of the THM behaviour will help to optimise repository design (spacing in between HLW cells, load on casing/canister).

Subtask 2.1 – Experiments near field with EDZ

Start: Month 1 – End: Month 48 – Subtask Leader: [CNRS-3SR (ULorraine)]

Subtask contributors: [CNRS-3SR (ULorraine)] [UKRI-BGS] [RWM]

Total PM: 54,4

Subtask 2.1 will be focussed on the near field in order to assess a possible extension of the excavation-induced fracture network. Subtask 2.1 is based on lab experiments to provide answers to the following two questions

a) Can an extension of the fracture zone occur?

b) What is the permeability evolution of the fracture zone?

Experimental methodologies will take advantage of lessons learned from a previous European project TIMODAZ and the improvement of technologies (for example X-ray and neutron tomography) in order to go further in the analysis of processes than was done during the TIMODAZ and SELFRAC projects.

1. The possible extension of the fracture zone

o Effect of temperature on THM behaviour: Elastic properties and shear resistance of the material and volumetric/pore water pressure response during heating and cooling under drained/undrained conditions (isotropic and triaxial conditions) and under different stress paths.

o Propagation of fractures under a thermal field to characterise the effect of the temperature increase on the behaviour of the excavation-induced fracture zone.

2. The permeability evolution of the fracture zone.

o From a mechanistic point of view, the self-sealing capacity of fractured claystone is associated with various thermo-hydro-mechanical and –chemical processes and controlled by the prevailing state conditions. Mechanical closure of fractures (e.g. crack closure, fracture sliding) and hydro-chemical interactions of the pore water with the clay-bearing solid phase of the geomaterial (e.g. swelling, disaggregation) have been identified as typical self-sealing mechanisms in clay-rich materials. The impact of temperature on the self-sealing processes has to be investigated experimentally. X-ray and neutron tomography scanning will be performed on fractured samples at different test stages and temperatures to analyse the closure of fractures under heat and water percolation.

o Time dependent deformation is a particular self-sealing mechanism of clay-based geomaterials. The significance of this “creep” mechanism is known to be affected by temperature as a potential self-sealing mechanism. Effect of creep related to permeability could be studied.

o To assess permeability change due to damage and possible effects of self-sealing.

Subtask 2.1 will focus on lab experiments on different clay host rocks (Boom Clay, Opalinus Clay, Callovo-Oxfordian clay):

o [CNRS-3SR (ULorraine)] will perform mechanical tests on COX and Opalinus claystones in a transparent triaxial cell under X-ray nano-tomography to study the propagation of fractures at elevated temperatures (40 °C, 60°C, 80 °C, 100 °C) and to characterize fracture shape and size at different stages of a triaxial loading.

o Self-sealing will be studied by [CNRS-3SR (ULorraine)] [UKRI-BGS] [RWM] on 3 clay materials. Experiments will be conducted under triaxial loading on fractured samples (with two bedding orientations) mimicking the damage expected in the near field under X-ray tomography [CNRS-3SR (ULorraine)] and under different constant temperatures (40 °C, 60°C, 100 °C) completed by neutron tomography monitoring to assess water flux. [CNRS-3SR (ULorraine)] [UKRI-BGS] [RWM] will investigate the self-sealing and hydromechanical properties of a number of clay-based materials under different thermal loads in a shear box. The effect of heating on the material properties (e.g. strength and permeability) and the self-sealing capacity of the clay will be studied simultaneously. The benefit of conducting both stages is that the approach is holistic and will give a complete understanding of the self-sealing properties of the tested clay materials.

Related Deliverable: D7.3

Subtask 2.2 – Experiments on far field - effect of over pressure due to thermal load

Start: Month 1 – End: Month 48 - Subtask Leader: [UKRI-BGS]

Subtask contributors: [RWM] [CNRS (ULorraine)] [CEA] [UKRI-BGS]

Total PM: 62,2

Subtask 2.2 will focus on the thermal pressurisation and the risk of damage when the effective stress increases up to the overburden weight.

The temperature rise in a low permeability porous medium, such as Callovo-Oxfordian and Opalinus claystones, generates a pore pressure increase essentially due to the difference between the thermal expansion coefficients of water (~10-4K-1) and the argillaceous rock skeleton (~1.28 10-5K-1 for Cox). Thermal pressurisation is the key mechanism for the potential damage induced by the heat emitted from the waste. There is a competition between excess pore pressure due to thermal pressurisation and drainage due to pore pressure gradient increase. With the periodic distribution of an important number of similar parallel tunnels/micro tunnels and their lengths, it can be expected that the induced pore pressure between tunnels could not be dissipated in the horizontal direction. Due to the symmetry conditions, horizontal displacement, thermal flow and fluid flow are set to zero on the lateral boundaries of the model. The periodic distribution of parallel cells prevents lateral expansion of the rock and thus provokes compression of the thermal stresses in the horizontal direction. The decrease of the total stress sets off the effect of the pore pressure build-up on the horizontal components of the effective stress tensor. However, the vertical effective stress increases and can reach the tensile strength of the rock (i.e potential appearance of sub-horizontal cracks).

The main objectives of the subtask are:

o to better assess the behaviour of claystone under such stress paths (thermal pressurisation effect,...).

o to determine the damage appearance and the effect of a macro cracking over the pore pressure field.

In order to achieve these objectives, the subtask 2.2 is dedicated to experimental work in order to increase knowledge through:

lab tests on samples to better determine the behaviour of claystone under such stress paths during heating (high temperature, increase of lateral stress and decrease of vertical stress).

pressurisation tests under isotropic stress.

triaxial tests with temperature in drained and undrained conditions (up to the tensile effective strength).

Table 3 shows for Subtask 2.1 and Subtask 2.2 the different lab tests that will be performed by the different teams to characterise the THM behaviour of the three clay materials. Due to the existing data in the state of the art (subtask 1.2), the budget and the need of the different participants of the subtask 2, the lab test programme will differ for the different clay materials but will remain sufficient in order to make comparison of the different THM behaviours and to determine the key parameters.

Subtask 2.2 will focus on lab experiments on different clay host rocks (Boom Clay, Opalinus Clay, Callovo-Oxfordian claystone):

- [CNRS (ULorraine)] proposes to experimentally investigate the short- and long-term thermo-mechanical behaviour of 2 claystones (Opalinus Clay, Callovo-Oxfordian claystone) at elevated temperatures (40, 60, 80 and 100 °C):
 - Short-term triaxial tests to characterise mechanical properties (failure criterion, elastic coefficients) at macroscopic (decimetric) scale. Experiments will reproduce stress paths during heating (i.e., high temperature, overpressure, and increase in lateral stress and decrease in vertical stress). Ultrasonic velocities and acoustic emissions will be measured to assess the evolution of elastic properties and then damage (micro-cracking). Thermal profiles will be performed before and after TM tests with the optical scanning method to determine the evolution of thermal properties with damage.
 - Long-term triaxial tests under 2 confining pressures (2 and 12 MPa) to characterise creep properties at macroscopic (decimetric) scale. Acoustic emissions will be measured during creep tests in order to assess the evolution of damage (micro-cracking).
- [CEA] will perform several biaxial tests at elevated temperatures under drained or undrained conditions. These tests will allow measurement of the response and potential damage of the rock to different kinds of thermo-mechanical loading paths, especially along an extension path. Two different clay host rocks (Opalinus Clay, Callovo-Oxfordian claystone) will be tested. They will also perform creep test (on Opalinus and Boom Clays) complementary to those performed by CNRS-GéoRessource. The aim is to determine : a) the failure criterion for the host rock along an extension path for different maximum temperatures (100°C, 120°C); b) the creep coefficient of the fully saturated rock under deviatoric stress for different temperature increments (40, 60, 80 and 100°C).
- [UKRI-BGS] [RWM] will perform tests on intact samples of all host rocks under representative thermal gradients to assess the evolution of pore pressure (overpressure) and permeability (which will strongly influence the size of the overpressure) during the heating phase. [UKRI-BGS] [RWM] will combine isotropic, constant volume and triaxial testing to define the influence of thermal load on the evolution of mechanical properties, as well as changes in material permeability. These fundamental tests will therefore provide information on the coupled nature of the THM properties of each of the materials tested providing insight to multiple end-users.

Related Deliverables: D7.4 and D7.5

Subtask 2.3 – THM modelling of effect of temperature in near and far field – Benchmark exercise

Start: Month 1 – End: Month 48 - Subtask Leader: [Andra]

Subtask contributors: [Andra] [BGE] [CNRS-3SR] [CEA (EDF)] [LEI] [NAGRA] [ONDRAF-NIRAS (EURIDICE) (Uliege)] [CIEMAT (UPC)]

Total PM: 146,5

Subtask 2.3 will focus on the development of THM models which are able to consider processes studied in subtasks 2.1 and 2.2. Many models still exist but could be improved in the task, taking into account the results of the previous subtasks. THM models could be used in near and far field and, in that way, the model development activities have been gathered and not split from the experiment activity (Task 2.1 and 2.2). Results obtained in Tasks 2.1 and 2.2 will be used to calibrate the model in order to perform benchmark exercises on existing in-situ experimental data. The benchmark exercise is the most important part of the subtask for demonstrating the availability and efficiency of such models to perform THM calculations.

The modelling exercise will be performed on in-situ experiments (from 1.2) which address the two main subjects studied in subtask 2.1 (near field EDZ) and subtask 2.2 (far field) like experiments Praclay (Boom clay, Hades URL), FE (Opalinus Clay, Mont Terri URL) and HA cell (Callovo-Oxfordian claystone, Meuse Haute-Marne URL). Specific experiments like CRQ performed at Meuse Haute-Marne URL on fracturing under thermal loading with a stress path depicted in between HLVL cells could be used as a benchmark exercise (from subtask 2.2) to check if the models are able to predict/depict the damaging (fracturing) of the rock under elevated temperatures in the far field and the consequences for rock mass properties.

The number of benchmark exercises has to be limited to three depending on the outcomes from task 1.2 and task 2.1 and 2.2. Teams involved in subtask 2.3 will participate at least to 2-3 benchmark exercises on two different clay stones. A final comparison on the THM behaviour of different clay stones will be done in order to establish similarities and differences in terms of processes which have to be taken into account in the modelling approaches.

Subtask 2.3 will focus on development of THM model, calibration and benchmark exercises on in-situ experiments (not funded in the WP) on different clay host rocks (Boom Clay, Opalinus Clay, Callovo-Oxfordian claystone):

- [Andra] [ONDRAF-NIRAS (EURIDICE)] and [NAGRA] will provide experimental data from the large-scale and long-term in-situ HA cells and CRQ experiments (Meuse Haute Marne URL), FE experiment (Mont Terri URL) and PRACLAY heater test (URL HADES). Data and selected experimental lab test results on the THM behaviour will be available for use as benchmark exercises. Andra, EURDICE and [NAGRA] will give the modelling teams access to the database and coordinate the effort for each specific benchmark. Andra will also participate in the benchmark exercise on CRQ experiment using a probabilistic damage model to study the effect of the rock heterogeneity on its possible cracking due to the effective stress change. In the same way, [ONDRAF-NIRAS (EURIDICE)] will participate in the benchmark exercise on PRACLAY heater test using anisotropic thermo-elasto-plastic approaches to evaluate the effects of EDZ and of its evolution on the near and far field Boom Clay THM behaviour.

- Thermo-visco-elasto-plastic model will be developed and used for the benchmark by:

[BGE]: a basic elasto-plastic model for claystone taking into account dependency of permeability on irreversible strains is existing and will be developed taking into account strength and stiffness anisotropy and time-dependent deformation. Improvement will be performed taking into account the second Gradient Model for Damage

[CEA (EDF)]: the constitutive model LKR (thermo-viscoelastic model) has been developed in Code_Aster in a poromechanical formalism (THM). The anisotropy in the visco-plasticity law (first model currently developed with a PHD student) is in progress and can be used in the current WP. Improvement of permeability evolution with strain will be developed and HPC modelling for 3D computation will be done

[LEI] will develop their constitutive model and participate in the benchmark exercise

[ONDRAF/NIRAS (ULIEGE)] has been partner of TIMODAZ. Their FE code (Lagamine) has been validated on a number of THM benchmarks. Constitutive modelling has been improved, mainly on the volumetric compression and deviatoric stress paths. The major effect of anisotropy has been taken into account (thermal plume, fluid flow, extent of EDZ). A Rankine yield surface will be tested to model extension fractures. Strain localisation will be taken into account thanks to our second grade models, which regularise the problem and control the fracture zone thickness. The fracture's interdistance will be obtained in relation with the material permeability, which will evolve strongly in fractured zones. The fracture closure due to the self-sealing process at high temperature will be modelled in interface finite elements, whose constitutive models will be improved to take into account the time dimension in the sealing process, which is related to the small-scale water availability. This activity will benefit from development in EURAD Gas WP.

[CIEMAT (UPC)]: A recently developed stress-strain law for clay rocks will be made available. It includes non-linearity and plasticity before peak strength, softening after peak, anisotropy of stiffness and strength, creep (visco-elastic and visco-plastic) and permeability variation due to damage and self-sealing. The law will be further developed by introducing thermo-plasticity. Another key development will be the simulation fracture generation due to overpressure and/or temperature and their propagation. Again, a recently developed non-local formulation has proved capable of predicting the development and propagation of discontinuities under isothermal conditions. The formulation will be generalised to include specific thermal effects taking into account the variation of permeability in the discontinuity.

[CNRS-3SR] will develop and use constitutive modelling of the THM behaviour by a double scale FEM2 approach. At the microscale, the microstructure of the material is defined by inclusions (quartz, carbonate, etc...) imbedded in a clay matrix, separated by cohesive interfaces. Fluid can percolate in the pore network that is formed by these interfaces and fluid pressure acts statically on the (impermeable) grains. The homogenised response to kinematic loading of this REV is used to provide the macroscopic material point behaviour. The new contribution here is the thermal coupling extension of this double scale hydro-mechanical model. Thermal effects concern the heterogeneity of the thermal strain of the microstructure (inclusions, clay matrix, pore fluid) that can induce relative damage at the interfaces and pore fluid channel modification inducing permeability change. It will result in a macro-behaviour that will include a thermal dependence on the hydro-mechanical response. Related Deliverable: D7.6

Task 3 - Clay buffers >100°C

Start: Month 1 – End: Month 48 - Task Leader: [SÚRAO (CTU)]

Task contributors: [Andra (BRGM)] [CHRD (KIPT) (SIIGNASU)] [CIEMAT (UAM) (UPC)] [KIT (BGR)] [POSIVA] [SÚRAO (CTU) (CU) (UJV)] [RWM] [SKB] [UHelsinki (GTK) (JYU)] [UKRI-BGS] [VTT]

Total PM: 392,2

Task objectives: The overall objective is to evaluate whether an increase of temperature is feasible and safe by applying (i) existing and (ii) the within the task newly produced knowledge about the behaviour of clay buffer materials at elevated temperatures.

The increase of temperature may result in strong evaporation near the heater and vapour movement towards the external part of the buffer. As a consequence, part of the barrier, or all of it, depending on the particular disposal concept, will remain unsaturated and under high temperatures during periods of time that can be very long. Moreover the high temperature gradient (and pore pressure) even crossing boiling point of water will lead to several adverse effects as Sauna effects (Birgersson, 2017).

The European Project PEBS identified the following uncertainties for this case (Johnson et al. 2014):

- The impact of the duration of the elevated temperature period on the property change is not clear, but changes can occur even after short heating/cooling cycles.
- Although the existing data do not point to very significant impacts, a comprehensive view on the impact of temperatures up to 150°C on THM properties is not yet in place. The data supporting the modelling between 100°C and 150°C is sparser compared to the support at temperatures lower than 100°C.
- In relation to the above, some impact of vapour on bentonite properties under repository relevant conditions (120-150°C) can be expected and should be clarified taking into account repository relevant vapour regimes. This impact might be due to minor surface cementation effects although this needs further confirmation.
- The modelling performed at the URL highlighted the sensitivity of the modelled temperatures and relative humidity to the evolution of the thermal conductivity, especially when the bentonite is at very low saturation, and to the parameters determining the relative permeability curve.

Taking these uncertainties into account the objectives of Task 3 have been defined:

- Assessment of the impact of having clay buffer subjected to high temperatures over long time periods on the clay buffer properties. (Subtask 3.1)
- Determination of bentonite hydro-mechanical properties for temperatures higher than 100°C, which will provide parameters for the modelling work. (Subtask 3.2)
- Identification of key processes at high temperature, particularly those affecting the saturation rate, because this will condition the time the buffer is in dry conditions and under high temperature. (Subtask 3.3)
- Calibration and development of suitable THM models for clay buffer at higher temperatures. (Subtask 3.3)

The experimental work will mostly focus on bentonites that are well characterised for temperatures below 100°C and proposed in several disposal concepts: MX-80, FEBEX and BGV. The target will be to extend the knowledge above 100°C into the range up to 130-150°C.

Subtask 3.1– Characterisation of material treated by high temperature

Start: Month 1 – End: Month 48 - Subtask Leader: [SKB]

Subtask contributors: [CIEMAT (UAM)] [KIT (BGR)] [ChRDI (KIPT) (SIIGNASU)] [SKB] [SÚRAO (CTU) (CU) (UJV)] [UHelsinki] [VTI]

Total PM: 136

Objectives:

- Investigate material changes after high temperature treatment on the safety functions (important properties) and on its integrity (e.g. mineralogy, chemistry, mechanical parameters...)
- Determination of parameters necessary for mathematical modelling e.g. to fill up blank spots in material database for temperatures above 100°C

Material subjected to the high temperature will be studied and changes of properties (mechanical, hydro physical, transport, geotechnical, chemical and mineralogical) will be determined. Both laboratory treated material and samples from in-situ experiments are included (note: in-situ experiments itself are not part of the WP).

The material studied in Subtask 3.1 will come from three main sources:

- In-situ experiment(s)
- Small scale laboratory experiments (Subtask 3.3)
- Laboratory treatment

1) Materials subjected to high temperature under repository-like conditions (in-situ experiments).

At the moment of preparing this WP only the ABM-5 in situ test is planned to be dismantled in the course of the WP. Hence, samples coming from this experiment (provided by SKB), in which different bentonites are being used, will be analyzed by different labs:

[CIEMAT] will analyse changes in the FEBEX bentonite solid and liquid composition. Squeezing tests will be performed to extract the liquid phase

[KIT (BGR)] will analyse the mineralogical changes in relation to the thermal gradient.

[SKB] will analyse the chemistry and mineralogy of blocks of the MX80, DepCAN (Milos), Asha505 (Kutch) and Calcigel bentonites

New high temperature experiments are planned by various National Programmes. Depending on the timing samples from those experiments can be included in Subtask 3.1.

Note: in-situ experiments itself are not part of the WP

2) Within Subtask 3.3 small scale experiments simulating repository like conditions are planned. These experiments will provide input into Subtask 3.1.:

[CIEMAT (UAM)] will focus on the post mortem analyses of the laboratory-scale thermo-hydraulic cells performed by CIEMAT mainly concerning mineralogical changes that could explain the macroscopic changes observed.

[SÚRAO (CTU) (CU) (ÚJV)] will focus on the post mortem analyses of the small scale laboratory experiments performed by CTU. CTU will focus on geotechnical properties. ÚJV will focus on geochemical analysis.

3) Materials subjected to high temperature in the laboratory and then tested to determine different properties. The bentonite will be first subjected to high temperature (either in batch or compacted conditions) and then their properties will be tested at room temperature and compared with those expected for the untreated materials:

[ChRDI (SIIGNASU)] will analyze mineralogical alterations in local bentonite treated with saline solutions or synthetic groundwater in autoclave at 170-190°C.

SÚRAO:

- o [SÚRAO (CTU)] will treat BCV bentonite by high temperature and investigate changes in geotechnical properties especially permeability, swelling pressure and Atterberg limits.

- o [SÚRAO (CU)] will investigate swelling under constant load tests, oedometric load-unload tests and water retention tests on heat treated BCV bentonite.

- o [SÚRAO (ÚJV)] will perform geochemical analyses on BCV treated by CTU (CEC, specific surface (EGME and BET), mineralogy (XRD) with respect to change of expandable structures of clay minerals (combination of methods TG, FTIR) and re-hydration.

[UHelsinki] will treat the bentonite in batch tests at temperatures up to 200°C and then determine rheological and mechanical properties, morphological features, thermal stability and nanoparticle formation.

[ChRDI (KIPT)] will treat a local bentonite at 150°C treatment for periods of time longer than 3 months and investigate material changes after each of periods of high temperature treatment, in particular, mechanical parameters, swelling pressure and permeability. Analytical investigations will be carried out to detect any temperature-induced changes in material structure, and chemical/transport changes in bentonite after various periods of 150 °C heat treatment will be studied too.

[VTT] will treat MX-80 bentonite as dry powder and as wet compacted samples at temperatures up to 200°C (also cyclic heating-cooling periods) and perform experiments on the heat treated samples (in room temperature): a) triaxial shear and isotropic compression tests (to study the mechanical behaviour), b) XRD analysis (to study the interlayer distance and clay mineralogy) and c) post mortem chemical analysis (bentonite chemistry).

Other tasks' participants will review the testing plans [POSIVA] assist in the preparation of the experimental programme and participate in the interpretation of results [SÚRAO].

Related Deliverables: D7.7

Subtask 3.2– Determination of parameters at temperatures >100°C

Start: Month 1 – End: Month 48 - Subtask Leader: [BGS]

Subtask contributors: [Andra (BRGM)] [UKRI-BGS] [ChRDI (KIPT)] [CIEMAT] [RWM] [SÚRAO (CTU) (CU)] [UHelsinki (GTK) (JYU)] [VTT]

Total PM: 154,2

Objectives:

- Investigate processes and material properties at high temperature
- Determination of parameters necessary for mathematical modelling (input into Subtask 3.3)

The aim of this task is to check how the hydro-mechanical properties of the bentonite change with temperature, i.e. when they are measured at temperatures other than room temperatures. This effect has been investigated in previous researches, but for many properties the results available are scarce and refer to temperatures below 100°C. Hence, an effort will be made to modify the testing technique to allow for testing at temperature >100°C.

[Andra (BRGM)] will measure swelling pressure during the hydration of a bentonite (Kunipia-G or MX-80) at temperatures between 100 and 150°C with solutions of different compositions (cations and ionic strength) using an oedometer cell suitable for X-ray tomography acquisition to visualize in situ the evolution of the microstructure evolution. Swelling experiments will be simulated accounting for both mechanical compaction, temperature changes, water flow and chemical effects. A comparison of modelling approaches will be made with the Charles University hypoplastic model for swelling clays.

[UKRI-BGS] will measure the evolution in permeability and swelling pressure of pre-compacted samples of MX80 bentonite at temperatures ranging between 100 and 200°C to ensure the integrity of the buffer remains intact. Dry density will also be varied to assess impact on permeability and swelling pressure. Changes in microstructure will be assessed post-mortem with optical microscopy, SEM and X-Ray CT imaging.

[ChRDI (KIPT)] will investigate the material properties (swelling pressure and hydraulic conductivity) of a local bentonite at high temperature (120°C and 150°C).

[CIEMAT] will determine the water retention capacity of bentonites with different exchangeable cations (FEBEX, MX-80) at temperatures of up to 150°C, with particular accuracy in the low suction range (using sensors in bentonite compacted to different dry densities with different water contents).

SÚRAO:

- [SÚRAO (CTU)] will study permeability and swelling pressure of BCV bentonite at temperature up to 150°C
- [SÚRAO (CU)] will study BCV material at 100 °C and 150 °C in specialized cell. 2 swelling pressure tests with suction control, 2 swelling under constant load tests with suction control, 1 oedometric load-unload test will be performed.

[UHelsinki (GTK) (JYU)] will study swelling of bentonite (MX80 or equivalent) samples using non-intrusive X-ray tomographic techniques at elevated temperatures up to 150 °C.

[VTT] will perform a) triaxial shear and isotropic compression tests for compacted MX-80 samples at temperatures above 100°C (to study the mechanical behavior of bentonite), b) XRD analysis for samples undergone the high temperature triaxial tests (to study the changes in interlayer distances and mineralogy), and c) chemical monitoring of compacted bentonite samples at high temperatures up to 200°C by using in situ ion selective electrodes. Differential scanning calorimetry (DSC) will be used to select suitable temperatures for the other experiments.

[SÚRAO] will assist in the preparation of the experimental programme and participate in the interpretation of results of its LTP.

[RWM] will evaluate the results of the experimental work they will fund being undertaken by the BGS (see below), and prepare a synthesis report on how RWM will use the findings of the BGS experiments in our geological disposal programme. RWM will share the findings of our report, and participate in discussions through participation at selected Task 3 meetings. RWM will fund the 50% of BGS's experimental costs (the 50% not covered by EU) for Task 3.2. The scope of these test is summarized above under 'BGS'.

Milestones:

- Mathematical models – description of models and plan for improvements (Description of conceptual models and tools, plan for the models improvement, UPC, M12).
- Modelling benchmarks – description (Description of calibration case, verification cases and benchmarks selected for T3.3 in cooperation with DONUT, UPC, M24).

Related Deliverables: D7.8

Subtask 3.3– Small scale experiments, model development and verification

Start: Month 1 – End: Month 48 - Subtask Leader: [CIEMAT (UPC)]

Subtask contributors: [CIEMAT (UPC)] [POSIVA] [SÚRAO (CTU) (CU)] [VTT]

Total PM: 102

Objectives:

Understanding of processes at larger scale

Development and validation of mathematical models (at concept/element level)

Benchmark of available and developed codes to assess their suitability for high temperatures

Laboratory tests in cells, in which the conditions of the repository will be simulated (hydration under thermal gradient), will provide online information for the validation of THM models and their post mortem analyses (performed in subtask 3.1) will complement this information and provide insights into the processes occurred. The advantage of this kind of tests is that the boundary conditions are well controlled and can be easily varied to respond to the uncertainties identified. Additionally, the modelling work will aim at verifying the validity of the available models when applied to higher temperature and incorporate in them if necessary the processes identified in this subtask and the other ones.

[CIEMAT] will perform

o a set of thermo-hydraulic tests in cells (3 or 4), in which hydration under different thermal gradients (two heater temperatures) will be accomplished. Depending on conversation with other partners and conclusions from the SoA, two different bentonite-based buffer materials could be tested (in principle FEBEX and/or MX-80 bentonites).

o A THM test in a 50-cm long cell has been going on at [CIEMAT]'s facilities since 2012. In this test pellets of MX-80 bentonite are used and the heater is set at a temperature of 140°C, while it is hydrated with Pearson water. It simulates the conditions of the HE-E in situ test going on at the Mont Terri URL. This cell would be dismantled in the course of the WP (in the first or second year)

Because of the high temperatures, parts of the bentonite columns will remain unsaturated for long time periods and the effect of this on the bentonite properties will be analysed. Part of the post mortem analyses (mineralogy and geochemistry) will be performed by UAM in subtask 3.1.

o [CIEMAT (UPC)] will perform modelling addressing two aspects: Process modelling and benchmarks/experiments simulation. For process modelling, the main objective is to develop a conceptual framework and a mathematical model (at element level) for clay buffer materials able to incorporate the effects of high temperature on their predicted thermo-hydro-mechanical behavior. For modelling benchmarks and experiments, the main objective is the demonstration that the numerical formulation and computer code are able to reproduce and to predict the benchmarks selected from T3.3 that involve clay buffer material at temperatures higher than 100°C.

SÚRAO:

o [SÚRAO (CTU)] has two objectives in T3.3:

The first objective is to investigate bentonite barrier at high temperature at system level. A set of small-scale experiments is planned. The small scale experiments are designed to simulate a section bentonite barrier with temperature gradient

and (forced if necessary) saturation. A pressure vessel will be used in order to allow simulating the conditions in a deep repository.

The second objective is to further develop (high temperature effects) and calibrate a CU's hypoplastic model in the CTU's SIFEL FEM package. A dataset obtained in T3.1, 3.2 and 3.3 will be used for model development, calibration and benchmarking.

o [SÚRAO (CU)] will further develop and validate a hypoplastic model for bentonite at high temperature. [SÚRAO (CU)] will particularly focus on simulations of CTU's experiments.

[VTT] & [POSIVA] aims in T3.3 are 1) to contribute to experiments design in T3.1 and T3.2 from modelling perspective to ensure the ability to utilize the experimental results in THM modelling, 2) to interpret and compile obtained experimental data for modelling purposes and 3) to perform benchmark exercises with available models using the new experimental data.

[SÚRAO] will assist in the preparation of the experimental programme and participate in the interpretation of results of its LTP.

Related Deliverables: D7.9 and D7.10

Task 4 - Impacts and deployment of results

Start: Month 24 – End: Month 48 - Task Leader: [VTT]

Task Contributors: [Andra] [BGE] [ENRESA] [NAGRA] [ONDRAF/NIRAS (EURIDICE)] [POSIVA] [SÚRAO] [RWM] [SKB] [VTT]

Total PM: 20,1

Task objectives:

- The objective for T4.1 is to formulate the existing and new knowledge into a form possible to be utilised in different Safety Cases to enable the update of those studies up to higher temperatures – I=
- Final reporting T4.2

While, in the Task 1.2, assessment criteria will be created, the success of the Work package will be compared to these criteria T4.2

Subtask 4.1– Guidance for safety case development and repository optimization

Start: Month 24– End: Month 48 - Subtask Leader: [NAGRA]

Subtask contributors: [Andra] [BGE] [ENRESA] [ONDRAF/NIRAS (EURIDICE)] [NAGRA] [POSIVA] [RWM] [SKB] [SÚRAO]

Total PM : 13,1

This task will be based on the progress beyond the state of the art that was realized in Task 2 and Task 3 to develop guidance for the WMOs (D7.11). Individual WMOs, with safety cases already in place and optimization question being raised, will assess the impact for each of their specific safety cases and optimization targets (safety and cost). The guidance will aid all other programmes facing questions related to thermal dimensioning of the repository.

In the case of bentonite being used as an engineered barrier, it will be assessed by each WMO planning to use bentonite in their reference concept or as part of their catalogue of options [SKB] [POSIVA] [NAGRA] [RWM] [SÚRAO] [ENRESA] [BGE] how the progress beyond the state-of-the-art in Task 3 allows to reduce the uncertainties and increase the margin by which the safety functions can be fulfilled. In terms of repository optimization it will be assessed how the canister loading can be optimized and what the consequences will be when higher temperatures are permitted and to what extent the performance of the bentonite is still intact.

In the case of the geological barrier consisting of a clay hostrock, it will be assessed by each WMO that considers clay host rocks either as a reference or as an option [NAGRA] [Andra] [[ONDRAF/NIRAS (EURIDICE)] [BGE] [RWM] [ENRESA] how the progress beyond the state-of-the-art in Task 2 contributes to confirming the threshold criteria that have been put forward to ensure the integrity of the geological barrier in the respective safety cases. In terms of repository optimization, it will be assessed how higher thermal loads, changes in canister pitch and/or tunnel spacing affect the likely performance of the geological barriers. This includes an assessment of the consequences of locally surpassing the thresholds.

This analysis will provide clear insight in the role of thermal dimensioning of a repository and its flexibility during repository design and safety assessment. The anticipated increase in process understanding at higher temperatures in both the bentonite barrier and the clay hostrock is expected to contribute to defining and/or confirming performance criteria and thresholds in these higher temperature ranges. Before the start of EURAD, both the parameter values and the process understanding were insufficiently characterized to support this.

Subtask 4.2– Final workshop, final report and evaluation of progress achieved within HITEC WP

Start: Month 37– End: Month 48 - Task Leader: [VTT]

Total PM: 7

At the end of the WP, a general workshop (MS204) on Influence of temperature on clay-based material behaviour will be planned to facilitate the release of main findings of this WP within the whole scientific community and the end-user (lead organisation: VTT, month 46)

Furthermore, this subtask aims to coordinate the writing of the final HITEC technical report (D7.12). The HITEC final technical report utilises the State-of-the-art (D7.2) and the Guidance for safety case development and repository optimization (D.7.11) together with technical reports from T2 and T3, and from task 5 – Interaction with Civil Society. The final report aimed to be published in open access journals.

Deliverables (brief description and month of delivery)

- D7.1 - Initial State-of-the-art on THM behaviour of i) buffer clay materials and of ii) host clay materials – [CIEMAT] Month 6
- D7.2 - Updated State-of-the-art on THM behaviour of i) buffer clay materials and of ii) host clay materials [CIEMAT] Month 48
- Contribution to D6.3 – HITEC/GAS Training materials: course material (copy of the presentations of each doctoral school organised during the course of the project Delivery date: [Month 6] – Lead beneficiary: [ONDRAF/NIRAS (ULiège)]
- Contribution to D6.4 – HITEC/GAS Training materials: course material (copy of the presentations of each doctoral school organised during the course of the project) Delivery date: [Month 48] – Lead beneficiary: [ONDRAF/NIRAS (ULiège)]
- D7.3 – Final technical report on thermal effects on near field properties (subtask 2.1) – This deliverable shall contain i) Dataset of self-sealing capacities under elevated temperature, ii) Dataset of fracture propagation under elevated temperature; iii) Dataset of mechanical properties of fractured media under elevated temperature and iv) Comparison of the results for different host claystones. Month 46 Lead: [CNRS (ULorraine)].
- D7.4 – Specific GAS/HITEC technical report on self-sealing processes - Similar self-sealing experiments will be performed by HITEC WP subtask 2.1 (influence of temperature) and GAS WP subtask 3.2 (influence of gas pressure). Report will include test results, self- sealing process understanding, similarities and differences between different claystones and effectiveness under temperature and gas. Month 46 Lead: [Andra].
- D7.5 - Final technical report on effect of temperature on far field properties (subtask 2.2) – will include i) Dataset of short-term thermo-mechanical properties; ii) Dataset of long-term thermo-mechanical properties; iii) Impact of heating on overpressure and permeability and iv) Comparison of the result on different host claystones. Month 46 Lead: [CNRS (ULorraine)].
- D7.6 - Final modelling report on effect of temperature on near field properties (subtask 2.3) – will include Model description, Benchmark description, Comparison of the model and a Synthesis. Direct input to task 4 (input from all participants) Month 46 Lead: [CNRS (ULorraine)].
- D7.7: HITEC technical report on Material characterisation – Task 3.1 final results - [SKB] Month 46
- D7.8: HITEC technical report on test at high temperature – Task 3.2 final results – material investigation – [UKRI-BGS] M46
- D7.9: Experimental works (small and mid-scale laboratory experiments) – final report (Results of the experimental works of T3.3, [CIEMAT] M46
- D7.10: Modelling - final report (Results of all modelling task carried in T3.3 in cooperation with DONUT, UPC, M46
- D7.11 Guidance for safety case development and repository optimization [NAGRA] Month 46
- D7.12: Final report on Influence of temperature on clay-based material behaviour [VTT] Month 48

Participation per Partner

Partner number and short name	WP7 effort
1 - ANDRA	13.70
BRGM	16.70
4 - BGE	13.70
5 - CEA	15.00
EDF	10.50
6 - CIEMAT	37.00

Partner number and short name	WP7 effort
UPC	48.50
UAM	6.00
7 - ChRDI	0.00
KIPT	48.00
SIIGNASU	21.00
8 - CNRS	50.00
ULorraine	33.00
14 - ENRESA	2.10
24 - KIT	0.00
BGR	9.00
25 - LEI	10.00
27 - NAGRA	3.40
32 - ONDRAF/NIRAS	0.00
EURIDICE	4.90
ULiège	40.50
33 - POSIVA	2.50
37 - RWM	10.90
39 - SKB	9.00
42 - SÚRAO	11.00
CU	45.00
CTU	54.00
ÚJV	10.00
48 - UHelsinki	28.00
JYU	28.00
GTK	6.00
49 - UKRI	84.80
50 - VTT	28.50
Total	700.70

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D7.1	HITEC - Initial State-of-the-art on THM behaviour of i) buffer clay materials and of ii) host clay materials	6 - CIEMAT	Report	Public	6

List of deliverables

Deliverable Number¹⁴	Deliverable Title	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
D7.2	HITEC -Updated State-of-the-art on THM behaviour of i) buffer clay materials and of ii) host clay materials	6 - CIEMAT	Report	Public	48
D7.3	HITEC -Final technical report on thermal effects on near field properties	8 - CNRS	Report	Public	46
D7.4	HITEC -Specific GAS/ HITEC technical report on self-sealing processes	1 - ANDRA	Report	Public	46
D7.5	HITEC -Final technical report on effect of temperature on far field properties	8 - CNRS	Report	Public	46
D7.6	HITEC - Final modelling report on effect of temperature on near field properties	8 - CNRS	Report	Public	46
D7.7	HITEC - technical report on Material characterisation – Task 3.1 final results	39 - SKB	Report	Public	46
D7.8	HITEC - HITEC technical report on test at high temperature – Task 3.2 final results	49 - UKRI	Report	Public	46
D7.9	HITEC - Experimental works (small and mid-scale laboratory experiments) – final report (Results of the experimental works of T3.3)	6 - CIEMAT	Report	Public	46
D7.10	HITEC - Modelling – final report (Results of all modelling task carried in T3.3 in cooperation with DONUT	6 - CIEMAT	Report	Public	46
D7.11	HITEC - Guidance for safety case development and repository optimization	27 - NAGRA	Report	Public	46
D7.12	HITEC - Final report on Influence of temperature	50 - VTT	Report	Public	48

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
	on clay-based material behaviour				

Description of deliverables

D7.1 - Initial State-of-the-art on THM behaviour of i) buffer clay materials and of ii) host clay materials – [CIEMAT] Month 6

D7.2 - Updated State-of-the-art on THM behaviour of i) buffer clay materials and of ii) host clay materials [CIEMAT] Month 48

Contribution to D6.3 – HITEC/GAS Training materials: course material (copy of the presentations of each doctoral school organised during the course of the project Delivery date: [Month 6] – Lead beneficiary: [ONDRAF/NIRAS (ULiège)]

Contribution to D6.4 – HITEC/GAS Training materials: course material (copy of the presentations of each doctoral school organised during the course of the project) Delivery date: [Month 48] – Lead beneficiary: [ONDRAF/NIRAS (ULiège)]

D7.3 – Final technical report on thermal effects on near field properties (subtask 2.1) – This deliverable shall contain i) Dataset of self-sealing capacities under elevated temperature, ii) Dataset of fracture propagation under elevated temperature; iii) Dataset of mechanical properties of fractured media under elevated temperature and iv) Comparison of the results for different host claystones. Month 46 Lead: [CNRS (ULorraine)].

D7.4 – Specific GAS/HITEC technical report on self-sealing processes - Similar self-sealing experiments will be performed by HITEC WP subtask 2.1 (influence of temperature) and GAS WP subtask 3.2 (influence of gas pressure). Report will include test results, self-sealing process understanding, similarities and differences between different claystones and effectiveness under temperature and gas. Month 46 Lead: [Andra].

D7.5 - Final technical report on effect of temperature on far field properties (subtask 2.2) – will include i) Dataset of short-term thermo-mechanical properties; ii) Dataset of long-term thermo-mechanical properties; iii) Impact of heating on overpressure and permeability and iv) Comparison of the result on different host claystones. Month 46 Lead: [CNRS (ULorraine)].

D7.6 - Final modelling report on effect of temperature on near field properties (subtask 2.3) – will include Model description, Benchmark description, Comparison of the model and a Synthesis. Direct input to task 4 (input from all participants) Month 46 Lead: [CNRS (ULorraine)].

D7.7: HITEC technical report on Material characterisation – Task 3.1 final results - [SKB] Month 46

D7.8: HITEC technical report on test at high temperature – Task 3.2 final results – material investigation – [UKRI-BGS] M46

D7.9: Experimental works (small and mid-scale laboratory experiments) – final report (Results of the experimental works of T3.3, [CIEMAT] M46

D7.10: Modelling - final report (Results of all modelling task carried in T3.3 in cooperation with DONUT, UPC, M46

D7.11 Guidance for safety case development and repository optimization [NAGRA] Month 46

D7.12: Final report on Influence of temperature on clay-based material behaviour [VTT] Month 48

D7.1 : HITEC - Initial State-of-the-art on THM behaviour of i) buffer clay materials and of ii) host clay materials [6]
HITEC - Initial State-of-the-art on THM behaviour of i) buffer clay materials and of ii) host clay materials

D7.2 : HITEC -Updated State-of-the-art on THM behaviour of i) buffer clay materials and of ii) host clay materials [48]
HITEC -Updated State-of-the-art on THM behaviour of i) buffer clay materials and of ii) host clay materials

D7.3 : HITEC -Final technical report on thermal effects on near field properties [46]
HITEC -Final technical report on thermal effects on near field properties

D7.4 : HITEC -Specific GAS/HITEC technical report on self-sealing processes [46]
HITEC -Specific GAS/HITEC technical report on self-sealing processes

D7.5 : HITEC -Final technical report on effect of temperature on far field properties [46]
HITEC -Final technical report on effect of temperature on far field properties

D7.6 : HITEC -Final technical report on effect of temperature on near field properties [46]
HITEC -Final technical report on effect of temperature on near field properties

D7.7 : HITEC -Final technical report on material characterisation [46]
HITEC -Final technical report on material characterisation

D7.8 : HITEC -Final technical report on test at high temperature [46]
HITEC -Final technical report on test at high temperature

D7.9 : HITEC -Final technical report on experimental works [46]
HITEC -Final technical report on experimental works

D7.10 : HITEC -Final technical report on modelling [46]
HITEC -Final technical report on modelling

D7.11 : HITEC -Final technical report on safety case development [46]
HITEC -Final technical report on safety case development

D7.12 : HITEC -Final technical report on repository optimization [46]
HITEC -Final technical report on repository optimization

D7.6 : HITEC - Final modelling report on effect of temperature on near field properties [46]
HITEC - Final modelling report on effect of temperature on near field properties

D7.7 : HITEC - technical report on Material characterisation – Task 3.1 final results [46]
HITEC - technical report on Material characterisation – Task 3.1 final results

D7.8 : HITEC - HITEC technical report on test at high temperature – Task 3.2 final results [46]
HITEC - HITEC technical report on test at high temperature – Task 3.2 final results

D7.9 : HITEC - Experimental works (small and mid-scale laboratory experiments) – final report (Results of the experimental works of T3.3) [46]
HITEC - Experimental works (small and mid-scale laboratory experiments) – final report (Results of the experimental works of T3.3)

D7.10 : HITEC - Modelling – final report (Results of all modelling task carried in T3.3 in cooperation with DONUT [46]
HITEC - Modelling – final report (Results of all modelling task carried in T3.3 in cooperation with DONUT

D7.11 : HITEC - Guidance for safety case development and repository optimization [46]
HITEC - Guidance for safety case development and repository optimization

D7.12 : HITEC - Final report on Influence of temperature on clay-based material behaviour [48]
HITEC - Final report on Influence of temperature on clay-based material behaviour

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	EURAD Kick-off meeting (General Assembly n°1)	1 - ANDRA	1	EURAD Kick-off meeting (General Assembly n°1)
MS6	Kick-off HITEC WP Meeting 1	50 - VTT	1	Kick-off HITEC WP Meeting 1
MS12	EURAD EJP Newsletters	1 - ANDRA	3	EURAD EJP Newsletters (Due date : M3 and then every quarter)
MS28	HITEC/GAS training n°1 on multi-physical coupling in geomechanics (especially THM and Gas coupling issues)	50 - VTT	6	HITEC/GAS training n°1 on multi-physical coupling in geomechanics (especially THM and Gas coupling issues)
MS30	EURAD General Assembly n°2	1 - ANDRA	7	EURAD General Assembly n°2
MS36	HITEC WP Meeting 2	50 - VTT	7	HITEC WP Meeting 2
MS42	EURAD Annual Work Plan 2	1 - ANDRA	9	EURAD Annual Work Plan 2
MS47	HITEC experimental progress report	50 - VTT	9	HITEC experimental progress report
MS48	HITEC Task 2.2 Experimental test plan	50 - VTT	9	HITEC Task 2.2 Experimental test plan
MS49	HITEC Selection of benchmark exercises for task 2.3	50 - VTT	9	HITEC Selection of benchmark exercises for task 2.3

Schedule of relevant Milestones

Milestone number¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS62	HITEC Task 2.1 Experimental test plan	50 - VTT	12	HITEC Task 2.1 Experimental test plan
MS63	HITEC Task 3.3 - Mathematical models – description of models and plan for improvements (Description of conceptual models and tools, plan for the models improvement)	50 - VTT	12	HITEC Task 3.3 - Mathematical models – description of models and plan for improvements (Description of conceptual models and tools, plan for the models improvement)
MS81	EURAD General Assembly n°3 + EURAD Annual Meeting 1	1 - ANDRA	13	EURAD General Assembly n°3 + EURAD Annual Meeting 1
MS83	GAS WP Meeting 3 jointly organised with the WP HITEC	32 - ONDRAF/NIRAS	13	GAS WP Meeting 3 jointly organised with the WP HITEC
MS84	HITEC WP Meeting 3 jointly organised with the WP GAS	50 - VTT	13	HITEC WP Meeting 3 jointly organised with the WP GAS
MS85	EURAD Periodic Report 1	1 - ANDRA	14	EURAD Periodic Report 1
MS103	EURAD General Assembly n°4	1 - ANDRA	19	EURAD General Assembly n°4
MS107	HITEC WP Meeting 4	50 - VTT	19	HITEC WP Meeting 4
MS112	EURAD Annual Work Plan 3	1 - ANDRA	21	EURAD Annual Work Plan 3
MS130	HITEC Task 3.3 -Modelling benchmarks – description (Description of calibration case, verification cases and benchmarks selected for T3.3 in cooperation with DONUT	50 - VTT	24	HITEC Task 3.3 -Modelling benchmarks – description (Description of calibration case, verification cases and benchmarks selected for T3.3 in cooperation with DONUT
MS136	EURAD General Assembly n°5 + EURAD Annual Meeting 2	1 - ANDRA	25	EURAD General Assembly n°5 + EURAD Annual Meeting 2
MS138	GAS WP Meeting 5 jointly organised with the WP HITEC	32 - ONDRAF/NIRAS	25	GAS WP Meeting 5 jointly organised with the WP HITEC
MS139	HITEC WP Meeting 5 jointly organised with the WP GAS	50 - VTT	25	HITEC WP Meeting 5 jointly organised with the WP GAS
MS140	EURAD Periodic Report 2	1 - ANDRA	26	EURAD Periodic Report 2
MS153	EURAD General Assembly n°6	1 - ANDRA	31	EURAD General Assembly n°6
MS158	HITEC WP Meeting 6	50 - VTT	31	HITEC WP Meeting 6
MS162	EURAD Annual Work Plan 4	1 - ANDRA	33	EURAD Annual Work Plan 4

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS185	EURAD General Assembly n°7 + EURAD Annual Meeting 3	1 - ANDRA	37	EURAD General Assembly n°7 + EURAD Annual Meeting 3
MS187	GAS WP Meeting 7 jointly organised with the WP HITEC	32 - ONDRAF/NIRAS	37	GAS WP Meeting 7 jointly organised with the WP HITEC
MS188	HITEC WP Meeting 7 jointly organised with the WP GAS	50 - VTT	37	HITEC WP Meeting 7 jointly organised with the WP GAS
MS189	EURAD Periodic Report 3	1 - ANDRA	38	EURAD Periodic Report 3
MS199	EURAD General Assembly n°8	1 - ANDRA	43	EURAD General Assembly n°8
MS203	HITEC WP Meeting 8	50 - VTT	43	HITEC WP Meeting 8
MS206	EURAD Annual Work Plan 5	1 - ANDRA	45	EURAD Annual Work Plan 5
MS207	HITEC Final Workshop on Influence of temperature on clay-based material behaviour	50 - VTT	46	HITEC Final Workshop on Influence of temperature on clay-based material behaviour
MS209	HITEC/GAS training n°2 on multi-physical coupling in geomechanics (especially THM and Gas coupling issues)	50 - VTT	46	HITEC/GAS training n°2 on multi-physical coupling in geomechanics (especially THM and Gas coupling issues)
MS220	GAS Chapter on pathway closure and sealing processes of the WP thematic report on barrier integrity as input to D6.8 (in common with HITEC WP)	32 - ONDRAF/NIRAS	48	GAS Chapter on pathway closure and sealing processes of the WP thematic report on barrier integrity as input to D6.8 (in common with HITEC WP)
MS222	EURAD General Assembly n°9 + EURAD Annual Meeting 4	1 - ANDRA	49	EURAD General Assembly n°9 + EURAD Annual Meeting 4
MS224	EURAD Periodic Report 4	1 - ANDRA	50	EURAD Periodic Report 4
MS234	EURAD General Assembly n°10	1 - ANDRA	55	EURAD General Assembly n°10
MS240	EURAD General Assembly n°11 + EURAD Annual Meeting 5	1 - ANDRA	60	EURAD General Assembly n°11 + EURAD Annual Meeting 5
MS241	EURAD Periodic Report 5	1 - ANDRA	60	EURAD Periodic Report 5 (Due date: 60+2)

Work package number ⁹	WP8	Lead beneficiary ¹⁰	39 - SKB
Work package title	Spent Fuel Characterization and Evolution Until Disposal (SFC)		
Start month	1	End month	48

Objectives

Objectives

- To produce experimentally verified procedures to reliably determine the nuclide content (here called source terms) of spent nuclear fuel (SNF), including realistic uncertainties.
- To establish beyond state-of-the-art characterization techniques for spent nuclear fuel during its evolution from reactor unloading until disposal (here called pre-disposal activities).
- To establish beyond state-of-the-art uncertainty quantification of the characteristics of the spent fuel during its evolution during pre-disposal activities.
- To understand the performance of the spent fuel during prolonged storage prior to its transport, during the transport and emplacement in a deep geological repository, in order to build the capability for ensuring the safety of all safety relevant operations.
- To understand the behaviour of fuel, cladding, pellet-cladding interaction and ageing effect under normal and postulated accident scenarios until disposal, in order to identify relevant or typical bounding cases at time of re-conditioning and pre-disposal activities (treatment, conditioning and transport).
- To provide contributions to operational safety concepts for fuel handling at SNF packaging facilities.
- To contribute to education, training and building of competence in the subject.

Please note that in the text of this work package, we use the words “source term” to denote only the nuclide content of spent fuel. We do not extend its meaning to release processes and corresponding mechanisms.

Interactions with existing European projects

The properties and behaviour of the spent nuclear fuel during its disposal after it is placed in the repository is out. SNF dissolution after emplacement in a deep geological repository is not part of this work package, since it is extensively covered in other projects (e.g. First Nuclides, DISCO).

Safety cases (as already done elsewhere) are out because they are often too nationally focused. General cases that can be of use for all of Europe can be included.

The work package will focus on BWR- and PWR-assemblies in the first wave of the programme, due to budget constraints. Other types, e.g. RBMK or VVER, will be deferred to be studied in a second wave for tasks where the budget was not enough. In this way, studies of those fuel types can then benefit from the methods and procedures developed in this first wave.

Three specific measurement techniques targeted to conditioned nuclear waste are studied in the CHANCE project; Calorimetry, Muon Tomography (MT) and Cavity Ring-Down Spectroscopy (CRDS). In this work package, calorimetry on nuclear fuel assemblies is studied which is complementary to the studies of conditioned waste studied in CHANCE. MT and CRDS are not studied in this WP.

Complementary to the CAST project, which dealt with the fate of a single radionuclide C-14 in metals, ion-exchange resins, Zircaloy, in task 2 we intend to determine inventories of a variety of radionuclides (fission products, activation products, even actinides).

The WP is complementary to the planned work in on back-end issues for Phase IV of the Studsvik Cladding Integrity Project (SCIP). Both projects have creep investigations but with different emphasis (e.g. local effects). Special or failed fuel rods are not focused here. Hydride reorientation in this WP is discussed mainly in comparison with the development of un-irradiated mock-up material. Fracture mechanics investigations are on classical hydride embrittlement (not delayed hydride failure as in SCIP-IV).

Expected impacts

Regarding RWM implementation needs

o The decay heat and reactivity of nuclear fuel assemblies determine the number of assemblies that can be loaded in a canister. Hence, these characteristics have an impact on the volume of underground galleries in a geological disposal. Therefore, a reduced uncertainty of the decay heat implies very large economical savings when constructing the repository.

Regarding safety

o Reduced uncertainties on safety related parameters.

o To contribute and further develop guidance on the operational safety of both interim storage and fuel packaging facilities.

o This WP will improve the current knowledge on the safety of spent nuclear fuel (SNF), by analysing the likely scenarios expected in a short-term framework for present operational facilities. Safety assessment on existing pre-disposal technologies will enable to predict the consequences of design changes, for example in case of a planned extension of operating time.

Regarding increasing scientific and technical Knowledge (beyond the state-of-the-art) in RWM

o Both fuel and cladding experience in time several degrading mechanisms (oxidation, corrosion, irradiation, etc.) that will inevitably affect their chemistries (oxidation state, chemical composition, microstructure, etc.) and hence alter their thermo-mechanical properties. The WP will provide new and meaningful insight on these mechanisms that are still not explained.

o The present WP is a significant contribution to the scientific and technical knowledge in the field of RWM as the conducted pioneering researchers will overcome several identified gaps and propose beyond-the-state-of-the-art scientific results.

o This WP will increase knowledge specific to the European case. Indeed, numerous experimental data gained from SNF tests mainly in the U.S. are known from literature. Such data are specifically correlated to the selected materials and do not cover European conditions, esp. higher burn-up of spent fuel, MOX fuel, temperature profiles and histories from vacuum drying procedures and subsequent storage conditions throughout Europe.

o In addition, the combination of both numerical calculations and experimental methods will also provide a complete and thorough understanding of the mechanisms driving the behaviour of the SNF rods during its extended storage in both normal and accidental conditions.

Regarding radioactive waste management routes

o Results from this WP will have a valuable impact from performance assessment and regulatory requirements point of view. These issues are closely connected in several EU countries to the licensing process for alternative storage schemes before the final disposal. The inclusion of WMOs in the project ensures that the research conducted in the proposed project will be relevant and useful for the ultimate goal of safe radioactive waste management. In addition, it provides a direct communication channel between researchers and implementing organizations.

o The results obtained in the project will contribute to the implementation of the EU Waste Directive and of the EC communication as the nuclear illustrative programme PINC.

The project will provide a better understanding of long-term uncertainties which would in turn address and reply to the fears and doubts of the EU citizens regarding the idea to develop a nuclear storage. The results obtained will provide a rigorous scientific approach to develop the technical bases for continued safe and secure storage of spent nuclear fuel, in terms of transport, retrieval and predisposal options

Description of work and role of partners

WP8 - Spent Fuel Characterization and Evolution Until Disposal (SFC) [Months: 1-48]

SKB, CEA, CIEMAT, ChRDI, CNRS, FTMC, ENRESA, JUELICH, JSI, JRC, KIT, LEI, MTA EK, NAGRA, PSI, SCK•CEN, SSTC NRS, SÚRAO, TUS, VTT

Description of work (where appropriate, broken down into tasks), lead partner and role of participants

Task 1 is focused on coordination of the work package. The S/T tasks are focused on building knowledge that is compiled and used in task 4. Task 5 is focused on the interaction with civil society in the S/T activities. The graphic below illustrates how the work package is constructed. Two groups of interested external parties, an “advisory group” and a “spent fuel owners’ group”, are constructed to provide a platform for exchange of experience and information. To these groups, representatives from other entities have been invited. A list of organisation that have initially shown an interest to participate are shown below. This list may be expanded during the programme.

List of organisation that have initially shown an interest to participate in an “advisory group” and a “spent fuel owners’ group”:

Organisation Country

Chalmers University of Technology SE

Czech Radioactive Waste Repository Authority (SÚRAO) CZ

Electric Power Research Institute (EPRI) USA

Endesa SP

Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) DE

Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) IT

Kharkov Institute of Physics and Technology UA

Lawrence Livermore National Laboratory USA

National Nuclear Laboratory UK

Oak Ridge National Laboratory USA

OECD NEA Data Bank OECD

Pacific Northwest National Laboratory USA

Radioactive Waste Management (RWM) UK

Studsvik (SCIP project) SE

Swedish Academic Initiative on Nuclear Technology Research (SAINT) SE

TS Enercon HU

University of Bristol UK

Tokyo Institute of Technology JP

Task 1 – S/T coordination, State-of-the-art and training material

Start: Month 1 – End: Month 48 - Task Leader: [SKB (UU)]

Task contributors: [CIEMAT] [JRC] [KIT-BAM] [NAGRA] [SKB (UU)]

Total PM: 12,3

Task objectives:

- To provide efficient management and administration of the work package, to identify potential problems at an early stage and provide timely and effective solutions.
- Developing/updating State-of-the-art, performing WP-specific gap analysis.
- Developing training materials as an input to KM.
- Collecting data from tasks 2-4.
- Collecting experience from the project to guide efforts in a possible future 2nd wave of the programme.

Subtask 1.1 – S/T coordination

Start: Month 1 – End: Month 48 –S/T Coordinator: [SKB (UU)]

Total PM: 4,3

The scientific and technical coordination of SFC will be performed by the WP Leader [SKB (UU)]. The WP Leader will be supported by the Task leaders and co-task leaders: [JRC] [KIT (BAM)] [CIEMAT] [PSI] [JUELICH (HZDR)] and [NAGRA] which together with [SKB (UU)] constitute the WP Board of SFC.

WP operational management and performance monitoring: The subtask will monitor compliance of the work package with the time schedule and ensure that all resources committed to this work package are mobilized. Monthly, ~one hour, remote status reporting meetings will be organised between the WP leader and task leaders with the purpose of monitoring progress with, and possible deviations from, the project plan. Performance and progress of the tasks are to be reported to the PMO.

WP information and communication management: The work package leader and task leaders are responsible for the internal information dissemination, not at least to ensure that project results are communicated for effective exploitation and dissemination of results.

Subtask 1.2 – State-of-the-art and Gap analysis

Start: Month 1 – End: Month 48 – Sub-task Leader: [NAGRA]

Subtask contributors: [KIT (BAM)] [CIEMAT] [JRC] [NAGRA]

Total PM: 4

1. Current state-of-the-art: The current state-of-the-art of nuclear fuel characterisation and evolution of its properties will be summarized in a state-of-the-art report (Deliverable 8.1). Already known gaps in knowledge should be included. Both experimental techniques and computational capabilities will be covered. The report will be living document that shall be distributed at least to other work packages and will be updated throughout the project. Deliverables of tasks 2-4 will be used to collect material for the report. The state-of-the-art report can contain commercial fuel types not currently included in tasks 2-4 such as, e.g., RBMK and VVER fuels.

2. Updated state-of-the-art: At the end of the project, the report describing state-of-the-art will be complemented with text on how state-of-the-art has been improved by contributions from the project (Deliverable 8.2). It shall include gaps of knowledge identified, but not covered, by the project as a means to guide future efforts in a possible 2nd wave of EURAD-1. All tasks in the work package will report updated state-of-the-art and gaps of knowledge throughout the project.

Subtask 1.3 – Training materials

Start: Month 24 – End: Month 48 – Sub-task Leader: [CIEMAT]

Subtask contributors: [KIT (BAM)] [CIEMAT] [JRC] [NAGRA]

Total PM: 4

Training material, in the form of e.g. lecture materials, containing state-of-the-art of nuclear fuel modelling, characterisation and evolution of nuclear fuel until disposal, is to be developed during the project in close link with KM Training/Mobility WP. Tasks 2-4 provides this training material as part of their respective reporting. In this subtask,

training materials are collected from participating organizations by the task leaders, and summarized in short annual reports describing the form of the materials (Deliverable 8.3).

Task 2 - Fuel properties characterisation and related uncertainty analysis

Start: Month 1 – End: Month 48 - Task Leader:[JRC]

Task Contributors: [CIEMAT] [FTMC] [SÚRAO (CTU)] [ENRESA] [JRC] [JSI] [KIT (PEL)] [LEI] [NAGRA] [SSTC NRS] [PSI] [SCK•CEN] [TUS] [SKB (UU)] [VTT]

Total PM: 190

Task objectives

The main objective is to produce experimentally verified procedures to determine reliable source terms of spent nuclear fuel (SNF), including realistic uncertainties. The focus is on source terms which are of primary importance for a safe, secure, ecological and economical handling, transport, intermediate storage and final disposal of SNF. The main source terms of interest are gamma-ray and neutron emission rate spectra, decay heat and the inventory of specific nuclides, i.e. activation products (e.g. ^{14}C and ^{36}Cl), long lived fission products (FP), fissile nuclides (^{235}U , ^{239}Pu) and minor actinides (^{241}Am , $^{242,244}\text{Cm}$). The inventory of fissile nuclides is needed for reactivity calculations to prevent criticality and for nuclear safeguards requirements. The inventory of activation products and long-lived FP are important to study the impact to the biosphere. Some of the FP (e.g. ^{148}Nd) are used for burnup determination.

The source term estimates are based on a combination of theoretical calculations and results of NDA measurements. The calculations involve neutron transport and nuclide creation and depletion codes. The results of such calculations strongly depend on nuclear data (including cross sections, FP yields, neutron emission probabilities and spectra, decay data,...), fuel fabrication data (design, composition), and reactor operation and irradiation conditions (burnup, neutron spectrum). The design, composition, production, operation and irradiation conditions will be referred to as "fuel history".

Procedures to estimate the source terms taking into account the different levels/qualities of fuel history documentation will be defined. In addition, recommendations will be given to improve the source term estimation. These recommendations include nuclear data requests for the nuclear data community, which will be an input for the NRFP-2018 call, and required details regarding fuel irradiation history to achieve targeted uncertainties. In a first phase the focus will be on medium burn-up SNF from BWR and PWR reactors. However, general purpose procedures will be proposed which are also valid for SNF of high burn-up UO_2 and MOX fuel. The focus on BWR and PWR is due to the availability of experimental data that can be used to verify and validate codes and the available budget.

The objectives will be realised by:

- comparing performance of different deterministic and stochastic transport and depletion codes
- performing theoretical calculations, including sensitivity analysis and full uncertainty propagation, using state-of-the-art methods and tools
- radiochemical analysis of BWR SNF samples with an average burn-up of 50 GWd/tHM with well documented fuel irradiation histories
- developing innovative methods to determine the nuclide inventory of SNF samples (UO_2/MOX) by NDA
- developing and improving NDA methods/systems to characterise SNF (UO_2/MOX) samples and assemblies
- characterisation by NDA of a SNF pellet with a well-known fuel history
- studying the importance of impurities in fuel and structural materials for characterisation of SNF and structural material irradiation
- determining the importance of fuel assembly structural materials to the overall SNF source term
- establishing correlation schemes between experimental observables and fuel parameters to improve information about SNF assemblies
- applying dedicated statistical analysis schemes to estimate average source terms including realistic confidence limits of a batch of SNF assemblies

The activities in Task 2 profit from the SKB-50 project, which is executed within the JRC(EURATOM)/DOE agreement, the First Nuclides project of FP7 and the REGAL Programme, which is organised by the SCK•CEN and supported by the JRC. The REGAL project provides access to results of radiochemical analysis. The SKB-50 project will provide results of the characterisation of BWR and PWR SNF assemblies by neutron (active and passive), gamma-ray and heat NDA measurements. It offers the possibility to have access to such data avoiding large investments to design and build dedicated NDA equipment and to pay for access to SNF material with a well-known fuel history. As compensation, we will improve the analysis procedures of the SKB-50 NDA measurements. Additionally, the objectives of the Task 2 activities are complementing the efforts organised by SKB and the OECD/NEA, with 20 organizations, to assess possible code biases and uncertainties in a so-called "blind test" for the determination of quantities of interest for issues related to SNF long-term storage or disposal. In general, this task will contribute with the generation of complementary and new data (i.e. neutron emission, decay heat, SNF reference sample) to what exists at present. Evidently this is of interest for the entire back-end chain (interim storage, cask transport, disposal) and demonstrates the relevance of Task 2 to current development in the back-end fuel cycle.

Subtask 2.1 – Theoretical study of SNF source terms

Start: Month 1 – End: Month 48 - Subtask Leader: [PSI]

Subtask contributors: [CIEMAT] [JSI] [NAGRA] [PSI] [SCK•CEN] [VTT]

Total PM: 39,1

SNF source terms can be determined theoretically by dedicated neutron transport and nuclide creation and depletion code systems. Confidence limits of calculated SNF source terms strongly depend on the quality of both the nuclear data and the documentation of the fuel history. It was shown that uncertainties on estimated SNF decay heat and neutron emission rates based on realistic cycle irradiation and nuclear data files can be higher than 10%, depending on the assembly burnup and cooling time. The impact of the model (single assembly or full core) and of the irradiation history is not negligible on calculated uncertainties, depending on the quantity of interest. This indicates the impact of the assumptions which are at the start of the SNF source term simulations. It shows the importance of user effects and calls for guidelines and recommendations to reduce user bias and define realistic confidence intervals.

To rationalise future recommendations, dedicated sensitivity analyses will be performed to define the nuclear data and fuel irradiation history parameters that have a dominant impact on the estimations. Realistic uncertainty margins based on the present status of the nuclear data libraries will be determined. In addition, nuclear data requirements to improve the source term estimations will be defined.

The performance of different code systems will be compared. To identify bias effects and obtain best estimates of the source terms together with their uncertainties, the same fuel assemblies will be used by all participants. This will indicate how well we believe SNF quantities can be calculated and with which confidence limits. To be efficient and in-line with the available budget, a small number (between 3 and 5) of PWR and BWR assemblies will be selected. They can refer to the SKB-50 project, with a large variety of assemblies, or the REGAL programme, as well as SFCOMPO, and can be complemented in subtask 2.2 by measured quantities. These assemblies will be defined at the start of the project. The performance of different stochastic and deterministic code systems will be compared based on the selected assemblies, presenting their advantages and drawback for SNF calculations and indicating the possible sources of biases. The considered systems are SCALE, SERPENT, MCNP (in combination with ACAB, ALEPH2, FISPACT and ORIGEN), and finally CASMO/SIMULATE/SNF. Source term uncertainty calculations will be based on the specific methods developed by each participant (e.g. Monte Carlo, conventional uncertainty propagation, Bayesian analysis).

This subtask involves the following activities:

- Compare and benchmark state-of-the-art codes for SNF depletion calculations based on the selected assemblies.
- Perform sensitivity studies and propagate nuclear data uncertainties to define confidence limits based on the present status of nuclear data libraries and identify nuclear data requiring improvement.
- Identify fuel irradiation history parameters that influence the source terms and propagate uncertainties of these parameters to the observables.
- A workshop will be organised to present the results of the different calculations: summarise the present status of transport and depletion codes and provide a list of nuclear data to be improved (month 24)

Subtask 2.2 – Develop, improve and demonstrate NDA methods/systems for SNF characterisation

Start: Month 1 – End: Month 48 - Subtask Leader: [SCK•CEN]

Subtask contributors: [CIEMAT] [JRC] [ENRESA] [SCK•CEN] [SKB (UU)]

Total PM: 85,1

The main objective is to assess and improve current NDA methods and develop innovative ones for the characterisation of SNF. The metrological parameters of the measurement and analysis processes will be identified to reduce bias effects and to evaluate uncertainties of the experimental observables. It will result in improved NDA systems providing data to verify and validate codes estimating the SNF source terms. Two types of measurement systems will be investigated: systems to characterise small SNF samples (including pellets) and systems to characterise entire SNF assemblies.

One of the most ambitious objectives is to demonstrate the characterisation of SNF samples by NRTA (Neutron Resonance Transmission Analysis). This NDA method determines the inventory of U, Pu and Am isotopes and main FP avoiding a complex chemical analysis. A successful completion of this activity will open new roots to characterise SNF samples with a substantial reduction in time, cost and man-power independent of the fuel type, hence, also applicable to MOX. In addition, a NDA detection system will be developed to measure directly the neutron output of a SNF pellet outside a hot cell in a conventional controlled area. The results obtained with NRTA together with decay heat and neutron emission measurements will complement existing radiochemical assays at pellet-level and electron probe micro-analyser (EPMA) measurements for elemental inventory.

NRTA will be applied to contribute to the most complete characterisation, world-wide, of a SNF pellet. Also the neutron emission rate and gamma-ray emission spectrum of the pellet will be determined by NDA. The pellet is part of a fuel pin from the REGAL programme for which both design and fabrication data, and the fuel irradiation history are extensively documented. Since the SNF pellet will not be destroyed for chemical analysis and fully characterised by NDA it can

be considered as a first world-wide reference fuel pellet. Neighbouring pellets of the reference pellet are characterised by radiochemical analysis as part of the REGAL programme.

Calorimetric, gamma-ray spectroscopic and active (DDA, Differential Die-Away) and passive (DDSI, Differential Die-Away Self-Interrogation) neutron measurements are carried out within the SKB-50 project to characterise a set of PWR and BWR assemblies at CLAB. The data reduction and analysis procedures of the calorimetric decay heat measurements at CLAB will be improved to achieve a target uncertainty of less than 2%. DDA and in particular DDSI have the potential to be included in the routine verification process of each SNF assembly. We will contribute to improve the analysis procedures for routine operation. These NDA methods including the analysis procedures and final results will be fully documented.

Innovative radiation resistant detectors, i.e. a CLYC detector and one based on diamond technology, will be developed and tested in high intense neutron and gamma-ray fields. These detectors can be used as stand-alone devices or can be integrated in larger detection systems such as DDA or DDSI

In addition to the characterisation of SNF by NDA, the nuclide inventory of a series of samples originating from BWR fuel that was irradiated to an average burn-up of above 40 GWd/tHM, determined by radio-chemical analysis will be provided. The samples being investigated cover a range of initial enrichments and coolant void histories. The results will be used for code validation.

This subtask involves the following activities:

- Develop and demonstrate beyond state-of-the-art NDA systems to characterise SNF pellets (determine the neutron emission rate and nuclide inventory)
- Improve the data analysis and uncertainty evaluation procedures of the NDA systems used at CLAB as part of the SKB-50 project: target uncertainty of less than 2% on the measured heat output
- Nuclide inventory by radiochemical analysis of a set of BWR SNF samples and results of the characterisation of a SNF pellet as part of the REGAL project (part of Deliverable 8.5)
- Develop and test innovative neutron and gamma-ray detectors for SNF characterisation
- A report will be produced (Deliverable 8.4) describing the principles and performance of NDA systems and innovative detection techniques used for the characterisation of SNF samples and assemblies
- Workshop presenting the results of the activities (month 36)

Subtask 2.3 – Determine the inventory of activation and fission products in cladding material

Start: Month 1 – End: Month 48 - Subtask Leader: [KIT]

Subtask contributors: [CIEMAT] [SÚRAO (CTU)] [KIT] [LEI] [NAGRA] [VTT]

Total PM: 17,7

The main objective is to analyse inventories of activation products and fission products of irradiated Zircaloy. The inventory of these products comprise the fraction that is formed during irradiation within Zircaloy and the fraction that is precipitated on the inner surface of the cladding. For the experimental studies, two kinds of samples will be used:

- clad fuel pellets of UO₂ (50 GWd/tHM) and mixed oxide fuel (38 GWd/tHM) irradiated in a pressurised water reactor (PWR).

- a plenum cladding obtained from a UO₂ fuel rod segment irradiated in a PWR.

Subsamples of these highly active claddings will be analysed by means of different (radio-)chemical analytical methods, such as classical nuclear spectroscopic methods (gamma-spectrometry, alpha-spectrometry, LSC) and ICP-mass spectrometry. Special efforts will be made to determine radionuclides critical for long-term safety of SNF, such as ¹⁴C and ³⁶Cl. These radionuclides will be separated using various extraction techniques and the extraction yield will be determined. Experimentally determined radionuclide inventories will be compared to calculated ones.

This subtask involves the following activities:

- preparation of sub-samples of irradiated materials in the KIT-INE shielded box-line
- digestion of sub-samples
- separation of ¹⁴C and ³⁶Cl using various extraction techniques and determination of the extraction yield; (radio-)chemical analyses of activation and fission products and actinides in dissolved samples (part of Deliverable 8.5)
- calculation of radionuclide inventories based on chemical compositions of the materials before irradiation (including trace contaminations) and irradiation histories based on a comparison of calculated and measured data, improved procedures for inventory determination will be assessed.

Subtask 2.4 – Define and verify procedures to determine the source terms of SNF assemblies with realistic confidence limits

Start: Month 13 – End: Month 48 - Subtask Leader: [KIT (PEL)]

Subtask contributors: [CIEMAT] [FTMC] [JRC] [ENRESA] [JSI] [SSTC NRS] [KIT (PEL)] [SCK•CEN] [TUS] [SKB (UU)]

Total PM: 48,1

The main objective is to define, verify and recommend state-of-the-art procedures to determine the source terms of SNF assemblies with realistic uncertainties. This is accomplished by focussing on at most two or three codes selected by the evaluation from 2.1 and applying them to a big SNF data set. One code will represent current industry standards (“best practice industry”) and another code (“sophisticated”) will represent the state-of-the-art developed in 2.1. The big data approach will minimize uncertainties from sources random in character: reactor irradiation histories, manufacturing parameters, experimental procedures and focus on the remaining, systematic biases in nuclear data, modelling and measurement methods.

The results of the calorimetric, gamma-ray spectroscopic, DDA and DDSI carried out within the SKB-50 project to characterise a set of PWR and BWR assemblies at CLAB will be made available to this WP. These data together with data produced in subtask 2.2 will be used in 2.4. Possibly also the results of the blind test measurements of SKB and selected data from SFCOMPO will be taken into consideration. Evidently, results of other projects that would offer full access to experimental data on characterisation of SNF assemblies and their history will also be considered.

Based on the analysis with the “best practice industry” code and the “sophisticated” code the reliability of current methods will be analysed and recommendations made for future developments and improvements.

Since experimental capacities are limited for the characterisation of SNF assemblies in an industrial environment, correlation schemes between observables of NDA experiments (gamma-ray spectroscopic, DDA and DDSI) and fuel history parameters will be extracted from the above analysis. This will reduce bias effects related to incomplete knowledge about fuel history parameters of a SNF assembly.

One of the codes considered in subtask 2.1 will be chosen based on its ability to propagate, as completely and as consistently as possible, the impact of nuclear data uncertainties, irradiation and burnup boundary conditions. Complementary to this the “best practice industry” code represents off-the-shelf, current industrial practices. To be efficient with the available budget and to maximise the payoff for all participants the focus will be on working on a common dataset and by selecting codes available to most participants.

Based on the comparison of results between these two categories of codes, procedures to estimate the SNF source terms in a production or industrial environment will be defined and recommended. They include realistic uncertainty margins based on recommended nuclear data libraries and depending on the quality of the input of the fuel irradiation history. These procedures will be largely focused on LWR SNF assemblies and the present status of the nuclear data files.

This subtask involves the following activities:

- Selection of two codes based on recommendations from 2.1 and distribution of workload among groups in order to make predictions for all of SKB-50’s results and the data produced in subtask 2.2 for all selected codes. If budget and time schedule allows data from SFCOMPO will be added.
- Document results and performance of “sophisticated” and “best-practice industry” code for the considered data sets. Quantify biases and stochastic components. Analyse for trends in results with regards to fuel parameters or irradiation histories. (Deliverable 8.6)
- Create correlation schemes between conventional fuel history parameters, e.g. burnup, initial enrichment, cooling time, and source term strengths (part of Deliverable 8.7)
- Define a procedure to estimate the SNF source terms including realistic uncertainty margins based on theoretical calculations with “best-practice industry” code and NDA measurements which can be routinely performed (Deliverable 8.6)
- workshop to present the final results of Task 2 (month 48)

Task 3 - Behaviour of nuclear fuel and cladding after discharge

Start: Month 1 – End: Month 48 - Task Leader: [KIT (BAM)]

Task contributors: [CIEMAT (UPM)] [CNRS-ICSM/CEMHTI (UMontpellier)] [JUELICH (HZDR)] [JRC] [KIT (BAM)] [MTA EK] [NAGRA] [PSI] [TUS] [VTT]

Total PM: 406,5

Task objectives

The aim of the work is to understand and describe numerically the behaviour of spent nuclear fuel (SNF), irradiated cladding, fuel/cladding chemical interaction (FCCI) and ageing effect under conditions of extended interim storage, transportation and emplacement in a final disposal system. These objectives will be achieved by involving experimental works and modelling studies.

The focus of the experimental studies is on the effect of hydrogen load, hydride distribution and fuel / clad interaction on the cladding integrity. Physicochemical and mechanical properties of claddings and of fuel pellets are influenced by various factors which will be examined in this task. Intrusion of air into a cladged SNF rod may cause oxidation and a significant swelling of the pellets, which may in turn stress the cladding and thereby contribute to crack initiation or propagation. Concerning the cladding degradation, one key issue influencing the nuclear fuel rod integrity is radial

hydride precipitation which reduces ductility during dry storage and raises the risk of accidents during handling. The experimental programme is planned to examine the integrity of the cladding in order to improve the predictive models on the dependence of the stress state and mechanical properties with the hydrogen chemical potential and temperature. The experimental studies will be applied over various non-irradiated and irradiated fuel types (UO₂, doped UO₂, high burn-up spent UO₂ fuel, spent MOX fuel) and clads. Provision of new experimental data on fuel behaviour (coupled with cladding) will improve the knowledge on consequences of extended storage on cladding stability, embrittlement, fissuring, creep, effect of corrosion resistance on SNF-cladding behaviour as well as oxidation of fuel and mechanical impact during storage and handling until disposal.

The modelling studies rely on general purpose software for finite element calculation and software for special applications. On one hand the experiments provide data for validation of the numerical simulations. On the other hand these numerical simulations are used to generate results beyond the available experimental data. By simulation of well-arranged experiments the understanding of the underlying processes and mechanisms is improved. Individual effects can be combined to complex scenarios which is the scientific background for the assessment of complex accident scenarios during storage e.g. a drop or an impact of SNF rods within casks. The change of initial or boundary conditions in the models enables predictions which can be hardly achieved by experimental work, e.g. extrapolation of results from hot cell experiments at room temperature to elevated temperatures.

Subtask 3.1 – Thermo-mechanical-chemical properties of the SNF rods and cladding

Start: Month 1 – End: Month 48 - Subtask Leader: [CIEMAT (UPM)]

Subtask contributors : [KIT (BAM)] [CIEMAT (UPM)] [JRC] [MTA-EK] [NAGRA] [PSI] [TUS] [VTT]

Total PM: 181,4

The subtask 3.1 focuses on the integrity of spent nuclear fuel rods affected by thermo-mechanical conditions as well as fuel/cladding chemical interaction. Objectives of the experimental studies are to quantify the effects of hydrogen load, hydride distribution and re-orientation as well as mechanical loading. Comparing studies of irradiated high-burnup material with non-irradiated but treated mock-up material allow the evaluation of validity and significance of laboratory tests outside of hot cells. Physicochemical and fracture mechanical properties of clads are influenced by various processes which will be examined by numerical simulations being complementary to the experimental studies of this sub-task (Deliverable 8.8).

The experimental conditions consider thermo-mechanical loads which would be expected during storage and transportation of used fuel. Generated experimental data and developed calculation methods including derived material models and parameters as well as failure criteria are an essential base for trustworthy simulations of accidental scenarios in task 4.

Subtask 3.2 – Behaviour of SNF pellets under interim storage conditions

Start: Month 1 – End: Month 48 - Subtask Leader: [CIEMAT]

Subtask contributors : [CIEMAT] [CNRS-CEMHTI/ICSM (UMontpellier)] [JUELICH (HZDR)]

Total PM: 147,5

The subtask 3.2 focuses on the behaviour of irradiated fuels and simulated spent nuclear fuel pellets both under (ab-)normal dry interim storage conditions and under conditions of water contact, i.e. container or cladding failure scenarios, respectively. The main goal is to provide new insights on the ageing and degradation mechanisms of the SNF (e.g. He build-up, oxidation of the SNF, influence of the various fission products, etc.). The potential evolution of the SNF in case of mal operations conditions (e.g. moisture, aqueous dissolution of the UO₂ matrix, corrosion of the SNF, etc.) will be also considered. The whole of these phenomena will be investigated combining both numerical methods and experimental techniques. Cutting-edge synchrotron methods at the Rossendorf beamline (i.e. high resolution diffraction, x-ray absorption spectroscopy and x-ray emission spectroscopies) will be performed to understand these degrading mechanisms at the atomic level (Deliverable 8.9).

Subtask 3.3 – Pellet-cladding interaction under conditions of extended storage, transport and handling of SNF rods.

Start: Month 6 – End: Month 48 - Subtask Leader: [CIEMAT]

Subtask contributors : [CIEMAT] [KIT] [MTA-EK] [PSI]

Total PM: 77,6

The objective of this subtask 3.3 is to study the pellet-cladding interaction, in particular chemical effects of activation and fission products on the cladding integrity, and activity release considerations under dry storage and subsequent transportation conditions.

Analyses of pellet/cladding interactions will be performed using non-irradiated UO₂ fuel, high burn-up UO₂ fuel and MOX fuel irradiated in commercial PWR. Morphological and chemical/spectroscopic analyses of the fuel/cladding interfaces and claddings will be performed by means of XPS, RAMAN, SEM, XAS to elucidate FCCI mechanisms and provide radionuclide inventories and chemical speciation. High energy resolution XAS and XES analyses of the

radionuclide speciation at the interface of the various fuel types and claddings will be carried out, going beyond conventional fluorescence XAS studies (Deliverable 8.10).

Task 4 - Accident scenario and consequence analysis

Start: Month 1 – End: Month 48 - Task Leader: [CIEMAT]

Task contributors: [CEA] [ChRDI] [CIEMAT (IDOM)] [NAGRA] [TUS]

Total PM: 74,1

The main goal of this work package is to study SNF behaviour under accident conditions which may lead to a potential loss of confinement during storage, transport and pre-disposal activities. As a result, the task will be fed by the empirical formulations in conjunction with mathematical numerical models produced in task 2 and task 3 and building up synergetic activities, to the development of concepts for the mitigation of the consequences. One key issue which may influence the performance of nuclear fuel rods during dry storage is hydrogen embrittlement, especially radial hydride precipitation. Radial hydrides may affect the cladding ductility, which can be critical in relevant operations, i.e. transport, handling, etc. In addition, in those countries where centralised interim storage is considered, other potential accident scenarios can be considered.

In the postulated case of loss of integrity of the cladding barrier, the penetration of oxygen into the spent fuel matrix should also be considered, which can lead to a relatively fast corrosion process with consequent degradation of the fuel. The task 4 will amalgamate the experimental findings like mechanical response of the SNF to external loading and fuel release quantification as consequence of cladding failure tackled in previous work but reshaped to the accidental scenarios conditions.

A further goal would be to perform criticality safety analysis for credible transport accident scenarios after long-term storage, including significant fuel rod failure and in-cask fuel distribution, and to determine the accumulated doses in materials relevant for moderation and/or shielding, e.g. polyethylene (PE) rods or plates.

The main tasks aim to contribute to ensuring the safe packaging of the fuel in the disposal canisters. This can be achieved through the following steps:

- Identification and description of potential accident scenarios (Deliverable 8.11);
- Study of potential accident scenarios during transport and long-term dry interim storage of spent nuclear fuel as well as fuel handling operations, such as fuel unloading from T/S casks (Deliverable 8.11);
- In-depth experimental study on spent rodlet (UOX or MOX) that underwent oxidation treatment, emulating accidental conditions (part of Deliverable 8.12);
- Development of a fuel assembly FEM (based on Task 3 findings like load-displacement curves derived with 3-point bending tests performed on commercial spent fuel rods) with the aim of evaluating mechanical response and possible failure locations under relevant operational/accident loading scenarios (Deliverable 8.12);
- To perform a consequence analysis of postulated accidents also by means of experimental investigations on fuel rod (also here based on Task 3 findings like impact/crash tests) and numerical simulations (Deliverable 8.12);
- To carry out an assessment of criticality safety for accident scenarios (fuel release estimation from Task 3 activities like impact/crash tests) (Deliverable 8.11);
- Consideration of environmental factors during storage and analysis of the degradation dynamics of the state of containers (Deliverable 8.13).

Subtask 4.1 – Accident scenario for fuel under dry interim storage conditions

Start: Month 6 – End: Month 48 - Subtask Leader: [NAGRA]

Subtask contributors : [CEA] [CIEMAT] [NAGRA] [TUS]

Total PM: 29,9

The subtask aims to provide a synthetic analysis of identified potential but credible accident scenarios related to the transport and long-term dry interim storage of SNF. Furthermore, given the availability of results from Tasks 2 and 3, to be translated into realistic operational conditions (such as in a dry storage facility), a finite element analysis will be conducted to estimate fuel response to normal and accident conditions during fuel handling (Deliverable 8.11).

The development of a methodology trying to link degradation mechanisms to fuel performance and possible accident scenarios would be beneficial to support future specific National Programmes in relation of a safe management of SNF during interim storage and related operations.

In the case of accident conditions during transport, two main specific objectives are planned (Deliverable 8.12):

1. Establishment of a comprehensive methodology for assessing the postulated scenarios, based on analytical tools with 3D capabilities (e.g. FEM with ANSYS);
2. Development of an engineering methodology capable of assessing the scenarios with considerably less computational cost and without losing accuracy (on the basis of previous scenarios analysis).

Regarding accident conditions in interim storage, two specific tasks are to be tackled (part of Deliverable 8.12):

1. Development of a vault model adapted to a lumped parameter code (e.g. MELCOR).

2. Based on this, establishment of a methodology for the determination of the potential source term (activities from Task 2 on characterisation of SNF to be used as supporting material).

An in-depth experimental study is also planned on spent UOX or MOX rodlet to determine which modification in the fuel may lead under accidental scenarios to cracks in the Zy4 cladding (Task 3 findings as starting point).

A possible activity in the T/S cask issue would be to address the case of loss of internal pressure in the cask, in particular the galvanic corrosion of metallic outer lid seals on multiple storage cask lids, between the aluminium seal and the stainless-steel cask body (Deliverable 8.12).

Subtask 4.2 – Consequence analysis of accident scenarios

Start: Month 13 – End: Month 48 - Subtask Leader: [ChRDI]

Subtask contributors : [ChRDI] [CIEMAT (IDOM)] [NAGRA] [TUS]

Total PM: 44,2

Experimental investigations and analytical studies from Tasks 2, 3 and 4.1 are considered to assess accident scenarios with loss of cladding integrity. The experimental derivation of fuel mass release from fuel impact and/or rupture tests (i.e. activities foreseen in Task 3.1) is intended to serve as a basis for defining worst-case accident scenarios with the aim of avoiding the over-conservative assumptions commonly used nowadays. This would be valuable for the assessment of accident scenarios during storage, transport or handling of the SNF, such as the possible re-criticality of the fuel. The safety margins of the fuel and related uncertainties (nuclear data, geometric uncertainties, design uncertainties...) will be carefully assessed.

The experience gained from investigating the real consequences of beyond design basis accident at Chernobyl NPP would also support the assessment of simulation models for radiation release and environmental impact.

Furthermore, experimental characterisation techniques developed in Task 2 (like Neutron Resonance Transmission Analysis) can be integrated here for the burn-up verification limit as requirement for criticality safety (acceptance criteria) (Deliverable 8.12).

Different transport accident scenarios including partial fuel rod failure of varying extent, are to be considered and criticality safety analysis for different loading schemes for transport/storage casks (loaded with LWR fuel) will be addressed. Shielding property degradation and the related impact on dose-rate are to be considered. Calculation tools: SCALE package, MCNP, GRS home-built DORTABLE (shielding only). The re-criticality of the irradiated fuel will be evaluated in the case of accident conditions. Detailed MCNP calculations will be performed to evaluate the possible re-criticality level of specific accident geometric re-configurations (Deliverable 8.12).

Other valuable studies foreseen are: analysis of the dynamics of the state of emergency radioactive waste packages that were stored after the Chernobyl catastrophe. Consideration of environmental factors during storage (results from monitoring data on the state of the containers for 32 years) with respect to the performance of engineering barriers; e.g. analysis of the degradation dynamics of the state of containers with liquid radioactive waste and solid radioactive waste stored at the specialised sites of Ukrainian NPPs. Modelling of degradation of containers for storage of spent nuclear fuel Transportation of emergency radioactive materials and emergency nuclear fuel to places of their temporary storage, forecasting of possible radiation accidents during transportation (part of Deliverable 8.12; deliverable 8.13).

Participation per Partner

Partner number and short name	WP8 effort
5 - CEA	10.90
6 - CIEMAT	160.27
IDOM	14.21
UPM	48.00
7 - ChRDI	4.50
8 - CNRS	71.10
UMontpellier	8.00
10 - FTMC	3.83
14 - ENRESA	2.39

Partner number and short name	WP8 effort
15 - JUELICH	0.00
HZDR	36.00
22 - JSI	10.80
23 - JRC	63.48
24 - KIT	19.34
PEL	2.10
BAM	30.00
25 - LEI	7.00
26 - MTA EK	22.00
27 - NAGRA	8.84
34 - PSI	30.10
38 - SCK•CEN	15.54
39 - SKB	0.00
UU	54.72
40 - SSTC NRS	3.12
42 - SÚRAO	0.00
CTU	0.44
46 - TUS	16.97
50 - VTT	10.00
Total	653.65

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D8.1	SFC - State-of-the-art report	27 - NAGRA	Report	Public	6
D8.2	SFC - Updated State-of-the-art report	27 - NAGRA	Report	Public	48
D8.3	SFC - Summary of training materials produced during the SFC WP	6 - CIEMAT	Report	Public	48
D8.4	SFC - principles and performance of NDA systems and innovative detection techniques used for the characterisation of SNF samples and assemblies	23 - JRC	Report	Public	36

List of deliverables

Deliverable Number¹⁴	Deliverable Title	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
D8.5	SFC - results of the characterisation of SNF samples by NDA and radiochemical analysis: results from subtasks 2.2 and 2.3	38 - SCK•CEN	Report	Public	48
D8.6	SFC - performance of “sophisticated” and “best-practice industry” codes based on SKB-50 data and data produced in subtask 2.2 and 2.3	34 - PSI	Report	Public	48
D8.7	SFC - recommended procedures to determine the SNF source terms	39 - SKB	Report	Public	48
D8.8	SFC - Thermo-mechanical-chemical properties of unirradiated and irradiated samples of spent nuclear fuel rod segments and cladding	24 - KIT	Report	Public	48
D8.9	SFC - Influence of oxygen and fission products on microstructure of UO ₂ fuel and He within the UO ₂ matrix	15 - JUELICH	Report	Public	48
D8.10	SFC - Chemical and structural / crystallographic properties of simulated fuel pellets and irradiated fuel pellets at the cladding/fuel interface	24 - KIT	Report	Public	48
D8.11	SFC - Identification and analysis of potential accident scenarios for fuel assembly damage and fuel material release during fuel handling in an interim storage and/or packaging facility	27 - NAGRA	Report	Public	36
D8.12	SFC - Assessment of fuel performances for a postulated accident scenario under storage conditions: re-criticality, integrity under	6 - CIEMAT	Report	Public	48

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
	mechanical loads and container degradation studies				
D8.13	SFC - Analysis of the dynamics of the state-of-emergency radioactive waste packages from the Chernobyl catastrophe	7 - ChRDI	Report	Public	36

Description of deliverables

Task 1

- D8.1 State-of-the-art report - this report will summarize the state-of-the-art of nuclear fuel characterisation and evolution of its properties at the beginning of the WP

Lead [NAGRA] Month 6.

- D8.2 Updated State-of-the-art report - the report will describe how state-of-the-art has been improved by contributions from the WP. It shall include gaps of knowledge identified, but not covered, by the WP as a means to guide future collaborative research efforts

Lead [NAGRA] Month 48

- D8.3 Summary of training materials produced during the SFC WP - This report will compile training material, in the form of e.g. lecture materials, containing state-of-the-art of nuclear fuel modelling, characterisation and evolution of nuclear fuel until disposal, that will be developed during the WP in close link with KM Training/Mobility WP. Lead: [CIEMAT] Month 48

Task 2

- D8.4 principles and performance of NDA systems and innovative detection techniques used for the characterisation of SNF samples and assemblies Lead: [JRC] Month 36

- D8.5 results of the characterisation of SNF samples by NDA and radiochemical analysis: results from subtasks 2.2 and 2.3 Lead: [SCK•CEN] Month 48

- D8.6 performance of “sophisticated” and “best-practice industry” codes based on SKB-50 data and data produced in subtask 2.2 and 2.3 Lead: [PSI] Month 48,

- D8.7 recommended procedures to determine the SNF source terms including realistic source terms using “best-practice industry codes combined with results of NDA of the SNF assembly under industrial conditions during the loading process Lead: [SKB (UU)] Month 48

Task 3

- D8.8 Thermo-mechanical-chemical properties of unirradiated and irradiated samples of spent nuclear fuel rod segments and cladding Lead: [KIT (BAM)] Month 48

- D8.9 Influence of oxygen and fission products on microstructure of UO₂ fuel and He within the UO₂ matrix Lead: [JUELICH (HZDR)] Month 48

- D8.10 Chemical and structural / crystallographic properties of simulated fuel pellets and irradiated fuel pellets at the cladding/fuel interface Lead: [KIT] Month 48

Task 4

- D8.11 Identification and analysis of potential accident scenarios for fuel assembly damage and fuel material release during fuel handling in an interim storage and/or packaging facility.

Lead: [NAGRA] Month 36

- D8.12 Assessment of fuel performances for a postulated accident scenario under storage conditions: re-criticality, integrity under mechanical loads and container degradation studies. Lead: [CIEMAT] Month 48

- D8.13 Analysis of the dynamics of the state-of-emergency radioactive waste packages from the Chernobyl catastrophe Lead: [ChRDI] Month 3

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D8.1 : SFC - State-of-the-art report [6]

SFC - State-of-the-art report

D8.2 : SFC - Updated State-of-the-art report [48]
SFC - Updated State-of-the-art report
D8.3 : SFC - Summary of training materials produced during the SFC WP [48]
SFC - Summary of training materials produced during the SFC WP
D8.4 : SFC - principles and performance of NDA systems and innovative detection techniques used for the characterisation of SNF samples and assemblies [36]
SFC - principles and performance of NDA systems and innovative detection techniques used for the characterisation of SNF samples and assemblies
D8.5 : SFC - results of the characterisation of SNF samples by NDA and radiochemical analysis: results from subtasks 2.2 and 2.3 [48]
SFC - results of the characterisation of SNF samples by NDA and radiochemical analysis: results from subtasks 2.2 and 2.3
D8.6 : SFC - performance of “sophisticated” and “best-practice industry” codes based on SKB-50 data and data produced in subtask 2.2 and 2.3 [48]
SFC - performance of “sophisticated” and “best-practice industry” codes based on SKB-50 data and data produced in subtask 2.2 and 2.3
D8.7 : SFC - recommended procedures to determine the SNF source terms [48]
SFC - recommended procedures to determine the SNF source terms
D8.8 : SFC - Thermo-mechanical-chemical properties of unirradiated and irradiated samples of spent nuclear fuel rod segments and cladding [48]
SFC - Thermo-mechanical-chemical properties of unirradiated and irradiated samples of spent nuclear fuel rod segments and cladding
D8.9 : SFC - Influence of oxygen and fission products on microstructure of UO ₂ fuel and He within the UO ₂ matrix [48]
SFC - Influence of oxygen and fission products on microstructure of UO ₂ fuel and He within the UO ₂ matrix
D8.10 : SFC - Chemical and structural / crystallographic properties of simulated fuel pellets and irradiated fuel pellets at the cladding/fuel interface [48]
SFC - Chemical and structural / crystallographic properties of simulated fuel pellets and irradiated fuel pellets at the cladding/fuel interface
D8.11 : SFC - Identification and analysis of potential accident scenarios for fuel assembly damage and fuel material release during fuel handling in an interim storage and/or packaging facility [36]
SFC - Identification and analysis of potential accident scenarios for fuel assembly damage and fuel material release during fuel handling in an interim storage and/or packaging facility
D8.12 : SFC - Assessment of fuel performances for a postulated accident scenario under storage conditions: re-criticality, integrity under mechanical loads and container degradation studies [48]
SFC - Assessment of fuel performances for a postulated accident scenario under storage conditions: re-criticality, integrity under mechanical loads and container degradation studies
D8.13 : SFC - Analysis of the dynamics of the state-of-emergency radioactive waste packages from the Chernobyl catastrophe [36]
SFC - Analysis of the dynamics of the state-of-emergency radioactive waste packages from the Chernobyl catastrophe

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	EURAD Kick-off meeting (General Assembly n°1)	1 - ANDRA	1	EURAD Kick-off meeting (General Assembly n°1)

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS12	EURAD EJP Newsletters	1 - ANDRA	3	EURAD EJP Newsletters (Due date : M3 and then every quarter)
MS29	SOTA from RD&D SFC WP as input to UMAN T3.5	39 - SKB	6	SOTA from RD&D SFC WP as input to UMAN T3.5
MS30	EURAD General Assembly n°2	1 - ANDRA	7	EURAD General Assembly n°2
MS42	EURAD Annual Work Plan 2	1 - ANDRA	9	EURAD Annual Work Plan 2
MS64	SFC Task 2.3 Characteristics of irradiated material to be characterised	39 - SKB	12	SFC Task 2.3 Characteristics of irradiated material to be characterised
MS81	EURAD General Assembly n°3 + EURAD Annual Meeting 1	1 - ANDRA	13	EURAD General Assembly n°3 + EURAD Annual Meeting 1
MS85	EURAD Periodic Report 1	1 - ANDRA	14	EURAD Periodic Report 1
MS103	EURAD General Assembly n°4	1 - ANDRA	19	EURAD General Assembly n°4
MS112	EURAD Annual Work Plan 3	1 - ANDRA	21	EURAD Annual Work Plan 3
MS126	SFC Task 2.1 Workshop – 24	39 - SKB	24	SFC Task 2.1 Workshop – 24
MS136	EURAD General Assembly n°5 + EURAD Annual Meeting 2	1 - ANDRA	25	EURAD General Assembly n°5 + EURAD Annual Meeting 2
MS140	EURAD Periodic Report 2	1 - ANDRA	26	EURAD Periodic Report 2
MS153	EURAD General Assembly n°6	1 - ANDRA	31	EURAD General Assembly n°6
MS162	EURAD Annual Work Plan 4	1 - ANDRA	33	EURAD Annual Work Plan 4
MS175	SFC Task 2.2 Workshop – 36	39 - SKB	36	SFC Task 2.2 Workshop – 36
MS185	EURAD General Assembly n°7 + EURAD Annual Meeting 3	1 - ANDRA	37	EURAD General Assembly n°7 + EURAD Annual Meeting 3
MS189	EURAD Periodic Report 3	1 - ANDRA	38	EURAD Periodic Report 3
MS199	EURAD General Assembly n°8	1 - ANDRA	43	EURAD General Assembly n°8
MS206	EURAD Annual Work Plan 5	1 - ANDRA	45	EURAD Annual Work Plan 5
MS218	SFC Task 2.4 Workshop – 48	39 - SKB	48	SFC Task 2.4 Workshop – 48
MS222	EURAD General Assembly n°9 + EURAD Annual Meeting 4	1 - ANDRA	49	EURAD General Assembly n°9 + EURAD Annual Meeting 4
MS224	EURAD Periodic Report 4	1 - ANDRA	50	EURAD Periodic Report 4

Schedule of relevant Milestones

Milestone number¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS234	EURAD General Assembly n°10	1 - ANDRA	55	EURAD General Assembly n°10
MS240	EURAD General Assembly n°11 + EURAD Annual Meeting 5	1 - ANDRA	60	EURAD General Assembly n°11 + EURAD Annual Meeting 5
MS241	EURAD Periodic Report 5	1 - ANDRA	60	EURAD Periodic Report 5 (Due date: 60+2)

Work package number ⁹	WP9	Lead beneficiary ¹⁰	19 - IRSN
Work package title	Waste management routes in Europe from cradle to grave (ROUTES)		
Start month	1	End month	60

Objectives

Objectives

- Provide an opportunity to share experience and knowledge on waste management routes between interested organisations (from different countries, with programmes at different stages of development, with different amounts and types of radioactive waste to manage).
- Identify safety-relevant issues and their R&D needs associated with the waste management routes (cradle to grave), including the management routes of legacy and historical waste, considering interdependencies between the routes.
- Describe and compare the different approaches to characterisation, treatment and conditioning and to long-term waste management routes, and identify opportunities for collaboration between MS (Member-States).

The WP will consider experience of completed and on-going EU projects, such as THERAMIN, CHANCE on the topics of interest and other initiatives carried out at international level such as IAEA, NEA.

Expected impacts

Regarding RWM implementation needs

In the work package a gap analysis is conducted with respect to RD&D activities and strategic needs required for implementation of the different spent fuel and radioactive waste management and disposal routes in Europe. This gap analysis is based on experience and operational feedback from the participants and makes use of past and present EU projects on the topics of interest and other initiatives carried out at international level including those of the IAEA and OECD/NEA.

Regarding safety

Safety-relevant issues and R&D needs associated with the waste management routes (cradle to grave) will be identified, considering waste characterization, the development of waste acceptance criteria (WAC) prior to the availability of disposal facilities, options for disposal of small waste inventories, and options to share technology and facilities.

Regarding increasing scientific and technical Knowledge (beyond the state-of-the-art) in the field of RWM

No new research will be conducted in the work package. Rather, it will consolidate and integrate existing knowledge to identify good practices and challenges, and to provide guidance for research activities in the second wave of activities or in subsequent EURAD implementation phases..

Regarding radioactive waste management routes

In addition to providing an overview of good practices for different steps in radioactive waste management and guidance for research activities, the work package will provide an opportunity to consider sharing of technology and facilities. As such, it will support countries with early-stage programme / small inventory programmes (SIMS small inventory member state) in the development of their national RWM programmes, for compliance with the Council Directive 2011/71 EURATOM. The results will provide a strong input to KM WPs, in particular to support knowledge transfer in the RWM over generation.

Description of work and role of partners

WP9 - Waste management routes in Europe from cradle to grave (ROUTES) [Months: 1-60]

IRSN, ANDRA, ARAO, BEL V, CEA, CIEMAT, COVRA, FTMC, Dekom, EEAE, JUELICH, GRS, IAE, INCT, IST, IST ID, JSI, LEI, NCSR, NES, NJF, NRG, ONDRAF/NIRAS, RATEN, SCK•CEN, SKB, SSTC NRS, STUBA, SÚRAO, SURO, TS Enercon, TUS, UCyprus, VTT, VUJE

Description of work

Task 1 – S/T coordination, State-of-the-art and training material

Start: Month 1 – End: Month 60 - Task Leader: [IRSN]

Task Contributors: [Andra] [JUELICH] [IRSN] [NCRSD (DMT)] [ONDRAF/NIRAS] [COVRA] MKG

Total PM: 6,3

Subtask 1.1 – S/T coordination

Start: Month 1 – End: Month 60- Subtask Leader: [IRSN]

Total PM: 2

Coordination of the WP is performed both at the WP and the task level. Subtask 1.1 describes the coordination work performed by the WP leader at the WP level. The coordination work performed by other task leaders is included in the description of the other tasks. The technical coordination of ROUTES will be performed by the WP Leader [IRSN]. The WP Leader will be supported by the Task leaders [Andra] [JUELICH] [ONDRAF/NIRAS] [NCRSD (DMT)] [COVRA] which together with [IRSN] constitute the WP Board of ROUTES. The WP Leader will make sure that the rules of EURAD are followed by all partners, that the scientific milestones and deliverables are reached timely, and that the results are disseminated efficiently inside and outside the project.

Subtask 1.1 consists of the following actions:

- Organisation of the annual ROUTES WP meetings (WPM) and the WP Board meetings (2 per year);
- Participation in WP board meetings to ensure that the project is progressing according to the agreed specifications, milestones and planning ;
- Reporting to the PMO of the work progress and of possible modifications of the WP work plan;
- Coordinate the exchanges with NEA and IAEA and with relevant projects such as CHANCE, THERAMIN, , etc.

Some meeting points will be proposed with the SHARE CSA on decommissioning in order to exchange on needs/ solutions and build a common Roadmap in the field of management of waste coming from decommissioning. Some R&D topics coming out of SHARE roadmap could be addressed in common in the future. EURAD addresses all kinds of waste, not only from decommissioning and it could be of interest to discuss about common solution including waste from operations, legacy waste and waste from dismantling

A kick off meeting (month 2) will be organised in order to, in particular, develop a collective questionnaire for collecting information from the organisations involved in this WP on Member-States practices in waste management as an input the task 2, 3, 4 and 6. This will be done in collaboration with their task leaders.

List of ROUTES annual WP meetings (WPM):

- ROUTES Kick-off meeting (ROUTES WPM1) (month : 1)
- ROUTES WPM2 (Month: 13)
- ROUTES WPM3 (Month: 25)
- ROUTES WPM4 (Month: 37)
- ROUTES WPM5 (Month: 49)
- ROUTES WPM6 (Month: 60)

Subtask 1.2 – Interactions with KM WP

Start: Month 1 – End: Month 60- Subtask Leader: [IRSN]

Total PM: 2

Fundamental R&D will not be undertaken as part of strategic studies. Nonetheless, the work carried out in WP9- ROUTES Tasks 2 to 6 could lead to the development/improvement of strategies, approaches/tools, and collaboration between participants will raise the general level of knowledge across Europe. The knowledge consolidated or generated through knowledge/know-how sharing and discussions of common challenging issues will constitute a valuable input to EURAD KM activities (i.e. guidance, state-of-knowledge).

This subtask will consist in the following actions:

- Interacting with KM WPs regarding the input of the WP to the state-of-knowledge, guidance and training/mobility in terms of content and format (IRSN - 0,25 pm)
- Development of training material (input to KM WP3) (IRSN - 1,75 pm) D9.1

Subtask 1.3 – Integration

Start: Month 13 – End: Month 60- Subtask Leader: [IRSN]

Subtask contributors: [IRSN] [Andra] [JUELICH] [ONDRAF/NIRAS] [NCRSD (DMT)] [COVRA]

Total PM: 2,3

This subtask will consist in integrating the recommendations for future RD&D, strategic study and KM activities arising in other tasks – related deliverables: D9.2 and D9.3. [IRSN] [Andra] [JUELICH] [ONDRAF/NIRAS][NCRSD (DMT)] [COVRA]

Task 2 - Identify challenging wastes to be collaboratively tackled within EURAD

Mapping and shared understanding at EU level of practical issues on waste management routes

Start: Month 1 – End: Month 48 - Task Leader: [Andra] and [SSTC NRS]

Task contributors: [Andra] [BEL V] [CEA (ORANO)] [CIEMAT] [EEAE] [FTMC] [JUELICH] [GRS] [IAE] [INCT] [IRSN] [IST-ID] [IST-LPSR] [JSI] [LEI] [NCSRSD (DMT)] [NES] [NRG] [ONDRAF/NIRAS] [RATEN] [SÚRAO] [SCK.CEN] [SKB] [SSTC NRS] [STUBA] [SURO] [TS Enercon] [TUS] [UCY] [VTT (GSL)]

Total PM: 29,1

Task objectives:

- Identify challenging wastes and related difficult issues to be collaboratively tackled within the Joint Programme, such as: Sludge; Organic waste; Ion exchange resin; Bituminized waste; Graphite waste; Uranium/radium/thorium bearing waste; Decommissioning waste (soil, rubble etc.); Particular spent fuel such as metal uranium and aluminium cladding; Disused radioactive sealed sources (from category 1 to 5, including neutron sources and radium sources); Waste containing reactive metals such as aluminium, magnesium, zirconium, sodium; Waste containing chemotoxic material such as beryllium, mercury, asbestos, lead; Legacy waste.

- Map and share understanding at EU level of the practical issues on waste management routes, taking into account specific issues relating to challenging wastes and small inventory programmes.

Subtask 2.1 – Collection and analysis of existing work on categorisation and classification of radioactive waste with regard to disposal options, identification of waste for which there is not yet a complete management plan in each Member State, identification of waste management routes for pre-disposal steps Start: Month 1 – End: Month 24- Subtask Leader: [Andra] [SSTC NRS]

Subtask contributors: [BEL V] [CIEMAT] [FTMC] [JUELICH] [GRS] [VTT (GSL)] [RATEN] [IRSN] [IST-LPSR] [IAE] [JSI] [LEI] [NRG] [SCK.CEN] [ONDRAF/NIRAS] [CEA (ORANO)] [SKB] [SÚRAO] [SURO] [TS Enercon] [TUS] [UCY] [Andra] [SSTC NRS] [NCRSD (DMT)] [EEAE] [INCT] [NES] [STUBA]

Total PM: 23,2

This subtask will start with an up-to-date overview on radioactive waste categorisation/classification based on contributions from participants (collection and synthesis of answers to questionnaire, see Task 1). Outcomes of NEA and IAEA initiatives on waste classification will be used in parallel. Comprehensive contributions on waste without complete management plans in participating states will also be collected.

Experience and knowledge on pre-disposal steps will be shared, describing and comparing the different approaches, defining R&D needs and identifying opportunities of collaboration. The particular problems to be solved for challenging wastes will be described, relating to their pre-disposal steps and in view of their disposal. Specific challenges arising from having just a limited volume of waste will also be addressed. The work takes into account information gained in other EU projects such as CHANCE and THERAMIN.

Sharing experience and knowledge will make it possible to establish an accurate and consistent list of challenging wastes in terms of their categorisation as well as their management route.

An exchange meeting will be organized during Subtask 2.1 (month 7).

The results and outputs of Task 2.1 will be compiled in a final report D9.4.

Subtask 2.2 - Understanding at EU level of the practical issues on RWM routes for challenging waste Start: Month 13 – End: Month 48- Subtask Leader: [Andra] [SSTC NRS]

Subtask contributors: [BEL V] [CIEMAT] [FTMC] [NCRSD (DMT)] [EEAE] [VTT (GSL)] [INCT] [JUELICH] [GRS] [RATEN] [IRSN] [IST-LPSR] [JSI] [LEI] [NRG] [NES] [SCK.CEN] [ONDRAF/NIRAS] [CEA (ORANO)] [SKB] [SÚRAO] [SURO] [TS Enercon] [TUS] [UCY] [IST-ID] [STUBA]

Total PM: 5,9

Based on the outcomes of subtask 2.1, as well as outcomes from the other tasks of the ROUTES WP, this subtask 2.2 consists in mapping and sharing knowledge on waste inventories, classification and pre-disposal steps with regard to disposal routes. It aims at providing an overview of issues related to management and disposal of challenging wastes. This overview makes it possible to identify R&D needs, to be considered as part of future activities of EURAD.

The results and outputs of Task 2.2 will be compiled in a final reports D9.5 and D9.6. Draft and final syntheses are prepared and shared with participants.

Task 3 - Description and comparison of radwaste characterisation approaches

Start: Month 7 – End: Month 33 - Task Leader: [JUELICH] [CIEMAT]

Task contributors: [CEA (ORANO)] [CIEMAT] [EEAE] [JUELICH] [IRSN] [IST-ID] [JSI (EIMV)] [NCRSD (DMT)] [SCK.CEN] [SSTC NRS] [STUBA] [TUS] [UCY] [VUJE]

Total PM: 64,6

Task objectives

- Identification of characterisation techniques for radioactive waste (waste selected in Task 2);
- Comparison of the characterisation methods applied for the same radioactive waste in different countries;
- Analysis of the existing approaches and identification of the knowledge gaps;
- Recommendations for the future R&D to eliminate knowledge gaps;
- Recommendations for characterisation approaches for countries with non-developed waste management concept.

Subtask 3.1-Radioanalytical characterisation of radioactive waste and waste with complex/toxic properties

Start: Month 7 – End: Month 24- Subtask Leader: [JUELICH] [CIEMAT]

Subtask contributors: [IRSN] [JUELICH] [CIEMAT] [CEA (ORANO)] [JSI (EIMV)] [SCK•CEN] [EEAE] [ONDRAF/NIRAS] [NCRSD (DMT)] [UCY] [TUS] [SSTC NRS] [SKB] [Dekom] [INCT] [IST-ID] [STUBA] [VUJE]

Total PM: 43,7

Collection, analysis and comparison of the existing knowledge about techniques and practices for radioanalytical characterisation of radioactive waste, identified in Task 2. The motivations and criteria for characterisation of radioactive wastes (e.g. treatment, reprocessing or WAC for existing repositories) will be identified (input from Task 4), like certain radionuclides and their inventories, requirements of waste acceptance regarding radionuclides limits, radionuclide release rates and speciation. Based on that the contributors will provide experience on characterisation of radioactive waste in different countries. Along with that the issues in characterization of radioactive wastes with complex chemical properties (e.g. organic wastes or SIERS) and toxic radioactive wastes (e.g. beryllium, mercury, asbestos) will be addressed. Due to their special behaviour, routine waste characterisation approaches might not be directly applicable and will require some methodological refinements. Knowledge and experience on characterisation of these wastes will be collected and systematically analysed in order to identify the main issues and knowledge gaps in order to give recommendations for further R&D to eliminate them. The subtask will also consider the means of providing an efficient transfer of knowledge and experience to countries without mature waste disposal concept, e.g. to SIMS.

The outcomes of this subtask will be a report summarising good practices for radioanalytical characterisation of selected radioactive, toxic wastes and wastes with complex chemical properties, highlighting the main motivation for characterization, issues and difficulties in handling these materials, including knowledge gaps and recommendation for future R&D for closing them.

Three workshops will be organized during Subtask 3.1 (months 7, 16 and 20). The last meeting will be in common with the first meeting of subtask 3.2 (see below).

This subtask will take into account information gained in CORI WP, SFC WP and GAS WP.

The results and outputs of Task 3.1 will be compiled in D9.7

Subtask 3.2 – Characterization and segregation of legacy waste

Start: Month 19 – End: Month 33- Subtask Leader: [JUELICH] [CIEMAT]

Subtask contributors: [IRSN] [JUELICH] [CEA (Orano)] [CIEMAT] [JSI (EIMV)] [SCK•CEN] [NCRSD (DMT)] [SSTC NRS] [SKB] [UCY] [EEAE] [INCT] [ONDRAF/NIRAS] [TUS] [Dekom] [SURO] [IST-ID] [VUJE]

Total PM: 20,9

Characterization and segregation of legacy waste as well as of small amounts of waste will be investigated. The contributors will provide for systematic collection and analysis of existing knowledge about historical and legacy wastes, like amount and key radionuclides, in order to identify management issues. Contributors will also share their experience in handling or provide knowledge for building up an approach for characterization. Depending on the status of the radioactive wastes (e.g. conditioned, interim storage or undefined), further steps in R&D must be identified in order to be included into designing an integrated approach for management of historical and legacy wastes. This will include retrieval, sampling, characterization as well as treatment, conditioning and disposal.

The outcome of this subtask will be a comprehensive report on sampling and characterization methods for historical and legacy wastes, required for determining the acceptability of these of radioactive wastes for disposal (D9.8).

Two workshops will be organized during Subtask 3.2 (months 20 and 32). The first meeting will be in common with the last meeting of subtask 3.1.

Task 4 – Identification of WAC used in EU Member-States for different disposal alternatives in order to inform development of WAC in countries without WAC/facilities

Start: Month 1 – End: Month 40 - Task Leader: [ONDRAF/NIRAS] [VTT (GSL)]

Task contributors: [Andra] [CEA (ORANO)] [CIEMAT] [EEAE] [FTMC] [JUELICH] [GRS] [IAE] [INCT] [IRSN] [IST-LPSR] [JSI (EIMV)] [LEI] [NCSR] [ONDRAF/NIRAS] [RATEN] [SÚRAO] [SKB] [SSTC NRS] [STUBA] [SURO] [TUS] [VTT (GSL)]

Total PM: 37

Task objectives

- Overview of the current application in Member-States of WAC at different stages in the waste lifecycle.
- Offer a structured approach to support decision-taking of “no regret” waste management measures.
- Identification of R&D needs and opportunities for collaboration between Member-States

Subtask 4.1 –Current use of waste acceptance criteria (start Month: 1 – end Month: 15)

Start: Month 1 – End: Month 15- Subtask Leader: [RATEN] [VTT (GSL)]

Subtask contributors: [RATEN] [ONDRAF/NIRAS] [VTT (GSL)] [TUS] [Andra] [IRSN] [CEA (ORANO)] [JUELICH] [LEI] [IAE] [INCT] [JSI (EIMV)] [CIEMAT] [SKB] [SSTC NRS] [SÚRAO] [FTMC] [GRS] ; [STUBA]

Total PM: 7

This subtask will provide an up-to-date overview per country on the use of waste acceptance criteria (WAC) in Member-States, hereby focusing on the use of WAC as a tool for waste cycle management.

The inputs of subtask 4.1 consists of:

- A review of available existing information (e.g. from NEA and IAEA);

- Descriptions of the current use of WAC per country. The descriptions will be based on a questionnaire. Organisations of the same country shall consult with their WMO (if participating) to provide a single input from their country. Each description will comprise:

- Identification of currently used WAC (considering also preliminary/draft WAC);
- Methodology for setting up WAC and link with waste classification;
- How compliance with WAC is verified;
- How non-conformances are dealt with;
- other (e.g. qualifications, in order to ensure compliance with WAC, of operators' methods for waste characterisation or methods for waste conditioning).

The inputs will be integrated into an overview per country, in the form of a summary table or other. This work will not require an analysis, nor will it involve a meeting/workshop. At the discretion of the participants in Subtask 4.1, this overview could involve a summary of identified commonalities like in THERAMIN. The output of subtask 4.1 is an internal memorandum, presenting the above mentioned overview per country.

Subtask 4.2 – Sharing experience on waste management with/without WAC available

Start: Month 6 – End: Month 29- Subtask Leader: [ONDRAF/NIRAS] [VTT (GSL)]

Subtask contributors: [ONDRAF/NIRAS] [VTT (GSL)] [TUS] [RATEN] [Andra] [IRSN] [CEA (ORANO)] [LEI] [INCT] [JSI (EIMV)] [CIEMAT] [SSTC NRS] [SÚRAO] [FTMC] [IST-LPSR] [NCSRD] [EEAE] [GRS] [SURO]

Total PM: 14,4

This subtask will provide a GAP-analysis of different approaches of waste management while maintaining compatibility with the option(s) for disposal. This will offer a structured approach to support decision-taking of “no regret” waste management measures.

The input of subtask 4.2 consists of :

- Case descriptions, per country, of waste conditioning without a final disposal solution being available. Only challenging wastes (identified in Task 2) should be considered. Each description will comprise a summary of lessons learned. The descriptions will be based on a questionnaire. Organisations of the same country shall consult with their WMO (if participating) to provide a single input from their country;
- Case descriptions derived from a review of existing information available from e.g. NEA and IAEA;
- The 1st memorandum (i.e. output of subtask 4.1).

Based on this input, a comparative (GAP) analysis will be performed between the situation where final WAC for disposal are available (“ideal situation”) and the situation where only preliminary, draft or even no WAC for disposal are available. The GAP-analysis will make a distinction between routes leading to surface disposal and other routes. The analysis will identify differences and perceived shortcomings.

This comparative analysis will involve a workshop (in month 25). At the discretion of Task 1, this workshop could be organised together with a workshop of another task (e.g. Task 2).

The output of subtask 4.2 is a second internal memorandum, summarising the workshop outcomes.

Subtask 4.3 – R&D needs and opportunities of collaboration

Start: Month 29 – End: Month 40- Subtask Leader: [ONDRAF/NIRAS] [VTT (GSL)]

Subtask contributors: [INCT] [ONDRAF/NIRAS] [VTT (GSL)] [TUS] [Andra] [IRSN] [CEA (ORANO)] [LEI] , [JSI (EIMV)] [CIEMAT] [SSTC NRS] [SÚRAO] [FTMC] [RATEN] [NCSRD] [EEAE] [GRS] [SURO] [STUBA]

Total PM: 15,6

This subtask will identify and prioritise common R&D needs related to the management of challenging wastes and identify opportunities of collaboration between Member-States. This subtask will also integrate the overall results of Task 4 and document these in a deliverable report.

The inputs of subtask 4.3 consists of:

- Identification, per country, of R&D needs with respect to the management of challenging wastes (belonging to the list identified in Task 2), particularly in relation to the conditioning of waste while maintaining compatibility, with the option(s) for disposal. Organisations of the same country shall consult with their WMO (if participating) to provide a single input from their country.
- The 2nd memorandum (i.e. output of subtask 4.2).

Based on this input, a workshop will be held (Month 33) to:

- Assimilate and prioritise the R&D needs
- Identify opportunities for collaboration between organisations of different Member-States

The outcome of the workshop will be summarised in a third internal memorandum.

Consequently, the outputs of subtasks 4.1, 4.2 and 4.3 will be combined into one deliverable report D9.9.

Task 5 - RWM solutions for small amounts of wastes

Start: Month 6 – End: Month 36 - Task Leader: [NCRSD (DMT)] and [SURO]

Task contributors: [EEAE] [GRS] [INCT] [IST-ID] [IST-LPSR] [JSI] [NCRSD (DMT)] [NES] [SURO]

Total PM: 25,3

Task objectives

Disposal strategies established by SIMS are often less advanced. These countries have small amounts of waste from research reactors and from medicine, industry and research but not from nuclear power plants. Commensurate solutions are mostly not available for these countries, regarding safety, time and costs. Often, these countries have not the expertise for planning, licensing, erection, operation and closure of a disposal facility. Downscaling of disposal concepts for disposal of small amount is failing and special concepts for SIMS are needed.

- Collection, analysis and comparison of the actual existing knowledge about disposal options for small amounts of waste. This will be complementary to the relevant IAEA project taking into account the results of a planned IAEA consultancy meeting about disposal options for small radioactive inventories in Sept. 2018 and a Technical Meeting planned for mid-2019. The work of IAEA is based only on the contributions of their Member-States. Therefore, participants of this task will actively take part as IAEA Member-States in this IAEA project.
- Description of the necessary predisposal routes for the disposal options
- Evaluation of the possible small-scale disposal solutions and description of their positive and negative aspects, knowledge and experience will be reviewed in order to identify knowledge gaps
- Dissemination of the results to other SIMS and description of the spin off for countries with large amounts of radioactive waste
- Identification of R&D gaps

Subtask 5.1 – Collecting and analysing actual existing knowledge about disposal options for SIMS

Start: Month 6 – End: Month 24- Subtask Leader: [NCRSD (DMT)] and [SURO]

Subtask contributors: [NCRSD (DMT)] [SURO] [NES] [JSI] [INCT] [GRS] [EEAE] [IST-LPSR] [IST-ID]

Total PM: 15

This subtask needs some of the results of subtask 2.1 and 2.2, as well as information from the questionnaire with regard to information from SIMS. The waste data can be completed by data for non-problematic waste for SIMS, if not already available, to get a reliable basis for the required size of a disposal facility. Information from EC Candidate Countries with small inventory of radioactive waste will be included if available.

Several options are in principle suitable. These options might be (listed here with increasing depth from the surface):

- a long-term interim storage on surface for decay to reduce the amount of waste [NES]
- a disposal near surface e.g. in silo-type facilities, shallow borehole (some tens meters), bunkers and caverns underground [JSI] supported by [SURO]
- a disposal in old mines, tunnels, deep shafts or boreholes adjusted to amount and activity (some 100 meter) [NCRSD (DMT)] supported by [SURO]
- a very deep borehole disposal (some km) [GRS]

In some countries like Denmark and Norway first conceptual designs up to already operating facilities are existing. These options have to be collected together with studies for other options being still under discussion. This will also include a consideration of combinations of the disposal options mentioned above. This work will be performed complementary to the relevant IAEA project.

For this purpose, two workshops will be organised (months: 7 and 16).

The results and outputs of Task 5.1 will be compiled in a final report D9.10

Subtask 5.2 – Describe the necessary predisposal routes for the disposal options of subtask 5.1

Start: Month 18 – End: Month 36- Subtask Leader: [NES] and [NCRSD (DMT)]

Subtask contributors: [NES] [NCRSD (DMT)] [SURO] [IST-LPSR] [EEAE] [GRS] [JSI]

Total PM: 15,6

Using the information on waste volumes and characteristics from task 2, questionnaire and if necessary the information generated in subtask 5.1, an evaluation will be made available predisposal routes coming from subtask 2.2, which are suitable even without WAC. For this purpose, a workshop will be organised (month: 30). The report of the workshop is the deliverable of this subtask.

The scope of this subtask is not within the scope of the planned activities of IAEA for small inventories.

The results and outputs of Task 5.2 will be compiled in a final report D9.11

Task 6 – Shared solutions in European countries (start Month: 1 – end Month: 42)

Start: Month 1 – End: Month 42 - Task Leader: [COVRA]

Task contributors: [ARAO] [CEA (ORANO)] [CIEMAT] [COVRA] [DEKOM] [EEAE] [FTMC] [JUELICH] [IRSN] [IST-ID] [IST-LPSR] [JSI (EIMV)] [NCRSD (DMT)] [NES] [NJF] [SKB] [SSTC NRS] [SURO] [VTT (GSL)]

Total PM: 29,6

Task objectives

- Describe and assess knowledge on and approaches to sharing technology and facilities between Member-States.
- Provide an overview of the interest in and experience with sharing technology/facilities in the different steps of waste management.
- Identify gaps and define needs for R&D, strategic priorities and opportunities for collaboration between Member-States, as applied to challenging wastes as defined in task 1 and early stage RWM programmes and Small Inventory Programmes.

Subtask 6.1: State of the art on shared development and use of technologies and facilities

Start: Month 1 – End: Month 12- Subtask Leader: [COVRA] and [Dekom]

Subtask contributors: [COVRA] [DEKOM] [ARAO] [JUELICH] [SSTC NRS] [CIEMAT] [SKB] [EEAE] [NCRSD (DMT)] [NES] [SURO] [IRSN] [JSI (EIMV)] [FTMC] [IST-LPSR] [VTT (GSL)] [CEA (ORANO)]

Total PM: 5,5

Summarise EC and IAEA studies on shared development and use of technologies and facilities for characterisation, treatment, storage and disposal. Summarise any existing or planned sharing of facilities between Member-States.

Activities:

1) Review EC projects (including SAPIERR, SAPIERR II, Chance, Theramin) and IAEA studies on the topic, based in part on contributions of organisations involved in (previous or ongoing) projects on the development of shared solutions for radioactive waste.

2) Review the National Programmes submitted to the EC that describe existing and planned waste management routes in Member-States, to indicate interest in shared development and use of technologies and facilities. Obtain information from participating organisations on such sharing.

The output of subtask 6.1 is D9.12, which will document and integrate the internal report. It will provide a state-of-the-art of the European experience in developing shared solutions for radioactive waste management. A workshop will be organized for this subtask (month 7).

Subtask 6.2: Case studies on shared development and use of technologies and facilities.

Start: Month 13 – End: Month 30- Subtask Leader: [COVRA] and [CEA (ORANO)]

Subtask contributors: [CEA (ORANO)] [JSI (EIMV)] [VTT (GSL)] [DEKOM] [ARAO] [JUELICH] [SSTC NRS] [CIEMAT] [SKB] [EEAE] [NCRSD (DMT)] [NES] [SURO] [IRSN] [FTMC] [IST-LPSR] [COVRA] [STUBA]

Total PM: 10

Document experience of Member-States in sharing technologies and facilities.

Activities:

1) Participants are asked to prepare a general description with:

a) their experience with sharing (one or more cases), for example:

i) treatment, conditioning, storage and disposal of waste from/in other Member-States,

ii) mobile technologies for waste characterisation, treatment and conditioning.

b) the lessons learned.

i) Participants from the same country are requested to coordinate with each other, in order to provide one contribution per country.

2) A workshop (in month 19), in which participants will:

a) review the interest in sharing,

b) examine the experience,

c) analyse the requirements for this to take place, and

d) assess the feasibility.

The output of subtask 6.2 is D9.13, which reports on the results of the workshop.

Subtask 6.3: Assess the feasibility of developing further European shared solutions for waste management from cradle to grave

Start: Month 25– End: Month 42- Subtask Leader: [COVRA] and [CEA (ORANO)]

Subtask contributors: [COVRA] [CEA (ORANO)] [VTT (GSL)] [DEKOM] [ARAO] [JUELICH] [SSTC NRS] [CIEMAT] [SKB] [EEAE] [NCRSD (DMT)] [NES] [SURO] [IRSN] [JSI (EIMV)] [FTMC] [IST-LPSR] [IST-ID] [STUBA]

Total PM: 14,1

A gap analysis will be performed whereby the interests and needs of Member-States to share technologies and facilities from cradle to grave is compared with present and past experience in Europe. A comparison and assessment will be made of possible approaches to and structures for sharing of characterisation, conditioning, storage and disposal technologies

and facilities. A specific focus will be given to the challenging waste defined in task 1 and LAPs. The identified gaps will be examined in a workshop to define needs for R&D, strategic priorities and opportunities for collaboration.

Activities:

1) A gap analysis is conducted using the outputs the Subtask 6.1 and 6.2 and tasks 2-4(5):

- a) Outputs of Task 2 will enable assessment of the level of interest in developing shared solutions for waste for which there is not yet a complete management plan and to identify the R&D needs for further development
- b) Outputs of Task 3 will enable identification of R&D needs and opportunities for the development of shared characterisation approaches, techniques or shared (common or centralised) laboratories for specific type of waste or radionuclides
- c) Outputs of Task 4 will enable identification of R&D opportunities and needs of shared approaches or facilities for waste management routes or waste streams and/or countries for which there are no applicable WAC

2) A workshop will be held to:

- a) Discuss the gap analysis
- b) Assimilate the R&D needs and strategic priorities
- c) Prioritise the R&D needs according to potential for challenging waste and LAPs
- d) Identify opportunities of collaboration between (organisations from) the Member-States.

The workshop (in month 36) will involve the same participants as in the workshop of subtask 6.2.

The output of subtask 6.3 is D9.14.

Task 7 – Interactions with Civil society

Start: Month 1 – End: Month 60 - Task Leader: [IRSN (NTW)]

Task contributors: [IRSN (NTW)] [JSI (EIMV)]

Total PM: 6,6

In the framework of EURAD, the broader objectives and approach of the interactions with Civil Society are described under Section 3.1.e.

Task objectives

- To facilitate the translation of scientific/technical results of the WP to allow effective interaction with CS group
- To create the conditions for the CS Group to express their expectations or views in link with the topic addressed in the ROUTES WP.
- To improve the mutual understanding on the RD&D needed to develop safe acceptable solutions in the processing and disposal of radioactive waste.

Task 7 will be carried out by CS experts interacting with the CS Group according to the methodology described under Section 3.1.e. of EURAD description.

The work within task 7 will be carried out in three subtasks.

The CS experts will work in an organised process together with representatives from WMOs, TSOs and REs in the tasks 2-6 of the WP as described in the subtasks below.

Subtask 7.1– Scoping of ROUTES tasks 2-6, initial input from the CS experts and development of Interaction with Civil Society (ICS) action plan

Start: Month 1– End: Month 12 - Task Leaders: [JSI (EIMV), [IRSN (NTW)]

Subtask contributors: [JSI (EIMV), [IRSN (NTW)]

The inception phase of the WP will be an opportunity for CS experts to better apprehend and scope the subjects and activities performed in ROUTES tasks 2-6. During the first year subtask 7.1 will perform a scoping of the objectives and actions in ROUTES tasks 2-6 in order to identify issues that are deemed of more specific interest in the perspective of developing interactions between civil society and EURAD partners along the course of the WP. This will be done in dialogue and collaboration between the CS Experts and scientific/technical experts from WMOs, TSOs and REs in the WP.

Part of the work of the CS experts will be to analyse the ROUTES WP in a larger context - how is it related to on-going RWM activities and connected with disposal projects and the challenges they are facing. The CS experts will attend the kick-off meetings of EURAD and the WP in Month 1 and representatives of task 7 will attend a selection of task 2-6 meetings during Month 1-11.

The scoping exercise carried out during the first year will give the CS experts the possibility to identify specific interests and actions that will allow greater input and participation in the WP. Although it is too early to know exactly what topics the CS experts in consultation with the CS group will identify as especially interesting, possible topics include the comprehension of RD&D activities and strategic needs required for implementation of the different spent fuel and radioactive waste management and disposal routes in Europe, radioactive waste management options for unusual or small amounts of wastes, and an analysis of the advantages and disadvantages of shared radioactive waste management option in Europe.

The result will be described in an ICS action plan. Therefore, the focus of the work of task 7 will be primarily oriented each year (year 2, 3 and 4) to a specific topic as selected in the development of the action plan.

As part of the subtask there will be a dedicated meeting in Month 8 involving CS experts and a panel of WMOs, TSOs and REs representatives from tasks 2-6 is foreseen in order to discuss the draft ICS action plan (at least by videoconference). In addition, Task 7.1 will organise a dedicated ROUTES session within the ICS workshop (Year 1) organised at EURAD level by the PMO WP task 8.

There will be a Deliverable 9.15 "Scoping of ROUTES, initial ICS input and ICS action plan" in Month 11.

The results of the task will be presented at the first WP annual meeting (Month 12) within a specific session (CS experts + WP Board) including attendance from members of the CS group (Month 12).

Subtask 7.2– Implementing ICS action plan

Start: Month 13– End: Month 48 - Task Leaders: [JSI (EIMV), [IRSN (NTW)]

Subtask contributors: [JSI (EIMV)] [IRSN (NTW)]

Subtask 7.2 will implement the ICS action plan (D9.15). Interactions involving both the CS group and a panel of WMOs, TSOs and REs will be steered by the CS experts on the yearly specific topics (year 2, 3 and 4) identified in the ICS action plan.

The subtask will contribute to enhance mutual understanding and dialogue skills among the different categories of participants. The CS experts will continuously follow, discuss tasks 2-6 in the work package and the results (with a focus on each of the yearly specific topics). This will be done in dialogue and collaboration between the CS Experts and scientific/technical experts from WMOs, TSOs and REs in the WP.

CS experts will, with reservation about available resources, attend the meetings of other tasks, and comment the most relevant deliverables from tasks 2-6 of the WP (preferably in the draft versions).

In order to better support interactions with the CS group, Task 7.2 will organise a dedicated ROUTES session within the ICS workshops (year 2, 3 and 4) organised at programme level by the PMO WP task 8.

At each annual WP meeting (Month 24, Month 36, Month 48) the CS experts will present the progress of their work including comments, suggestions, questions and other observations.

These activities will bring the opportunity to present the work achieved and discuss the results.

Yearly feedback to ROUTES 2-6 tasks will be organised by subtask 7, providing them with an input on the first and second specific topics identified in the ICS action plan (D9.16, D9.17, D9.18).

Subtask 7.3– Synthesis work and dissemination

Start: Month 49– End: Month 60 - Task Leaders: [JSI (EIMV), [IRSN (NTW)]

Subtask contributor: [JSI (EIMV)] [IRSN (NTW)]

Towards the end of the WP, the CS experts will summarise the conducted work in task 7 and documentation will be done of the interaction framework developed in the work package. This will be done in dialogue and collaboration between the CS Experts and scientific/technical experts from WMOs, TSOs and REs in the WP.

Task 7.3 will organise a dedicated ROUTES session within the ICS workshops (year 5) organised at programme level by the PMO WP task 8

D9.19 will be a synthesis report of the work and results of task 7 including the documentation of the interaction framework developed and used, including recommendations for future CS interaction.

The results and deliverable D9.19 will be presented at the final WP annual meeting.

Task 7.3 will contribute to a popularised description of the results of the WP in collaboration with the other tasks in the WP and the KM WP (D9.20)

Participation per Partner

Partner number and short name	WP9 effort
1 - ANDRA	5.40
2 - ARAO	1.20
3 - BEL V	0.30
5 - CEA	0.00
Orano	6.30
6 - CIEMAT	6.60
9 - COVRA	4.00

Partner number and short name	WP9 effort
10 - FTMC	3.10
12 - Dekom	2.00
13 - EEAE	3.10
15 - JUELICH	6.00
16 - GRS	2.00
17 - IAE	1.10
18 - INCT	5.60
19 - IRSN	9.10
NTW	4.90
20 - IST	4.40
21 - IST ID	4.40
22 - JSI	1.50
EIMV	6.90
25 - LEI	1.90
28 - NCSR	4.90
DMT	7.60
29 - NES	4.90
30 - NJF	1.50
31 - NRG	0.30
32 - ONDRAF/NIRAS	5.50
36 - RATEN	3.00
38 - SCK•CEN	1.30
39 - SKB	1.70
40 - SSTC NRS	9.40
41 - STUBA	3.20
42 - SÚRAO	1.90
43 - SURO	6.70
45 - TS Enercon	0.30
46 - TUS	4.90
47 - UCyprus	0.90
50 - VTT	0.00
GSL	7.50
51 - VUJE	2.00
Total	147.30

List of deliverables

Deliverable Number¹⁴	Deliverable Title	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
D9.1	ROUTES - Training materials	19 - IRSN	Report	Public	60
D9.2	ROUTES - Recommendations for future RD&D, strategic study and KM activities for the 2nd wave of EURAD-1	19 - IRSN	Report	Public	18
D9.3	ROUTES - Recommendations for future RD&D, strategic study and KM activities for future European collaboration	19 - IRSN	Report	Public	58
D9.4	ROUTES - Overview of existing work on categorization/ classification of RWs in participating states	1 - ANDRA	Report	Public	10
D9.5	ROUTES - Overview of issues related to challenging wastes	1 - ANDRA	Report	Public	24
D9.6	ROUTES - Common understanding of the practical issues on waste management routes	1 - ANDRA	Report	Public	48
D9.7	ROUTES - Review of radioanalytical characterisation of selected radioactive wastes and wastes with complex chemical and toxic properties	15 - JUELICH	Report	Public	24
D9.8	ROUTES - Review of characterization of legacy and historical wastes	15 - JUELICH	Report	Public	33
D9.9	ROUTES - Report suggestions for the management of challenging wastes while maintaining compatibility with the option(s) for disposal	50 - VTT	Report	Public	40
D9.10	ROUTES - Report about the knowledge for existing and potential	28 - NCSR	Report	Public	24

List of deliverables

Deliverable Number¹⁴	Deliverable Title	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
	disposal options for SIMS				
D9.11	ROUTES - Report presenting the results of the workshop dealing with possible conditioning routes for SIMS	29 - NES	Report	Public	36
D9.12	ROUTES - Studies and plans for developing shared solutions for radioactive waste management in Europe	9 - COVRA	Report	Public	12
D9.13	ROUTES - Case studies of shared development and use of technologies and facilities	5 - CEA	Report	Public	24
D9.14	ROUTES - Report on the feasibility of developing further European shared solutions for waste management from cradle to grave	9 - COVRA	Report	Public	42
D9.15	Scoping of ROUTES, initial CS input and ICS action plan (task 7.1)	22 - JSI	Report	Public	11
D9.16	Implementation of the ROUTES ICS action plan first phase - CS discussion and input focused on the first topic identified in the ICS action plan (task 7.2)	19 - IRSN	Report	Public	23
D9.17	Implementation of the ROUTES ICS action plan second phase - CS discussion and input focused on the second topic identified in the ICS action plan (task 7.2)	19 - IRSN	Report	Public	35
D9.18	Implementation of the ROUTES ICS action plan third phase - CS discussion and input focused on the third topic identified in the ICS action plan (task 7.2)	19 - IRSN	Report	Public	47

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D9.19	Final synthesis ROUTES report of the work and results of task 7 including the documentation of the interaction framework developed, including recommendations for future CS interaction	22 - JSI	Report	Public	60
D9.20	Contribution to ROUTES factsheet presenting the results and outcomes of ROUTES and in a larger context	19 - IRSN	Report	Public	60

Description of deliverables

Deliverables (brief description and month of delivery)

- D9.1 - ROUTES Training materials (Lead organisation: IRSN. Due month: 60)
- D9.2 - Recommendations for future RD&D, strategic study and KM activities for the 2nd wave of EURAD-1: This deliverable identifies the needs for future RD&D, strategic study and KM activities for the 2nd wave of EURAD-1 that arise from the WP activities carried out during the first 18 months. Lead organisation: IRSN. Due month: 18.
- D9.3 - Recommendations for future RD&D, strategic study and KM activities for future European collaboration: This deliverable identifies the needs for future RD&D, strategic study and KM activities for a possible EURAD-2 that arise from the WP activities. Lead organisation: IRSN. Due month: 58.
- D9.4 - Overview of existing work on categorization/classification of RWs in participating states (Andra, SSTC NRS; draft version: Month 6; final version: Month 10)
- D9.5 - Overview of issues related to challenging wastes (Andra, SSTC NRS; Month: 24) This deliverable provides a comprehensive list of challenging wastes taking into account the situation in participating Member-States. It describes the particular problems to be solved for these wastes taking into account pre-disposal and disposal steps. A preliminary draft of the deliverable will be available at month 13 in order to provide information to other tasks
- D9.6 - Common understanding of the practical issues on waste management routes (Andra, SSTC NRS; Month: 48) This final deliverable identifies practical issues and R&D needs on the basis of current knowledge on waste inventories, classification, pre-disposal steps and disposal.
- D9.7 - Review of radioanalytical characterisation of selected radioactive wastes and wastes with complex chemical and toxic properties. This deliverable corresponds to the completion of subtask 3.1. and provides for a comprehensive radioanalytical description of properties of radioactive wastes taking into account particular situations in Member-States. It describes particular problems to be solved for these wastes in the context of conditioning and disposal approaches. D3.1 will be coordinated by [JUELICH] due date 24 months.
- D9.8 - Review of characterization of legacy and historical wastes. This deliverable consolidates information on characterization approaches for historical and legacy wastes, and data on waste inventory, and provide good practice on handling and conditioning for disposal. D3.2 will also indicate existing issues and knowledge gaps in characterization of legacy and historical wastes, providing suggestions for solving these issues and closure of knowledge gaps, where appropriate. Lead organisation: [JUELICH] due date: Month 33
- D9.9 - Report suggestions for the management of challenging wastes while maintaining compatibility with the option(s) for disposal. This report will i) give an overview of the current application in Member-States of WAC at different stages in the waste lifecycle ; ii) identify differences and perceived shortcomings of different approaches of waste management while maintaining compatibility with the option(s) for disposal; iii) Support decision-taking of “no regret” waste management measures; iv) identify and prioritise common R&D needs related to the management of challenging wastes and v) Identify opportunities of collaboration between Member-States - Lead organisation: [VTT (GSL)] - Due month: 40
- D9.10 - Report about the knowledge for existing and potential disposal options for SIMS. This report will be based on a collection of IAEA standards, guidelines and TecDocs related to small amounts of radioactive waste, which will

soon be published. It will also take into account the results of an IAEA Consultancy Meeting about disposal options for countries with small inventories planned for 2018 and a Technical Meeting for the same issue planned for Mid of 2019. This report will also list further needs of R&D in this issue. Lead organisation [NCSR] due month: 24

- D9.11 - Report presenting the results of the workshop dealing with possible conditioning routes for SIMS. Especially, Austria (NES) can demonstrate their best practice as an example for other SIMS. All participants can evaluate these different conditioning processes for their needs and contribute their own experiences and needs. Results will be given in a report. Lead organisation: NES - due month: 36

- D9.12 - Studies and plans for developing shared solutions for radioactive waste management in Europe - This deliverable summarises the knowledge on and approaches to sharing technology and facilities between Member-States. It also provides an overview of the plans of Member-States for shared solutions in different steps of the waste lifecycle. lead organisations: [COVRA] due month: 12

- D9.13 - Case studies of shared development and use of technologies and facilities. This deliverable i) provides practical examples of shared solutions in the different steps of the waste management lifecycle, ii) analyses the requirements for this to take place and iii) makes general observations and draw conclusions about feasibility (from reviewing Member-States' inputs) and gives an overview the different approaches (summarising the most pertinent information). lead organisation: [CEA (ORANO)] due month: 24

- D9.14 - Report on the feasibility of developing further European shared solutions for waste management from cradle to grave. This deliverable will integrate DX.X and DX.X and will also include a chapter on R&D needs, opportunities. It will i) document the performed gap analysis for the development of shared European facilities for characterisation, treatment, conditioning, storage and disposal of radioactive wastes; ii) identify and prioritise strategic priorities and R&D needs related to the management of challenging wastes; iii) Identify opportunities for collaboration between Member-States with respect to this R&D and iv) Give a common vision and the work to be done for sharing knowledge and developing facilities between Member-States. lead organisation: [COVRA] due month: 42

- D9.15 - Scoping of ROUTES, initial CS input and ICS action plan (task 7.1) - Lead organisations: [JSI (EIMV)] - Due month: 11

- D9.16 - Implementation of the ROUTES ICS action plan first phase - CS discussion and input focused on the first topic identified in the ICS action plan (task 7.2) - Lead organisations: [IRSN (NTW)] - Due month: 23

- D9.17 - Implementation of the ROUTES ICS action plan second phase - CS discussion and input focused on the second topic identified in the ICS action plan (task 7.2) - Lead organisations: [IRSN (NTW)] - Due month: 35

- D9.18 - Implementation of the ROUTES ICS action plan third phase - CS discussion and input focused on the third topic identified in the ICS action plan (task 7.2) - Lead organisations: [IRSN (NTW)] - Due month: 47

- D9.19 - Final synthesis ROUTES report of the work and results of task 7 including the documentation of the interaction framework developed, including recommendations for future CS interaction - Lead organisations: [JSI (EIMV)] - Due month: 59

- D9.20 - Contribution to ROUTES factsheet presenting the results and outcomes of ROUTES and in a larger context - how is it related to on-going RWM activities and connected with disposal projects and the challenges they are facing their impact on implementation, safety, governance, route – this deliverable is intended for the general public and will be prepared based on the material/documentation provided to the CS Group - Lead organisation: [IRSN (NTW)] - Due month: 60

D9.1 : ROUTES - Training materials [60]

ROUTES - Training materials

D9.2 : ROUTES - Recommendations for future RD&D, strategic study and KM activities for the 2nd wave of EURAD-1 [18]

ROUTES - Recommendations for future RD&D, strategic study and KM activities for the 2nd wave of EURAD-1

D9.3 : ROUTES - Recommendations for future RD&D, strategic study and KM activities for future European collaboration [58]

ROUTES - Recommendations for future RD&D, strategic study and KM activities for future European collaboration

D9.4 : ROUTES - Overview of existing work on categorization/classification of RWs in participating states [10]

ROUTES - Overview of existing work on categorization/classification of RWs in participating states

D9.5 : ROUTES - Overview of issues related to challenging wastes [24]

ROUTES - Overview of issues related to challenging wastes

D9.6 : ROUTES - Common understanding of the practical issues on waste management routes [48]

ROUTES - Common understanding of the practical issues on waste management routes

D9.7 : ROUTES - Review of radioanalytical characterisation of selected radioactive wastes and wastes with complex chemical and toxic properties [24]

ROUTES - Review of radioanalytical characterisation of selected radioactive wastes and wastes with complex chemical and toxic properties

D9.8 : ROUTES - Review of characterization of legacy and historical wastes [33]

ROUTES - Review of characterization of legacy and historical wastes

D9.9 : ROUTES - Report suggestions for the management of challenging wastes while maintaining compatibility with the option(s) for disposal [40]

ROUTES - Report suggestions for the management of challenging wastes while maintaining compatibility with the option(s) for disposal

D9.10 : ROUTES - Report about the knowledge for existing and potential disposal options for SIMS [24]

ROUTES - Report about the knowledge for existing and potential disposal options for SIMS

D9.11 : ROUTES - Report presenting the results of the workshop dealing with possible conditioning routes for SIMS [36]

ROUTES - Report presenting the results of the workshop dealing with possible conditioning routes for SIMS

D9.12 : ROUTES - Studies and plans for developing shared solutions for radioactive waste management in Europe [12]

ROUTES - Studies and plans for developing shared solutions for radioactive waste management in Europe

D9.13 : ROUTES - Case studies of shared development and use of technologies and facilities [24]

ROUTES - Case studies of shared development and use of technologies and facilities

D9.14 : ROUTES - Report on the feasibility of developing further European shared solutions for waste management from cradle to grave [42]

ROUTES - Report on the feasibility of developing further European shared solutions for waste management from cradle to grave

D9.15 : Scoping of ROUTES, initial CS input and ICS action plan (task 7.1) [11]

Scoping of ROUTES, initial CS input and ICS action plan (task 7.1)

D9.16 : Implementation of the ROUTES ICS action plan first phase - CS discussion and input focused on the first topic identified in the ICS action plan (task 7.2) [23]

Implementation of the ROUTES ICS action plan first phase - CS discussion and input focused on the first topic identified in the ICS action plan (task 7.2)

D9.17 : Implementation of the ROUTES ICS action plan second phase - CS discussion and input focused on the second topic identified in the ICS action plan (task 7.2) [35]

Implementation of the ROUTES ICS action plan second phase - CS discussion and input focused on the second topic identified in the ICS action plan (task 7.2)

D9.18 : Implementation of the ROUTES ICS action plan third phase - CS discussion and input focused on the third topic identified in the ICS action plan (task 7.2) [47]

Implementation of the ROUTES ICS action plan third phase - CS discussion and input focused on the third topic identified in the ICS action plan (task 7.2)

D9.19 : Final synthesis ROUTES report of the work and results of task 7 including the documentation of the interaction framework developed, including recommendations for future CS interaction [60]

Final synthesis ROUTES report of the work and results of task 7 including the documentation of the interaction framework developed, including recommendations for future CS interaction

D9.20 : Contribution to ROUTES factsheet presenting the results and outcomes of ROUTES and in a larger context [60]

Contribution to ROUTES factsheet presenting the results and outcomes of ROUTES and in a larger context

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	EURAD Kick-off meeting (General Assembly n°1)	1 - ANDRA	1	EURAD Kick-off meeting (General Assembly n°1)
MS9	ROUTES Kick-off meeting (ROUTES WPM1)	19 - IRSN	2	ROUTES Kick-off meeting (ROUTES WPM1)
MS12	EURAD EJP Newsletters	1 - ANDRA	3	EURAD EJP Newsletters (Due date : M3 and then every quarter)
MS13	ROUTES Questionnaire	19 - IRSN	3	ROUTES Questionnaire
MS30	EURAD General Assembly n°2	1 - ANDRA	7	EURAD General Assembly n°2
MS37	ROUTES Workshop 1 on Radioanalytical characterisation of radioactive waste and waste with complex/toxic properties (T3.1)	19 - IRSN	7	ROUTES Workshop 1 on Radioanalytical characterisation of radioactive waste and waste with complex/toxic properties (T3.1)
MS38	ROUTES Workshop 1 on disposal options for SIMS (T5.1)	19 - IRSN	7	ROUTES Workshop 1 on disposal options for SIMS (T5.1)
MS39	ROUTES workshop on European experience in developing shared solutions for RWM	19 - IRSN	7	ROUTES workshop on European experience in developing shared solutions for RWM
MS42	EURAD Annual Work Plan 2	1 - ANDRA	9	EURAD Annual Work Plan 2
MS65	ROUTES WPM2	19 - IRSN	12	ROUTES WPM2
MS66	ROUTES Workshop on Case studies on shared development and use of technologies and facilities	19 - IRSN	12	ROUTES Workshop on Case studies on shared development and use of technologies and facilities
MS71	Methodology for ICS activities assessment	19 - IRSN	12	Methodology for ICS activities assessment
MS81	EURAD General Assembly n°3 + EURAD Annual Meeting 1	1 - ANDRA	13	EURAD General Assembly n°3 + EURAD Annual Meeting 1
MS82	ICS Workshop 1	19 - IRSN	13	ICS Workshop 1
MS85	EURAD Periodic Report 1	1 - ANDRA	14	EURAD Periodic Report 1
MS88	ROUTES up-to-date overview per country on the use of waste acceptance criteria (WAC) in Member-States, hereby focusing on the use of WAC as a tool for waste cycle management	19 - IRSN	15	ROUTES up-to-date overview per country on the use of waste acceptance criteria (WAC) in Member-States, hereby focusing on the use of WAC as a tool for waste cycle management

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS90	ROUTES Workshop 2 on Radioanalytical characterisation of radioactive waste and waste with complex/toxic properties (T3.1)	19 - IRSN	16	ROUTES Workshop 2 on Radioanalytical characterisation of radioactive waste and waste with complex/toxic properties (T3.1)
MS91	ROUTES Workshop 2 on disposal options for SIMS (T5.1)	19 - IRSN	16	ROUTES Workshop 2 on disposal options for SIMS (T5.1)
MS103	EURAD General Assembly n°4	1 - ANDRA	19	EURAD General Assembly n°4
MS110	ROUTES Workshop 3 on Radioanalytical characterisation of radioactive waste and waste with complex/toxic properties (T3.1) + Workshop 1 on Characterization and segregation of legacy waste (T3.2)	19 - IRSN	20	ROUTES Workshop 3 on Radioanalytical characterisation of radioactive waste and waste with complex/toxic properties (T3.1) + Workshop 1 on Characterization and segregation of legacy waste (T3.2)
MS112	EURAD Annual Work Plan 3	1 - ANDRA	21	EURAD Annual Work Plan 3
MS127	ROUTES WPM3	19 - IRSN	24	ROUTES WPM3
MS132	ROUTES Workshop on waste management with/without WAC available (T4.2)	19 - IRSN	25	ROUTES Workshop on waste management with/without WAC available (T4.2)
MS136	EURAD General Assembly n°5 + EURAD Annual Meeting 2	1 - ANDRA	25	EURAD General Assembly n°5 + EURAD Annual Meeting 2
MS137	ICS Workshop 2	19 - IRSN	25	ICS Workshop 2
MS140	EURAD Periodic Report 2	1 - ANDRA	26	EURAD Periodic Report 2
MS144	ROUTES summary of Task 4.2 workshop outcomes on Sharing experience on waste management with/without WAC available	19 - IRSN	28	ROUTES summary of Task 4.2 workshop outcomes on Sharing experience on waste management with/without WAC available
MS151	ROUTES Workshop predisposal routes for the disposal options for SIMS (T5.2)	19 - IRSN	30	ROUTES Workshop predisposal routes for the disposal options for SIMS (T5.2)
MS152	Last input from ROUTES to UMAN	19 - IRSN	30	Last input from ROUTES to UMAN
MS153	EURAD General Assembly n°6	1 - ANDRA	31	EURAD General Assembly n°6
MS161	ROUTES Workshop 2 on Characterization and	19 - IRSN	32	ROUTES Workshop 2 on Characterization and

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
	segregation of legacy waste (T3.1)			segregation of legacy waste (T3.1)
MS162	EURAD Annual Work Plan 4	1 - ANDRA	33	EURAD Annual Work Plan 4
MS163	ROUTES Workshop on identification of R&D needs and opportunities of collaboration related to the management of challenging wastes (T4.3)	19 - IRSN	33	ROUTES Workshop on identification of R&D needs and opportunities of collaboration related to the management of challenging wastes (T4.3)
MS176	ROUTES WPM4	19 - IRSN	36	ROUTES WPM4
MS177	ROUTES Workshop on the feasibility of developing further European shared solutions for waste management from cradle to grave (T6.3)	19 - IRSN	36	ROUTES Workshop on the feasibility of developing further European shared solutions for waste management from cradle to grave (T6.3)
MS185	EURAD General Assembly n°7 + EURAD Annual Meeting 3	1 - ANDRA	37	EURAD General Assembly n°7 + EURAD Annual Meeting 3
MS186	ICS Workshop 3	19 - IRSN	37	ICS Workshop 3
MS189	EURAD Periodic Report 3	1 - ANDRA	38	EURAD Periodic Report 3
MS192	ROUTES Note on identification, per country, of R&D needs with respect to the management of challenging wastes	19 - IRSN	40	ROUTES Note on identification, per country, of R&D needs with respect to the management of challenging wastes
MS199	EURAD General Assembly n°8	1 - ANDRA	43	EURAD General Assembly n°8
MS206	EURAD Annual Work Plan 5	1 - ANDRA	45	EURAD Annual Work Plan 5
MS219	ROUTES WPM5	19 - IRSN	48	ROUTES WPM5
MS222	EURAD General Assembly n°9 + EURAD Annual Meeting 4	1 - ANDRA	49	EURAD General Assembly n°9 + EURAD Annual Meeting 4
MS223	ICS Workshop 4	19 - IRSN	49	ICS Workshop 4
MS224	EURAD Periodic Report 4	1 - ANDRA	50	EURAD Periodic Report 4
MS234	EURAD General Assembly n°10	1 - ANDRA	55	EURAD General Assembly n°10
MS235	ICS Workshop 5	19 - IRSN	55	ICS Workshop 5
MS239	ROUTES WPM6	19 - IRSN	60	ROUTES WPM6
MS240	EURAD General Assembly n°11 + EURAD Annual Meeting 5	1 - ANDRA	60	EURAD General Assembly n°11 + EURAD Annual Meeting 5

Schedule of relevant Milestones

Milestone number¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS241	EURAD Periodic Report 5	1 - ANDRA	60	EURAD Periodic Report 5 (Due date: 60+2)

Work package number ⁹	WP10	Lead beneficiary ¹⁰	3 - BEL V
Work package title	Uncertainty Management multi-Actor Network (UMAN)		
Start month	1	End month	48

Objectives

Objectives

The main objectives of the WP are as follows:

- Develop a common understanding among the different categories of actors (WMOs, TSOs, REs & Civil Society) on uncertainty management and how it relates to risk & safety. In cases where a common understanding is beyond reach, the objective is to achieve mutual understanding on why views on uncertainties and their management are different for different actors.
- Share knowledge/know-how and discuss common methodological/strategical challenging issues on uncertainty management.
- Identify the contribution of past & on-going R&D projects to the overall management of uncertainties.
- Identify remaining and emerging issues and needs associated with uncertainty management.

Expected impacts

The WP is expected to contribute to the EURAD Vision statement by:

- fostering mutual understanding and trust between actors;
- enhancing the understanding of the risks and uncertainties;
- ensuring societal visibility and transparency of RD&D.

The WP could be used as well to target future EURAD scope onto uncertainties that are most significant in terms of their impact on safety cases and facility implementation.

Regarding RWM implementation needs

The WP will contribute to the fulfillment of implementation needs by:

- compiling, reviewing, comparing and refining uncertainty management strategies, approaches and tools that could be used in a radioactive waste disposal programme (Task 2);
- addressing the identification & characterization of potentially safety-relevant uncertainties that need to be taken into consideration when implementing a disposal programme (Task 3);
- identifying possible options for the management of specific safety-relevant uncertainties at different programme phases (Task 4);
- providing an opportunity for technical experts to interact with various types of actors including civil society (Tasks 2 to 5);
- contributing to building mutual trust and understanding between various stakeholders.

Regarding safety

The WP will address safety case concerns by:

- compiling, reviewing, comparing and refining uncertainty management strategies, approaches and tools that could be used to demonstrate safety (Task 2);
- addressing the identification & characterization of potentially safety-relevant uncertainties that need to be taken into consideration in a safety case (Task 3);
- identifying possible options for the management of specific safety-relevant uncertainties in a safety case at different programme phases (Task 4);
- fostering a mutual understanding by the different actors of key concepts and paradigms underlying uncertainty management and the safety case at different steps of a geological disposal programme (Task 5);
- identifying methods for discussing and exchanging on uncertainties and uncertainty management during the development and review of the safety case (Task 5).

Regarding the outreach of EURAD-1

Collaborations and synergies with other international initiatives and organizations (such as IAEA, NEA, NUGENIA) are planned. In particular, interactions with NEA (IGSC) on uncertainty management strategies, approaches and tools (Task 2) and on interactions between different categories of actors, including Civil Society (Task 5) are foreseen. As regards pre-disposal issues, interactions with waste generators members of NUGENIA will be sought after (through questionnaire, invitation to workshops...).

Description of work and role of partners

WP10 - Uncertainty Management multi-Actor Network (UMAN) [Months: 1-48]

BEL V, ANDRA, BGE, CIEMAT, CNRS, COVRA, FTMC, ENRESA, JUELICH, GRS, IRSN, JSI, KIT, LEI, NAGRA, NRG, ONDRAF/NIRAS, POSIVA, PSI, RATEN, RWM, SCK•CEN, SSTC NRS, STUBA, SÚRAO, SURO, TS Enercon, TUS, VTT

Description of work

Task 1 – S/T coordination, State-of-the-art and training material

Start: Month 1 – End: Month 48 - Task Leader: [Bel V]

Task Contributors: [BEL V] [BGE] [GRS] [IRSN (MUTADIS)] [RATEN]

Total PM: 11,5

Subtask 1.1 – S/T coordination

Start: Month 1 – End: Month 48 – Subtask Leader: [Bel V]

Subtask contributors: [Bel V] [BGE] [GRS] [IRSN (MUTADIS)] [RATEN]

Total PM: 7

Coordination of the WP is performed both at WP and task level. Subtask 1.1 describes the coordination work performed by the WP leader at the WP level. The coordination work performed by other task leaders is included in the description of the other tasks. This subtask consists of the following actions:

- o Organization of WP meetings (3meetings organised together with 3seminars of Task 5) and of the meetings of the WP Board (2 per year) composed of the WP leader and of the task leaders [Bel V]
- o Participation in WP board meetings to ensure that the project is progressing according to the agreed specifications, milestones and planning [Bel V].
- o Reporting to the PMO of the work progress and of possible modifications of the WP work plan. [Bel V].

Subtask 1.2 – Interactions with KM WP

Start: Month 1 – End: Month 48 – Subtask Leader: [Bel V]

Total PM: 2

Owing to the nature of this WP, it is not foreseen to increase scientific knowledge. Nonetheless, the work carried out in Tasks 2 to 5 could lead to the development or improvement of strategies, approaches and tools. The knowledge consolidated or generated through knowledge/know-how sharing and discussions of common challenging issues could constitute a valuable input to KM activities (i.e. guidance, state-of-knowledge).

This subtask will consist in the following actions:

- o Interacting with KM WPs regarding the input of the WP to the state-of-knowledge, development of guidance and training activities in terms of content and format [Bel V]
- o Development of training material (input to KM WP3) [Bel V]) (Related deliverable: D10.1)

Subtask 1.3 – Integration

Start: Month 1 – End: Month 48 – Sub-Task Leader: [Bel V]

Subtask contributors: [Bel V] [BGE] [GRS] [IRSN (MUTADIS)] [RATEN]

Total PM: 2,5

This subtask will consist in integrating the recommendations for future RD&D, strategic study and KM activities identified by WP participants in other tasks. Milestones are foreseen to ensure that input from other tasks is provided in due time.

Task 2 - Strategies, approaches and tools

Start: Month 1 – End: Month 48 - Task Leader: [GRS]

Task Contributors: [Andra] [Bel V] [CIEMAT] [CNRS (IMT Atlantique)] [COVRA] [JUELICH (HZDR)] [GRS] [IRSN (MUTADIS)] [JSI (EIMV)] [KIT (TU Clausthal)] [LEI] [NAGRA] [NRG] [ONDRAF/NIRAS] [SÚRAO] [RWM] [SCK.CEN] [SSTC NRS] [STUBA] [TUS] [VTT (GSL)]

Total PM: 25,7

The overall objective of this task is to compile, review, compare and refine strategies, approaches and tools for the management of uncertainties in the safety analysis and the safety case that are being used, planned to be used or being developed in different countries.

Subtask 2.1– Generic strategies for managing uncertainties

Start: Month 1 – End: Month 36 – Subtask Leader: [VTT (GSL)]

Subtask contributors: [Andra] [Bel V] [IRSN (MUTADIS)] [LEI] [NAGRA] [NRG] [SÚRAO] [RWM] [VTT (GSL)]

Total PM: 7,5

Since the strategies applied depend on the applicable regulations as well as on the various quantitative or qualitative criteria that might be used for assessing safety, this work topic includes a comparing overview of the regulatory background and applied safety strategies in participating countries and their consequences. Possible strategies and approaches for managing uncertainties will be systematically compiled and assessed with regard to their pros and cons. This includes the approaches used in the safety assessment (e.g. for simplification purposes when going from a detailed performance analysis of the disposal system to its safety analysis, uncertainty propagation methods,...) as well as RD&D, site characterisation, site selection, design, construction and management measures aimed at avoiding, mitigating or reducing uncertainties. The interplay between these approaches and measures will also be investigated considering the stepwise nature of disposal programmes and the decisions associated with each programme phase. The identification of possible areas of development and the improvement of advanced strategies is also within the scope of this work topic. (Related deliverable: D10.2)

Interactions with other tasks:

- Task 3: Interactions with Subtask 3.1 where the different types of uncertainties are identified and their evolution discussed are foreseen.
- Task 4: the needs/views of the different kinds of actors for/on options for managing uncertainties associated to specific topics will be investigated in Task 4. Task 2 can provide Task 4 with generic options and strategies. Task 4 will give an input to Task 2 for identifying and elaborating appropriate strategies.
- Task 5: experts involved in Task 2 will liaise with their own community to collect available information and provide the material for interacting with a broader audience including civil society. These broader interactions and the methods to organise them will be developed and implemented within Task 5. Interactions with Task 5 are managed through a participation of Task 5 representatives (MUTADIS & Andra) in key meetings of Task 2 to ensure that the needs of Task 5 are properly understood.

Subtask 2.2– Uncertainty identification, classification and quantification

Start: Month 1 – End: Month 36 – Sub-Task Leader: [JUELICH (HZDR)]

Subtask contributors: [RWM] [SÚRAO] [NAGRA] [JSI (EIMV)] [JUELICH (HZDR)] [ONDRAF/NIRAS] [CIEMAT] [GRS] [SCK•CEN] [TUS] [STUBA] [SSTC NRS]

Total PM: 12,3

Approaches to identify uncertainties that might be of relevance will be compiled, assessed and improved where relevant and possible. This includes systematic expert elicitation. Possible schemes of classification of uncertainties will be described and refined if necessary. The classification process should be linked to the identification process as well as to the strategies and approaches considered in Subtask 2.1. Numerical uncertainties are generally quantified in the form of probability density functions. The selection of an appropriate function type (e.g. uniform or normal distribution) and its correct parametrisation, according to the available knowledge, will be addressed. Previous international work that specifically addressed these topics will be taken into account and possible areas of development will be identified. (Related deliverable: D10.3)

Interactions with other tasks

- o Task 3: the needs/views of the different kinds of actors for/on the identification, classification and quantification of uncertainties associated with specific topics will be investigated in Task 3. Task 2 will provide Task 3 with approaches for these uncertainty management steps. Task 3 will give an input to Task 2 for identifying and elaborating appropriate approaches. Interactions with Subtask 3.1 where the different types of uncertainties are identified and their evolution discussed are also foreseen.

Subtask 2.3– Methodological approaches to uncertainty and sensitivity analysis

Start: Month 13 – End: Month 48 – Sub-Task Leader: [KIT (TU Clausthal)]

Subtask contributors: [NAGRA] [RWM] [IRSN] [SCK•CEN] [CNRS (IMT Atlantique)] [GRS] [JUELICH (HZDR)] [Andra] [COVRA] [KIT (TU Clausthal)]

Total PM: 6

A variety of mathematical methods for uncertainty and sensitivity analysis are available. The goal of this work topic is to investigate how typical numerical PA models can best be analysed in view of uncertainty and sensitivity with classical and modern methods and, where sensible, to coordinate, initiate or recommend the development of appropriate computational tools. The work topic comprises:

- o identification of methods for uncertainty and sensitivity analysis already applied in repository PA
- o analysis of the general understanding of these methods and their outcome
- o identification of specific strengths and weaknesses of these methods
- o suggestions for application of newly developed methods
- o suggestions for refinement of methods

The work might also include exemplarily application of different methods to existing sets of probabilistic PA calculations.

(Related deliverable: D10.4)

Task 3 - Characterization and significance of uncertainties for different categories of actors

Start: Month 1 – End: Month 48 - Task Leader: [RATEN]

Task contributors: [Andra] [Bel V] [CIEMAT] [CNRS (IMT Atlantique)] [COVRA] [ENRESA] [FTMC] [IRSN (MUTADIS)] [JSI (EIMV)] [KIT] [ONDRAF/NIRAS] [POSIVA (Envirocase)] [PSI] [RATEN] [SÚRAO] [SCK.CEN] [SSTC NRS] [TS ENERCON] [VTT]

Total PM: 37,4

Task objectives

The overall objective of Task 3 is to synthesize existing knowledge and views of different kinds of actors on the identification, classification, characterisation and significance of uncertainties associated with specific topics, and to formulate recommendations for the future R&D, KM and strategic study activities.

APPROACH

For each Subtask, the work will be carried out by an expert group of 4 organisations (as far as possible representing the different kinds of actors). Subtask 3.1 will develop a framework for the activities carried out in the WP by defining the different types of uncertainties and temporal aspects to be considered by other tasks and subtasks. Subtasks 3.2 to 3.5 will compile, review and synthesize the existing information on the identification and characterization (including the methods) of relevant uncertainties and identify their potential implications for safety (based on national reports, IAEA TECDOCs, NEA Reports and related European research projects). This information will be also collected using questionnaires to liaise with the whole community. Where relevant, interactions with RD&D WPs will be developed and the state-of-the-art produced in these WPs will be used as input. These working groups will produce material that will be used as input for the discussions with a broader audience including civil society during the seminars organized in Task 5. The working groups will also identify needs for further RD&D, KM and strategic study activities.

The focus will be put in the 1st wave of EURAD-1 on uncertainties related to the waste inventory, spent fuel, human aspects, site and geosphere. These topics are of particular interest for National Programmes at an early stage and will allow addressing in particular the following high-priority subdomains of the Programme Document: inventory uncertainty, radionuclide release from wasteforms other than spent fuel, impacts of extended storage on waste packages, and site descriptive models. The selection of these topics allows as well addressing key pre-disposal issues like waste characterization and ageing associated with extended storage. It is foreseen to address during the 2nd wave of EURAD-1 uncertainties related to near-field evolution and to radionuclide migration so as to address uncertainties investigated by the RD&D WPs on cement-organic-radionuclide interactions, radionuclide mobility, gas, temperature and chemical evolution. These studies, if accepted, would start during the 3rd year of EURAD-1.

INTERACTIONS WITH OTHER TASKS

- Task 2: see Task 2 description.
- Task 4: in Task 4 the views of the different kinds of actors will be exchanged on how to treat, reduce, mitigate or avoid uncertainties. These exchanges will focus on uncertainties addressed in Task 3.
- Task 5: experts involved in Task 3 will liaise with their own community to collect available information and develop the material for interacting with a broader audience including civil society. These broader interactions and the methods to organise them will be developed and implemented within Task 5. Interactions with Task 5 are managed through a participation of Task 5 representatives (MUTADIS & IRSN) in key meetings to ensure that the needs of Task 5 are properly understood by Task 3 participants.

Subtask 3.1 – Types of uncertainties relevant to the safety analysis and the safety case

Start: Month 1 – End: Month 36 - Task Leader: [CNRS (IMT Atlantique)]

Subtask contributors: [ONDRAF-NIRAS] [JSI] [RATEN] [POSIVA (Envirocase)] [CNRS (IMT Atlantique)]

Total PM: 8,5

This subtask will address the following generic key questions:

- According to the views of the different actors, what types of uncertainties need to be addressed in a safety analysis and in a safety case?
- How could these uncertainties evolve throughout the different phases of a disposal programme and what are views of the different actors on these possible evolutions?

This subtask will provide a high-level integrated picture of the various types of uncertainties that are potentially relevant for safety (Related deliverable: D10.5). This picture will serve as framework for the activities carried out in the WP by defining the different types of uncertainties and temporal aspects to be considered by other tasks and subtasks. The activities will consist in the review of related literature, liaising with the community through a questionnaire and discuss the results in a seminar organized by Task 5 to exchange views on the various types of uncertainties and their evolution and establish a common approach or a common understanding of the different approaches.

Subtask 3.2 – Uncertainties on waste inventory and on the impact of predisposal steps

Start: Month 9 – End: Month 36 – Sub-task Leader: [SCK•CEN]

Subtask contributors: [TS Enercon] [ENRESA] [FTMC] [SCK•CEN]

Total PM: 7,2

Knowledge of the radionuclide and chemical inventory (including metals and organic compounds) of wastes requiring disposal in a deep geological repository is important for the transport, operations and post-closure safety cases. Data quality of waste inventories is often variable, with uncertainty often dominated by waste heterogeneity. Relevant uncertainties related to the inventory of radioactive wastes other than SF (e.g. vitrified waste, metallic waste, high-organic waste, graphite, cementitious waste forms,...), the evolution of these uncertainties and their potential significance for safety will be addressed. The possible impact of predisposal steps (e.g. ageing occurring during extended storage) will also be investigated. The aim is to focus the work in the 1st wave of EURAD-1 on a limited number of waste types that will be identified following interactions with Task3 of the WP on waste management routes dedicated to waste characterization. This task starts at Month 9 and ends at Month 30. All these activities will focus on safety-relevant radionuclides, their physico-chemical forms and release kinetics as well as on species altering their migration in the near-field. The Expert Group will first identify and characterize associated uncertainties based on available information from National Programmes and international initiatives (IAEA, NEA/OECD, NUGENIA,...), and relevant past and ongoing European RD&D projects in close collaboration with the Strategic Study WP on Waste Management Routes and, for the aspects related to waste containing organic matter, with the RD&D WP on Cement-Organic-Radionuclide-Interactions. The Expert Group review will be completed (via a questionnaire) with information from other EURAD-1 participants and possibly from waste generators members of NUGENIA.

This will lead to the elaboration of a draft of deliverable D10.6 to be used in Task 4 where possible options for the management of these uncertainties will be identified and in Task 5 for discussion with a broader stakeholder group. The views of different actors collected during the workshop dedicated to the management of these uncertainties organized in Task 4 and the seminars organized in Task 5, will then be used to update and finalize deliverable D10.6.

Subtask 3.3 – Site and geosphere related uncertainties

Start: Month 1 – End: Month 36 – Sub-Task Leader: [RATEN]

Subtask contributors: [PSI] [IRSN] [SÚRAO] [RATEN]

Total PM: 7,5

As stated in the Programme Document, there is a need to develop the state-of-the-art on the management of uncertainties associated with site characteristics. Such uncertainties need also to be taken into account when developing site descriptive models. This subtask will focus on the identification, characterization, evolution and significance of the following uncertainties related to both near-surface and geological disposal sites in the context of different host rocks (crystalline, clay and salt rocks):

- uncertainties to be taken into consideration when conceptualizing natural barriers and aquifers;
- uncertainties associated with geodynamics and tectonic perturbations of the site in the long-term (including seismic events and faulting) ;
- uncertainties associated with future climate changes, such as potential future glaciations and other possible processes (e.g. flooding and desertification, subglacial erosion and permafrost formation).

The Expert Group will first identify and characterize uncertainties based on available information from National Programmes and international initiatives (IAEA, NEA/OECD,...), and relevant past and ongoing European RD&D projects. The aspects related to radionuclide transport in the geosphere will be approached in close collaboration with the RD&D WP on Fundamental understanding of radionuclide mobility. The Expert Group review will be completed (via a questionnaire) with information from other EURAD-1 participants. This will lead to the elaboration of a draft of deliverable D10.7 to be used in Task 4 where possible options for the management of these uncertainties will be identified and in Task 5 for discussion with a broader stakeholder group. The views of different actors collected during the workshop dedicated to the management of these uncertainties organized in Task 4 and the seminars organized in Task 5, will then be used to update and finalize deliverable D10.7.

Subtask 3.4 – Uncertainties related to human aspects

Start: Month 1 – End: Month 36 – Sub-task Leader: [Andra]

Subtask contributors: [Andra] [VTT] [COVRA] [JSI (EIMV)]

Total PM: 7

This subtask will address the identification, characterization, evolution and significance of uncertainties associated with social, economic and other human aspects identified as potentially relevant to safety and the decision-making process, including the custodianship and transgenerational aspects associated with long-term operation of SF storage facilities. The relationships between these uncertainties, strategic choices (e.g. reversibility and retrievability) and programmatic decisions will be investigated. The Expert Group will first identify and characterize uncertainties based on available information from National Programmes and international initiatives (IAEA, NEA/OECD,...) and relevant past European RD&D projects. The Expert Group review will be completed (via a questionnaire) with information

from other EURAD-1 participants. This will lead to the elaboration of a draft of deliverable D10.8 to be used in Task 4 where possible options for the management of these uncertainties will be identified and in Task 5 for discussion with a broader stakeholder group. The views of different actors collected during the workshop dedicated to the management of these uncertainties organized in Task 4 and the seminars organized in Task 5, will then be used to update and finalize deliverable D10.8.

Subtask 3.5 – Spent fuel related uncertainties

Start: Month 1 – End: Month 48 - Task Leader: [CIEMAT]

Subtask contributors: [Bel V] [CIEMAT] [KIT] [SSTC NRS]

Total PM: 7

Knowledge of the radionuclides of spent fuel (SF) and of their chemical form is important for the safety case. Relevant uncertainties related to the source term of SF, centered on their radiological inventory and heat generation, their evolution and potential significance for safety will be addressed. These activities will focus on safety-relevant radionuclides, their physico-chemical forms and release processes. Uncertainties associated with ageing (due to extended storage and/or operational phase of the disposal facility) will also be investigated. In particular, the long-term behaviour and integrity of fuel cladding (oxidation, hydration, swelling) and the ageing of the cask and of its sealing system will be considered. The potential significance of uncertainties for the safety of transport, storage and disposal (both operational and post-closure safety) will be as well considered in this subtask. The Expert Group will first identify and characterize uncertainties based on available information from National Programmes and international initiatives (IAEA, NEA/OECD,...), and relevant past and ongoing European RD&D projects in close collaboration with the RD&D WP on SF. The Expert Group review will be completed (via a questionnaire) with information from other EURAD-1 participants and possibly from NUGENIA members involved in SF characterization, transport and/or storage.

This will lead to the elaboration of a draft of deliverable D10.9 to be used in Task 4 where possible options for the management of these uncertainties will be identified and in Task 5 for discussion with a broader stakeholder group. The views of different actors collected during the workshop dedicated to the management of these uncertainties organized in Task 4 and the seminars organized in Task 5, will then be used to update and finalize deliverable D10.9.

Task 4 - Uncertainty management options and preferences of different actors across the various programme phases

Start: Month 1 – End: Month 48 - Task Leader: [BGE]

Task contributors: [Andra] [Bel V] [BGE] [CNRS (IMT Atlantique)] [ENRESA] [IRSN (MUTADIS)] [KIT] [LEI] [NAGRA] [NRG] [ONDRAF/NIRAS] [STUBA] [SURO] [TUS]

Total PM: 24,2

Task objectives

The overall objectives of Task 4 are to identify, for different phases of a disposal programme and the associated decision-making, a bundle of possible options for:

- o treating uncertainties associated with specific topics in the safety assessment (e.g. uncertainty propagation methods, scenario development, stylisation approaches,...),
- o avoiding, reducing or mitigating these uncertainties,
- o making a safety case robust vis-à-vis these uncertainties.

The views and preferences of the different kinds of actors on these possible options will be identified considering their roles in the decision-making process. Task 4 will offer a platform for networking on relevant issues regarding uncertainty management as a part of risk and safety management throughout the implementation of a disposal programme. Special focus will be put on potential impacts of preferences of different categories of actors and derived management options.

INTERACTIONS WITH OTHER TASKS

- o Task 2: see Task 2 description.
- o Task 3: see Task 3 description.
- o Task 5: Task 4 will provide an input to Task 5 concerning possible uncertainty management options considering preferences of various actors. Task 4 will also provide a list of actors directly involved in or related to radioactive waste management processes and information about their roles, interests and preferences. Interactions with Task 5 are managed through:
 - o a participation of Task 5 representatives (MUTADIS & Topic 3 leader) in key meetings to ensure that the needs of Task 5 are properly understood by Task 4 participants,
 - o the review by Task 4 participants of deliverable D5.3 so as to ensure the consistency of all deliverables

Subtask 4.1 – Identification and characterization of the different actors across the entire radioactive waste management process

Start: Month 1 – End: Month 12 – Sub-task Leader: [BGE]

Subtask contributors: [BGE] [SURO]

Total PM: 2,5

The objective of this subtask is to identify and characterize the different actors across all phases of a disposal programme in order to improve understanding of their interests and preferences regarding the management of different types of uncertainties. The outcome of this work (Deliverable D10.10) will serve as input to Sub-Tasks 4.2 and 4.3 and Task 5 (Topic 3). To achieve this goal a questionnaire will be established. The questionnaire's structure will be based on the generic phases identified in the EURAD Roadmap. This will allow identifying the actors involved and their roles in the process while remaining independent from national regulations or specificities. All organisations participating in the strategic studies (i.e. in this WP as well as in the WP on Waste Management Routes) will be invited to fill out the questionnaire and give information about actors and their characterization. The answers to the questionnaire will be the basis for the analysis, description and grouping the different actors. Although the subtask will address all phases of a programme, the focus will be put in the first wave on uncertainties related to waste inventory, spent fuel, human aspects and the site/geosphere relevant to disposal.

Subtask 4.2 – Compilation and review of available information on possible uncertainty management options

Start: Month 6 – End: Month 42 - Task Leader: [NAGRA]

Subtask contributors: [Andra] [Bel V] [BGE] [SURO] [KIT] [LEI] [NAGRA] [NRG] [TUS]

Total PM: 12,3

The objective of this subtask is to develop a comprehensive overview about different approaches and uncertainty management options to assess and where relevant to reduce risks and optimise safety (Related deliverable: D10.11). Existing documentation (e.g. regulations, guidelines, handbooks, national reports, lists of options, cross-mappings, sets of interrelated or interacting elements) on the management of uncertainties including examples of pitfalls will be compiled, reviewed and synthesized. The schemes for classification of uncertainties resulting from Subtask 3.1 will serve as a tool to identify management options depending on the type of uncertainty and temporal aspects.

The focus will be put on the following topics also addressed in Task 3:

- o Site- and geosphere-related uncertainties (in particular in the course of host rock and site selection processes),
- o Uncertainties related to human aspects,
- o Uncertainties related to the waste inventory (including uncertainties associated with their pre-disposal management having implications for the safety of the disposal facility),
- o Uncertainties related to spent fuel (including those associated with their possible long-term storage and characterization).

Subtask 4.3 – Preferences of the different actors on uncertainty management options

Start: Month 13 – End: Month 48 – Sub-task Leader: [NRG]

Subtask contributors: [Andra] [Bel V] [BGE] [CNRS (IMT Atlantique)] [SURO] [ENRESA] [LEI] [IRSN (MUTADIS)] [NAGRA] [ONDRAF-NIRAS] [STUBA] [NRG]

Total PM: 9,5

The objectives of this subtask are as follows:

- o Preparing the material needed by Task 5 to interact with a broader audience on the views of different actors considering the whole process of radioactive waste management (input to Task 5),
- o Synthesizing the preferences of the different actors for uncertainties associated with specific topics based on the outcomes of Subtasks 4.1, 4.2 and 5.1,
- o Identifying needs for future RD&D, KM or strategic study activities.

Based on the results of Subtasks 4.1 and 4.2, the management options for the different types of uncertainties considered in the task and the preferences of different actors as well as the rationale behind them are discussed, analysed and described (Related deliverable: D10.12). Four workshops bringing together organisations contributing to Subtask 4.3, one of the expert groups of Subtasks 3.2 to 3.5 (depending on the addressed topic) as well as other interested EURAD partners, are planned:

- WS1 (Milestone MS108): Management options and preferences of different actors regarding site and geosphere related uncertainties (Month: 19)
- WS2 (Milestone MS134): Management options and preferences of different actors regarding human aspects related uncertainties (Month: 25)
- WS3 (Milestone MS146): Management options and preferences of different actors regarding SF-related uncertainties (Month: 28)
- WS4 (Milestone MS164): Management options and preferences of different actors regarding waste inventory related uncertainties (Month: 33)

The outcome of this work will be documented and serve as input for Task 5 organising the seminars where the discussions will be broadened to a larger audience including civil society.

Task 5 - Interactions between all categories of actors, including Civil Society

Start: Month 1 – End: Month 48 - Task Leader: [IRSN (MUTADIS)]

Task contributors: [Andra] [Bel V] [GRS] [IRSN (MUTADIS) (NTW)] [JSI (EIMV)] [KIT (TU Clausthal)] [POSIVA (Envirocase)] [RWM] [SSTC NRS] [TUS]

Total PM: 34,7

Task objectives

The overall objectives of this task are:

- To develop a common understanding or understanding of the different viewpoints among the different categories of actors on:
 - o uncertainty management and how it relates to risk & safety,
 - o whether and why a safety case is robust vis-à-vis uncertainties.

- To share knowledge/know-how and discuss common methodological/strategical challenging issues on uncertainty management among a broader group of actors.

Although not a goal in itself, the communication of uncertainty is embedded in the task through the preparation of seminars by “methodological groups” and Topic 4.

APPROACH

This task will organise a pluralistic analysis of key outcomes of other tasks of the WP with a pluralistic stakeholder group including Civil Society organisations (CSOs), TSOs, WMOs and Research Entities. This pluralistic analysis will take the form of a series of seminars gathering pluralistic stakeholder groups, supported and facilitated by a methodological group. Interactions with civil society will be organised at two levels. Besides the participation of CS experts in specific subtasks of Tasks 2 to 4 (Subtask 5.2), seminars organised by Subtask 5.1 will include a wider range of civil society actors: national civil society organisations, local organisations in communities directly engaged in geological disposal projects (e.g. representatives of local partnerships or local commissions). Participants will not include members of the general public. Organisations contributing to other WP tasks will be invited to the seminars as stakeholders (without person-month budget). Additional participants that are not members of the WP (CSOs, other EURAD-1 participants, other relevant stakeholders from outside EURAD-1,...) will be identified by the methodological group preparing and organising the seminar. Each potential participant in a seminar will be contacted by the methodological group. Their involvement in the seminars will be formalised by a memorandum of understanding. This memorandum of understanding will provide a clear framework for CSO engagement, where the expectations of CSOs and WP Task 5 members are made explicit and where the roles of the different participants in the seminars (WP members, CSOs and CS experts engaged in subtask 5.2, CSOs not directly involved in the WP,...) are identified. The seminars will include presentations of outcomes of the other WP tasks prepared by members of the methodological group (see Subtask 5.1), facilitated discussions with the participants in working groups.

Subtask 5.1 - Preparation, support and reporting of pluralistic analyses

Start: Month 1 – End: Month 48 - Task Leader: [IRSN (MUTADIS)]

Subtask contributors: [IRSN (MUTADIS)] [Andra] [KIT (TU Clausthal)] [RWM] [JSI (EIMV)] [TUS] [POSIVA (Envirocase)] [SSTC NRS] [Bel V] [GRS]

Total PM: 27,3

A methodological group will support the pluralistic analyses by:

- Setting up the stakeholder groups (identification of potential members of the stakeholder group, preparation of a memorandum of understanding, contact and liaison with the different stakeholders, etc.);
- Reviewing materials of Tasks 2 to 4 and preparing materials related to Topics 1 to 4 to be discussed during the seminars, under a form enabling discussion between expert and non-expert members of the stakeholder groups;
- Proposing methods for structured discussions between stakeholders on Topics 1 to 4;
- Animating/facilitating the multi-stakeholder seminars;
- Analysing the outputs of seminars and preparing deliverables;
- Organising interactions with Civil Society and other stakeholders.

The 4 following topics will be addressed in Task 5:

- Topic 1: Meaning for different actors of uncertainty management and of its relationships with risk, safety and the safety case. This topic will investigate the views of each type of actors regarding what uncertainty management involves as well as how it relates to risk, safety and the safety case considering the decisions associated with each phase of a disposal programme. It will use as input existing literature, the outcomes of Subtasks 2.1 (generic strategies for managing uncertainties), Task 3, where the significance of different types of uncertainties will be identified, and Subtask 4.1 (identification and characterization of actors), as well as the outcome of the 1st seminar and additional elements stemming from subsequent seminars. (Related deliverable: D10.13)
- Topic 2: Uncertainty pictures at different steps of a geological disposal programme. This topic will investigate the evolution of the different types of uncertainties and of their significance for the different types of actors throughout a disposal programme based on the outcomes of Task 3, of the 1st and 2nd seminars as well as on additional outcomes from the 3rd seminar. (Related deliverable: D10.14)

- Topic 3: Uncertainty management options for addressing uncertainties throughout a geological disposal programme. This topic will discuss the different options for the management of specific types of uncertainties and their implications. It will also investigate the preferences of the different types of actors on possible options. It will use as input the outcomes of Subtasks 2.1 and 4.3 and broaden the discussions initiated in Subtask 4.3 to a larger audience during the 3rd and 4th seminars. (Related deliverable: D10.15)

- Topic 4: Methods for a pluralistic assessment of uncertainties and their management along the disposal programme. This topic will explore methods that can be used for discussing and organising pluralistic assessments of uncertainties with civil society stakeholders throughout a disposal programme. This topic includes the communication of these issues and addresses both the development and the review of the safety case. It will be based on the outcome of Subtasks 2.1 and 4.1, on existing processes of exchanges between stakeholders in the EU, on the outcomes of the other topics as well as of the 4th seminar. (Related deliverable: D10.16)

4 seminars will be organised, covering the 4 topics (several topics can be addressed during 1 seminar):

- The 1st seminar (month 13) will set the scene by addressing the meaning for different actors of uncertainty management and of its relationships with risk, safety and the safety case (Topic 1). It will include discussions about the paradigms underlying the safety case. It will also address the outcome of the work performed in Subtask 3.1 concerning the different types of uncertainties to be addressed in a safety case.

- The 2nd seminar (month 25) will address uncertainty pictures at different steps of a geological disposal programme (Topic 2). Additionally, the seminar could also address available outcomes of Task 4.

- The 3rd seminar (month 37) will address options for managing uncertainties throughout a geological disposal programme (Topic 3). Additionally, the seminar could also address other outcomes of Task 2.

- During the 4th seminar (month 43) further exchanges on options for managing uncertainties (Topic 3) are foreseen, as well as exchanges on methods for a pluralistic assessment of uncertainties and their management along a disposal programme (Topic 4), on the basis of propositions of the methodological group.

Interactions with other tasks: Work, meetings and workshops in other tasks allow developing the « raw material » for the discussions with a broader audience during the multi-stakeholder seminars organised by Task 5 (see also other task descriptions).

Subtask 5.2 - Input of civil society experts

Start: Month 1 – End: Month 48 - Task Leader: [IRSN (MUTADIS)]

Subtask contributors: [IRSN (MUTADIS) (NTW)] [RWM]

Total PM: 7,4

A team of 4 civil society (CS) experts will be involved in different activities of the WP. However, for organizational convenience purposes, their contribution to the WP is described in a dedicated subtask. This allows having a clear framework for CSO engagement in WP activities that is methodologically coherent, regular in time, and coordinated with the other CSO activities in EURAD. The role of CS experts is to sketch out and map the key stakes related to the work performed in the different subtasks from a civil society point of view in order to facilitate liaison with the broader CS group involved in EURAD and, in particular, in the WP through the seminars organised by Subtask 5.1 (Related deliverable: D10.17). These CS experts will:

- Follow the work performed in Tasks 2 to 4 and participate in key working meetings of these tasks;
- Contribute to the preparation of Task 5 seminars by preparing and performing specific presentations mapping the progress of the different tasks and the associated stakes for civil society. This progressive mapping of WP UMAN outcomes will finally be synthesised in Deliverable D10.17 (see below).
- Contribute to skill building of the broader CS group by preparing and animating a specific session dedicated to the WP UMAN in the CS annual workshop (which are different from Task 5 multi-stakeholder seminars).

Interactions with other tasks

- Tasks 2 to 4: Follow-up of the work performed in these tasks and mapping of the stakes related to the outcomes of these tasks from a civil society point of view
- EURAD as a whole: WP UMAN session during the CS annual workshop

Participation per Partner

Partner number and short name	WP10 effort
1 - ANDRA	7.90
3 - BEL V	11.00

Partner number and short name	WP10 effort
4 - BGE	5.80
6 - CIEMAT	3.50
8 - CNRS	0.00
IMT Atlantique	3.50
9 - COVRA	1.50
10 - FTMC	2.00
14 - ENRESA	2.50
15 - JUELICH	0.00
HZDR	3.30
16 - GRS	4.30
19 - IRSN	5.50
MUTADIS	10.80
NTW	2.90
22 - JSI	1.50
EIMV	5.30
24 - KIT	2.50
Uni Clausthal	5.50
25 - LEI	3.50
27 - NAGRA	3.50
31 - NRG	3.80
32 - ONDRAF/NIRAS	2.30
33 - POSIVA	0.00
Envirocase	3.00
34 - PSI	1.50
36 - RATEN	7.30
37 - RWM	3.00
38 - SCK•CEN	4.00
40 - SSTC NRS	4.80
41 - STUBA	1.50
42 - SÚRAO	3.50
43 - SURO	3.00
45 - TS Enercon	1.20
46 - TUS	4.80
50 - VTT	1.50
GSL	2.50
Total	134.00

List of deliverables

Deliverable Number¹⁴	Deliverable Title	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
D10.1	UMAN - Training materials	3 - BEL V	Report	Public	48
D10.2	UMAN - Strategies for managing uncertainties	50 - VTT	Report	Public	36
D10.3	UMAN - Uncertainty identification, classification and quantification	15 - JUELICH	Report	Public	36
D10.4	UMAN - Methodological approaches to uncertainty and sensitivity analysis	24 - KIT	Report	Public	48
D10.5	UMAN - Uncertainties relevant to the safety case	8 - CNRS	Report	Public	36
D10.6	UMAN - Views of the different actors on the identification, characterization and potential significance of uncertainties on waste inventory and on the impact of predisposal steps	38 - SCK•CEN	Report	Public	36
D10.7	UMAN - Views of the different actors on the identification, characterization and potential significance of uncertainties on site and geosphere	36 - RATEN	Report	Public	36
D10.8	UMAN - Views of the different actors on the identification, characterization and potential significance of uncertainties on human aspects	1 - ANDRA	Report	Public	36
D10.9	UMAN - Views of the different actors on the identification, characterization and potential significance of uncertainties associated with spent fuel	6 - CIEMAT	Report	Public	48
D10.10	UMAN - Analysis and description of groups of different actors	4 - BGE	Report	Public	12

List of deliverables

Deliverable Number¹⁴	Deliverable Title	Lead beneficiary	Type¹⁵	Dissemination level¹⁶	Due Date (in months)¹⁷
D10.11	UMAN - Study on management options for different types of uncertainties and programme phases	27 - NAGRA	Report	Public	42
D10.12	UMAN - Identification, analysis and description of preferences of different actors on uncertainty management options	31 - NRG	Report	Public	48
D10.13	UMAN - Understanding of uncertainty management by the various stakeholders	24 - KIT	Report	Public	40
D10.14	UMAN - Pluralistic analysis of uncertainty pictures	19 - IRSN	Report	Public	40
D10.15	UMAN - Pluralistic analysis of uncertainty management options and preferences of stakeholders vis-à-vis uncertainty management	1 - ANDRA	Report	Public	48
D10.16	UMAN - Methods for a pluralistic assessment of uncertainties and their management along the disposal programme	19 - IRSN	Report	Public	48
D10.17	UMAN - Synthetic mapping of the stakes related to WP UMAN outcomes from a civil society point of view	19 - IRSN	Report	Public	48

Description of deliverables

- D10.1: Training materials - Lead: [Bel V] Due month: 48
- D10.2: Strategies for managing uncertainties: Regulatory background, overview of applied strategies, interactions between strategies, consideration of the stepwise nature of the decision-making process, identification of areas of possible further development. Lead: [VTT (GSL)]. Due month: 36.
- D10.3: Uncertainty identification, classification and quantification: Approaches to identifying uncertainties, expert elicitation, classification of uncertainties, objective quantification of uncertainties, and identification of areas of possible further development. Lead: [JUELICH (HZDR)]. Due month: 36.
- D10.4: Methodological approaches to uncertainty and sensitivity analysis: Overview of mathematical methods for uncertainty and sensitivity analysis, comparison of their specifics, identification of areas for further development. Lead: [KIT (TU Clausthal)] Due month: 48.

- D10.5: Uncertainties relevant to the safety case: This deliverable will describe the various types of uncertainties that need to be addressed in a safety analysis and in a safety case as well as how these uncertainties may evolve throughout the different phases of a disposal programme. Lead: [CNRS] Due Month: 36.
- D10.6: Views of the different actors on the identification, characterization and potential significance of uncertainties on waste inventory and on the impact of predisposal steps: This deliverable will describe the views of different categories of actors on the uncertainties associated with the waste inventory which need to be addressed in a safety case as well as on their characterization, evolution and potential significance including the impact of predisposal phases and their significance for the disposal safety. Recommendations for future R&D, KM or strategic study activities will be provided. Lead: [SCK•CEN]. Due Month: 36.
- D10.7: Views of the different actors on the identification, characterization and potential significance of uncertainties on site and geosphere: This deliverable will describe the views of different categories of actors on uncertainties associated with the site and geosphere that need to be addressed in a safety case for different disposal concepts as well as on their characterization, evolution and potential significance for safety, and will include recommendations for future RD&D, KM and strategic study activities. Lead [RATEN] Due Month: 36.
- D10.8: Views of the different actors on the identification, characterization and potential significance of uncertainties on human aspects: This deliverable will describe the views of different categories of actors on uncertainties on human aspects that need to be addressed in a safety case as well as on their characterization, evolution and potential significance for safety. The deliverable will also include recommendations for characterization of non-technical uncertainties as well as for future RD&D, KM and strategic study activities. Lead [Andra] Due Month: 36.
- D10.9: Views of the different actors on the identification, characterization and potential significance of uncertainties associated with spent fuel. This deliverable will describe the views of different categories of actors on uncertainties on SF storage, transport and disposal that need to be addressed in a safety case as well as on their characterization, evolution and potential significance for safety. The deliverable will also include recommendations for the future RD&D, KM and strategic study activities. Lead [CIEMAT] Due Month: 48.
- D10.10: Analysis and description of groups of different actors: This deliverable will identify the different categories of actors involved in each phase of a disposal programme as well as their roles and interests. Lead [BGE] Due month: 12.
- D10.11: Study on management options for different types of uncertainties and programme phases. This deliverable will identify possible management options for different types of uncertainties and programme phases based on existing information. Draft versions of this deliverable will provide a basis for the discussions and exchanges held in Subtask 4.3. Lead [NAGRA] Due month: 42.
- D10.12: Identification, analysis and description of preferences of different actors on uncertainty management options: This deliverable will identify and describe preferences on uncertainty management options by groups of different actors as well as the rationale behind these preferences. Draft versions of this deliverable will provide a basis for the discussions and exchanges held in the seminars organised by Task 5. Lead [NRG] Due month: 48.
- D10.13: Understanding of uncertainty management by the various stakeholders. This deliverable will document the work related to Topic 1. Lead organisation: TU Clausthal. Due month: 40.
- D10.14: Pluralistic analysis of uncertainty pictures. This deliverable will document the work related to Topic 2. Lead [IRSN] Due month: 40.
- D10.15: Pluralistic analysis of uncertainty management options and preferences of stakeholders vis-à-vis uncertainty management. This deliverable will document the work related to Topic 3. Lead [Andra] Due month: 48.
- D10.16: Methods for a pluralistic assessment of uncertainties and their management along the disposal programme. This deliverable will document the work related to Topic 4. Lead [MUTADIS] Due month: 48.
- D10.17: Synthetic mapping of the stakes related to WP UMAN outcomes from a civil society point of view. This deliverable will synthesise the stakes related to the work and outcome of the different tasks of the WP from a civil society point of view. Lead [MUTADIS] Due month: 48.

D10.1 : UMAN - Training materials [48]

UMAN - Training materials

D10.2 : UMAN - Strategies for managing uncertainties [36]

UMAN - Strategies for managing uncertainties

D10.3 : UMAN - Uncertainty identification, classification and quantification [36]

UMAN - Uncertainty identification, classification and quantification

D10.4 : UMAN - Methodological approaches to uncertainty and sensitivity analysis [48]

UMAN - Methodological approaches to uncertainty and sensitivity analysis

D10.5 : UMAN - Uncertainties relevant to the safety case [36]

UMAN - Uncertainties relevant to the safety case

D10.6 : UMAN - Views of the different actors on the identification, characterization and potential significance of uncertainties on waste inventory and on the impact of predisposal steps [36]

UMAN - Views of the different actors on the identification, characterization and potential significance of uncertainties on waste inventory and on the impact of predisposal steps

D10.7 : UMAN - Views of the different actors on the identification, characterization and potential significance of uncertainties on site and geosphere [36]

UMAN - Views of the different actors on the identification, characterization and potential significance of uncertainties on site and geosphere

D10.8 : UMAN - Views of the different actors on the identification, characterization and potential significance of uncertainties on human aspects [36]

UMAN - Views of the different actors on the identification, characterization and potential significance of uncertainties on human aspects

D10.9 : UMAN - Views of the different actors on the identification, characterization and potential significance of uncertainties associated with spent fuel [48]

UMAN - Views of the different actors on the identification, characterization and potential significance of uncertainties associated with spent fuel

D10.10 : UMAN - Analysis and description of groups of different actors [12]

UMAN - Analysis and description of groups of different actors

D10.11 : UMAN - Study on management options for different types of uncertainties and programme phases [42]

UMAN - Study on management options for different types of uncertainties and programme phases

D10.12 : UMAN - Identification, analysis and description of preferences of different actors on uncertainty management options [48]

UMAN - Identification, analysis and description of preferences of different actors on uncertainty management options

D10.13 : UMAN - Understanding of uncertainty management by the various stakeholders [40]

UMAN - Understanding of uncertainty management by the various stakeholders

D10.14 : UMAN - Pluralistic analysis of uncertainty pictures [40]

UMAN - Pluralistic analysis of uncertainty pictures

D10.15 : UMAN - Pluralistic analysis of uncertainty management options and preferences of stakeholders vis-à-vis uncertainty management [48]

UMAN - Pluralistic analysis of uncertainty management options and preferences of stakeholders vis-à-vis uncertainty management

D10.16 : UMAN - Methods for a pluralistic assessment of uncertainties and their management along the disposal programme [48]

UMAN - Methods for a pluralistic assessment of uncertainties and their management along the disposal programme

D10.17 : UMAN - Synthetic mapping of the stakes related to WP UMAN outcomes from a civil society point of view [48]

UMAN - Synthetic mapping of the stakes related to WP UMAN outcomes from a civil society point of view

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	EURAD Kick-off meeting (General Assembly n°1)	1 - ANDRA	1	EURAD Kick-off meeting (General Assembly n°1)

Schedule of relevant Milestones

Milestone number¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS12	EURAD EJP Newsletters	1 - ANDRA	3	EURAD EJP Newsletters (Due date : M3 and then every quarter)
MS21	UMAN Draft D10.5 as input to Task 2, Task 4, Task 5 and other subtasks of Task 3	3 - BEL V	6	UMAN Draft D10.5 as input to Task 2, Task 4, Task 5 and other subtasks of Task 3
MS22	UMAN Preliminary list of uncertainties from UMAN subtask 3.3 as input to Subtask 4.2	3 - BEL V	6	UMAN Preliminary list of uncertainties from UMAN subtask 3.3 as input to Subtask 4.2
MS23	UMAN Preliminary list of uncertainties from subtask 3.4 as input to Subtask 4.2	3 - BEL V	6	UMAN Preliminary list of uncertainties from subtask 3.4 as input to Subtask 4.2
MS24	UMAN Identification of the different actors across the various programme phases including a first characterization of their roles and interests (Draft D10.10)	3 - BEL V	6	UMAN Identification of the different actors across the various programme phases including a first characterization of their roles and interests (Draft D10.10)
MS25	UMAN Composition of the pluralistic stakeholder group for Seminar 1	3 - BEL V	6	UMAN Composition of the pluralistic stakeholder group for Seminar 1
MS26	SOTA from RD&D CORI WP as input to UMAN T3.2	24 - KIT	6	SOTA from RD&D CORI WP as input to UMAN T3.2
MS27	SOTA from RD&D FUTuRE WP as input to UMAN T3.3	15 - JUELICH	6	SOTA from RD&D FUTuRE WP as input to UMAN T3.3
MS29	SOTA from RD&D SFC WP as input to UMAN T3.5	39 - SKB	6	SOTA from RD&D SFC WP as input to UMAN T3.5
MS30	EURAD General Assembly n°2	1 - ANDRA	7	EURAD General Assembly n°2
MS40	UMAN Draft deliverable D10.2 as input to Tasks 4 and 5	3 - BEL V	7	UMAN Draft deliverable D10.2 as input to Tasks 4 and 5
MS42	EURAD Annual Work Plan 2	1 - ANDRA	9	EURAD Annual Work Plan 2
MS54	UMAN Preliminary list of uncertainties from subtask 3.5 as input to Subtask 4.2	3 - BEL V	10	UMAN Preliminary list of uncertainties from subtask 3.5 as input to Subtask 4.2
MS67	UMAN Recommendations for future RD&D, strategic study and KM activities for the 2nd wave of EURAD-1	3 - BEL V	12	UMAN Recommendations for future RD&D, strategic study and KM activities for the 2nd wave of EURAD-1
MS68	Materials to be discussed in UMAN Seminar 1	3 - BEL V	12	Materials to be discussed in UMAN Seminar 1

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS69	UMAN Mapping of the stakes related to the outcomes of Task 2 and Subtask 3.1 from a civil society point of view for the 1st Task 5 seminar	3 - BEL V	12	UMAN Mapping of the stakes related to the outcomes of Task 2 and Subtask 3.1 from a civil society point of view for the 1st Task 5 seminar
MS71	Methodology for ICS activities assessment	19 - IRSN	12	Methodology for ICS activities assessment
MS74	UMAN WP meeting 1	3 - BEL V	13	UMAN WP meeting 1
MS75	UMAN Draft D10.3 as input to Task 3	3 - BEL V	13	UMAN Draft D10.3 as input to Task 3
MS76	UMAN Draft D10.7 as input to Task 4 and 5	3 - BEL V	13	UMAN Draft D10.7 as input to Task 4 and 5
MS77	UMAN Seminar 1	3 - BEL V	13	UMAN Seminar 1
MS81	EURAD General Assembly n°3 + EURAD Annual Meeting 1	1 - ANDRA	13	EURAD General Assembly n°3 + EURAD Annual Meeting 1
MS82	ICS Workshop 1	19 - IRSN	13	ICS Workshop 1
MS85	EURAD Periodic Report 1	1 - ANDRA	14	EURAD Periodic Report 1
MS89	UMAN Compiled and reviewed information about possible management options for site and geosphere related uncertainties as input to Subtask 4.3	3 - BEL V	15	UMAN Compiled and reviewed information about possible management options for site and geosphere related uncertainties as input to Subtask 4.3
MS92	UMAN Preliminary list of uncertainties from subtask 3.2 as input to Subtask 4.2	3 - BEL V	16	UMAN Preliminary list of uncertainties from subtask 3.2 as input to Subtask 4.2
MS101	UMAN Draft D10.8 as input to Task 4 and 5	3 - BEL V	18	UMAN Draft D10.8 as input to Task 4 and 5
MS102	Composition of the pluralistic stakeholder group for UMAN Seminar 2	3 - BEL V	18	Composition of the pluralistic stakeholder group for UMAN Seminar 2
MS103	EURAD General Assembly n°4	1 - ANDRA	19	EURAD General Assembly n°4
MS108	UMAN Workshop 1 on management options and preferences of different actors regarding site and geosphere related uncertainties	3 - BEL V	19	UMAN Workshop 1 on management options and preferences of different actors regarding site and geosphere related uncertainties
MS111	UMAN Draft D10.9 as input to Task 4 and 5	3 - BEL V	20	UMAN Draft D10.9 as input to Task 4 and 5
MS112	EURAD Annual Work Plan 3	1 - ANDRA	21	EURAD Annual Work Plan 3

Schedule of relevant Milestones

Milestone number¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS113	UMAN Compiled and reviewed information about possible management options for uncertainties related to the human aspects as input to Subtask 4.3	3 - BEL V	21	UMAN Compiled and reviewed information about possible management options for uncertainties related to the human aspects as input to Subtask 4.3
MS118	UMAN Compiled and reviewed information about possible management options for uncertainties related to spent fuel as input to Subtask 4.3	3 - BEL V	23	UMAN Compiled and reviewed information about possible management options for uncertainties related to spent fuel as input to Subtask 4.3
MS128	Materials to be discussed in UMAN Seminar 2	3 - BEL V	24	Materials to be discussed in UMAN Seminar 2
MS129	Mapping of the stakes related to the outcomes of UMAN Tasks 2, 3 and 4 from a civil society point of view for the 2nd Task 5 seminar	3 - BEL V	24	Mapping of the stakes related to the outcomes of UMAN Tasks 2, 3 and 4 from a civil society point of view for the 2nd Task 5 seminar
MS133	UMAN WP meeting 2	3 - BEL V	25	UMAN WP meeting 2
MS134	UMAN Workshop 2 on management options and preferences of different actors regarding human aspects related uncertainties	3 - BEL V	25	UMAN Workshop 2 on management options and preferences of different actors regarding human aspects related uncertainties
MS135	UMAN Seminar 2	3 - BEL V	25	UMAN Seminar 2
MS136	EURAD General Assembly n°5 + EURAD Annual Meeting 2	1 - ANDRA	25	EURAD General Assembly n°5 + EURAD Annual Meeting 2
MS137	ICS Workshop 2	19 - IRSN	25	ICS Workshop 2
MS140	EURAD Periodic Report 2	1 - ANDRA	26	EURAD Periodic Report 2
MS143	UMAN Draft 10.6 as input to Task 4 and 5	3 - BEL V	26	UMAN Draft 10.6 as input to Task 4 and 5
MS145	UMAN Compiled and reviewed information about possible management options for uncertainties related to waste inventory as input to Subtask 4.3	3 - BEL V	28	UMAN Compiled and reviewed information about possible management options for uncertainties related to waste inventory as input to Subtask 4.3
MS146	UMAN Workshop 3 on management options and preferences of different actors regarding waste inventory related uncertainties	3 - BEL V	28	UMAN Workshop 3 on management options and preferences of different actors regarding waste inventory related uncertainties

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS147	Composition of the pluralistic stakeholder group for UMAN Seminar	3 - BEL V	29	Composition of the pluralistic stakeholder group for UMAN Seminar
MS152	Last input from ROUTES to UMAN	19 - IRSN	30	Last input from ROUTES to UMAN
MS153	EURAD General Assembly n°6	1 - ANDRA	31	EURAD General Assembly n°6
MS159	UMAN Input to Task 5 on management options and preferences of different actors regarding site and geosphere and human aspects related uncertainties	3 - BEL V	31	UMAN Input to Task 5 on management options and preferences of different actors regarding site and geosphere and human aspects related uncertainties
MS162	EURAD Annual Work Plan 4	1 - ANDRA	33	EURAD Annual Work Plan 4
MS164	UMAN Workshop 4 on management options and preferences of different actors regarding SF-related uncertainties	3 - BEL V	33	UMAN Workshop 4 on management options and preferences of different actors regarding SF-related uncertainties
MS166	Composition of the pluralistic stakeholder group for UMAN Seminar 4	3 - BEL V	35	Composition of the pluralistic stakeholder group for UMAN Seminar 4
MS178	Materials to be discussed in UMAN Seminar 3	3 - BEL V	36	Materials to be discussed in UMAN Seminar 3
MS179	Mapping of the stakes related to the outcomes of UMAN Tasks 2, 3 and 4 from a civil society point of view for the 3rd Task 5 seminar	3 - BEL V	36	Mapping of the stakes related to the outcomes of UMAN Tasks 2, 3 and 4 from a civil society point of view for the 3rd Task 5 seminar
MS182	UMAN WP meeting 3	3 - BEL V	37	UMAN WP meeting 3
MS183	UMAN Input to Task 5 on management options and preferences of different actors regarding waste inventory and SF related uncertainties	3 - BEL V	37	UMAN Input to Task 5 on management options and preferences of different actors regarding waste inventory and SF related uncertainties
MS184	UMAN Seminar 3	3 - BEL V	37	UMAN Seminar 3
MS185	EURAD General Assembly n°7 + EURAD Annual Meeting 3	1 - ANDRA	37	EURAD General Assembly n°7 + EURAD Annual Meeting 3
MS186	ICS Workshop 3	19 - IRSN	37	ICS Workshop 3
MS189	EURAD Periodic Report 3	1 - ANDRA	38	EURAD Periodic Report 3
MS197	Materials to be discussed in UMAN Seminar 4	3 - BEL V	42	Materials to be discussed in UMAN Seminar 4

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS198	Mapping of the stakes related to the outcomes of UMAN Tasks 2, 3 and 4 from a civil society point of view for the 4th Task 5 seminar	3 - BEL V	42	Mapping of the stakes related to the outcomes of UMAN Tasks 2, 3 and 4 from a civil society point of view for the 4th Task 5 seminar
MS199	EURAD General Assembly n°8	1 - ANDRA	43	EURAD General Assembly n°8
MS204	UMAN Seminar 4	3 - BEL V	43	UMAN Seminar 4
MS206	EURAD Annual Work Plan 5	1 - ANDRA	45	EURAD Annual Work Plan 5
MS208	Recommendations of UMAN for future RD&D, strategic study and KM activities for future EURAD implementation phase	3 - BEL V	46	Recommendations of UMAN for future RD&D, strategic study and KM activities for future EURAD implementation phase
MS222	EURAD General Assembly n°9 + EURAD Annual Meeting 4	1 - ANDRA	49	EURAD General Assembly n°9 + EURAD Annual Meeting 4
MS223	ICS Workshop 4	19 - IRSN	49	ICS Workshop 4
MS224	EURAD Periodic Report 4	1 - ANDRA	50	EURAD Periodic Report 4
MS234	EURAD General Assembly n°10	1 - ANDRA	55	EURAD General Assembly n°10
MS235	ICS Workshop 5	19 - IRSN	55	ICS Workshop 5
MS240	EURAD General Assembly n°11 + EURAD Annual Meeting 5	1 - ANDRA	60	EURAD General Assembly n°11 + EURAD Annual Meeting 5
MS241	EURAD Periodic Report 5	1 - ANDRA	60	EURAD Periodic Report 5 (Due date: 60+2)

Work package number ⁹	WP11	Lead beneficiary ¹⁰	4 - BGE
Work package title	State-of-Knowledge		
Start month	1	End month	60

Objectives

Objectives

The main goal of the KM SoK WP is to establish the State-of-Knowledge (SoK), i.e. preserving, capitalising of and providing open-access to knowledge generated in the field of radioactive waste management (RWM) research that can be extracted by present and future generations of experts and by any interested end-users in Europe and beyond (including for example WMO, TSOs, REs, Programme Owners,).

In EURAD, we define 'State-of-Knowledge' as the science and technology underpinning RWM in a given topic. Its management will be enhanced by providing access to a structured review and summary of relevant published scientific literature by producing corresponding documents. 'State-of-Knowledge' includes access to:

- State-of-the-art on scientific/technical knowledge that has been generated internationally over the past (EURATOM projects FP6, FP7, H2020), as well as the current status of understanding with respect to RD&D needs and potential impacts regarding implementation and safety; and
- Relevant complementary scientific/technical sources developed/generated in the framework of, IGD-TP, SITEX, IAEA, NEA, national programmes, etc. and that are publicly available. This includes training materials and initiatives, international guidance, etc.

Approach

The proposed stepwise approach of this WP consists of

- i) establishing procedures to document the State-of-Knowledge in a given topic, and how it can be regularly revised in order to integrate new knowledge.
- ii) testing and improving the procedures on a few demonstration cases. By developing such demonstration cases the general approach of the KM Programme will establish a clear specification (i.e. requirements, procedures and functionalities) for the SoK.
- iii) performing a review on experiences made for similar approaches by other organisations and in other areas. Subsequently the added-value of establishing a specific platform dedicated to provide access to SoK developed in EURAD will be evaluated. In addition, the EURAD community will be asked for feedback, prior to full development and initiation of a prioritised programme of SoK population.

The mission is to coordinate all work and mobilise and manage the necessary resources to allow the WP work to keep focussed on the 1st stage of the approach for the first two years and to prepare a proposal for decision by the GA on how to move forward at the end of the 2nd year. This approach will assure that there will be regular exchanges between WP11 with the colleges through the Bureau (respecting their needs), between and with WP12, WP13, to (including their needs) and with EURAD community at large to mobilise available internal resources and to limit needs for external experts.

The following tasks and deliverables are envisaged.

Description of work

Task 1- Screening and review of existing knowledge programmes

Start: Month 1– End: Month 22 - Task Leader: [JUELICH (HZDR, 4 pm)]

Task Contributors: [BGE, 4 pm] [SSTC NRS, 2 pm] [ANDRA, 0,5 pm] [CIEMAT, 0,5 pm], as well as EURAD experts and external experts.

Screening and review (Deliverable 11.1) of existing/available knowledge management approaches and/or tools that have been developed for similar purposes with respect to their functionalities and suitability for EURAD KM. This includes lessons learned and best practice. The work is managed by the WP team with input from the EURAD Bureau, from Experts identified as part of WP1 Task 4 EURAD.

Task 2 – Selection and development of demonstration cases

Start: Month 1 – End: Month 24 - Task Leader: [BGE, 8 pm]

Task Contributors: [JUELICH (HZDR), 8 pm] [SSTC NRS, 4 pm] [ANDRA, 0,5 pm] [CIEMAT, 0,25 pm]

Year 1

At the onset of the WP, a few topics suitable as demonstration cases are selected. The topics are deduced from the Roadmap. Criteria for final selection of the best suitable demonstration cases include already existing training materials from other projects or international guidance, relevance for end-users, access to information/knowledge, active RD&D projects and availability of experts. For implementation of the demonstration cases, a first proposal is made for accessibility of, mapping, selection, structuring and processing of existing knowledge. This is an iterative process,

including feed-back from the Bureau, PMO, etc. In a next step, an estimation is made for efforts and resources required for establishing further developed demonstration cases (individual cases), reflecting different levels of detail and width. This information is addressed to the Bureau, and is used for decisions on population options for the demonstration cases. (Deliverable 11.2)

Year 2

At latest at the start of the second, year, the Competence Matrix becomes available (D1.5). It is used for refining the access to expertise and competence for further population of the Demonstration cases. There is an ongoing refinement process including optimisation of criteria, procedures, by screening already existing training materials from other projects or international guidance, as well as a dissemination process. In addition, Quality Assurance and intellectual property issues are addressed and updated. Feedback by the EURAD colleges is collected and integrated through the Bureau. In case of intersection with ongoing R&D and SS WP's, the corresponding SOTA are also used. Assessment of the costs for populating the demonstration cases influence the final decision on the SoK structure and content, as well as the planning for broad SoK implementation in the following years (Deliverable 11.3)

Task 3 – Procedures to Involve Knowledge providers

Start: Month 3 – End: Month 13 - Task Leader: [BGE, 8 pm] & [JUELICH (HZDR), 8 pm]

Task Contributors [SSTC NRS, 4 pm]

This task establishes procedures for engagement of knowledge providers (covering both individual experts, institutions, and international organisations) and will be elaborated in cooperation with them (e.g. IAEA) Deliverable 1.14. Such knowledge providers are needed to give orientation on generic waste disposal issues, as well as direct scientific-technical involvement on specific topics.

Once developed, the competence matrix provides the key source for identification of knowledge providers. As necessary, additional competence carriers for specific needs in identifying, extracting and translating information and knowledge may be identified.

When writing the SoK and populating it, there is an interplay between KM WP11 and EURAD identified experts. The WP 11 partners will contribute by organizing the work, i.e. managing the process. The key sources of expertise, however, will be recruited by addressing the colleges and where relevant, on-going RD&D WPs.

Task 4 - Quality Management Plan

Start: Month 4 – End: Month 24 - Task Leader: [SSTC NRS, 12 pm]

Task Contributors: [JUELICH (HZDR), 4 pm] [BGE, 2 pm] [ANDRA, 2 pm]

The objective of this task is to develop QA procedures for the generation of SoK, assessing the appropriateness of the SoK generation process. For that purpose, with the support by the colleges, a QA plan is established, and revised and updated in several. The QA plan includes criteria, specifications, procedures for its implementation and control mechanisms. QA criteria reflect needs for end-users, including scientific excellence, inclusiveness, confidence levels and confidentiality levels. The GA approves the QA plan at the end of the second ProjectYear.

The QA plan will ensure that the SoK is balanced and inclusive, provides the basis for next generation of experts to enter the field, contains the scientific-technical state-of-the-art (SOTA) and is fit for purpose in the overall KM Programme. Furthermore, the QA plan will ensure that the SoK does not contain policy statements or other statements potentially compromising the interests of the WMOs, TSOs or REs (Deliverables 11.5 and 11.6)

Task 5 – Integration and preparation for the ongoing of the programme

Start date: Month 18 End Date; Month 24

Task Leader: [BGE, 3 pm]

The objective of this task is to prepare a results summary of the previous elaborated written specifications and documentation as well as the resulting technical implementation of SoK structure and content, QA Procedures, and Guidelines (Deliverable 11.7)

At the end of the second ProjectYear the decision is taken on how to proceed in the General Assembly. This could be done by a technical implementation tool which could be a single platform or a combination of different ones, making use of both existing ones (that possibly need adaptations) and new ones that need to be developed.

The tasks from month 25 to Month 60 will be developed in due time, as part of the 3rd Annual Work Programme

Description of work and role of partners

WP11 - State-of-Knowledge [Months: 1-60]

BGE, ANDRA, CIEMAT, JUELICH, SSTC NRS

Task 1- Screening and review of existing knowledge programmes

Start: Month 1– End: Month 22 - Task Leader: [JUELICH (HZDR), 4 pm]

Task Contributors: [BGE, 4 pm] [SSTC NRS, 2 pm] [ANDRA, 0,5 pm] [CIEMAT, 0,5 pm], as well as EURAD experts and external experts.

Screening and review (Deliverable 11.1) of existing/available knowledge management approaches and/or tools that have been developed for similar purposes with respect to their functionalities and suitability for EURAD KM. This includes lessons learned and best practice. The work is managed by the WP team with input from the EURAD Bureau, from Experts identified as part of WP1 Task 4 EURAD.

Task 2 – Selection and development of demonstration cases

Start: Month 1 – End: Month 24 - Task Leader: [BGE, 8 pm]

Task Contributors: [JUELICH (HZDR), 8 pm] [SSTC NRS, 4 pm] [ANDRA, 0,5 pm] [CIEMAT, 0,25 pm]

Year 1

At the onset of the WP, a few topics suitable as demonstration cases are selected. The topics are deduced from the Roadmap. Criteria for final selection of the best suitable demonstration cases include already existing training materials from other projects or international guidance, relevance for end-users, access to information/knowledge, active RD&D projects and availability of experts. For implementation of the demonstration cases, a first proposal is made for accessibility of, mapping, selection, structuring and processing of existing knowledge. This is an iterative process, including feed-back from the Bureau, PMO, etc. In a next step, an estimation is made for efforts and resources required for establishing further developed demonstration cases (individual cases), reflecting different levels of detail and width. This information is addressed to the Bureau, and is used for decisions on population options for the demonstration cases. (Deliverable 11.2)

Year 2

At latest at the start of the second, year, the Competence Matrix becomes available (D1.5). It is used for refining the access to expertise and competence for further population of the Demonstration cases. There is an ongoing refinement process including optimisation of criteria, procedures, by screening already existing training materials from other projects or international guidance, as well as a dissemination process. In addition, Quality Assurance and intellectual property issues are addressed and updated. Feedback by the EURAD colleges is collected and integrated through the Bureau. In case of intersection with ongoing R&D and SS WP's, the corresponding SOTA are also used. Assessment of the costs for populating the demonstration cases influence the final decision on the SoK structure and content, as well as the planning for broad SoK implementation in the following years (Deliverable 11.3)

Task 3 – Procedures to Involve Knowledge providers

Start: Month 3 – End: Month 13 - Task Leader: [BGE, 8 pm] & [JUELICH (HZDR), 8 pm]

Task Contributors [SSTC NRS, 4 pm]

This task establishes procedures for engagement of knowledge providers (covering both individual experts, institutions, and international organisations) and will be elaborated in cooperation with them (e.g. IAEA) Deliverable 1.14. Such knowledge providers are needed to give orientation on generic waste disposal issues, as well as direct scientific-technical involvement on specific topics.

Once developed, the competence matrix provides the key source for identification of knowledge providers. As necessary, additional competence carriers for specific needs in identifying, extracting and translating information and knowledge may be identified.

When writing the SoK and populating it, there is an interplay between KM WP11 and EURAD identified experts. The WP 11 partners will contribute by organizing the work, i.e. managing the process. The key sources of expertise, however, will be recruited by addressing the colleges and where relevant, on-going RD&D WPs.

Task 4 - Quality Management Plan

Start: Month 4 – End: Month 24 - Task Leader: [SSTC NRS, 12 pm]

Task Contributors: [JUELICH (HZDR), 4 pm] [BGE, 2 pm] [ANDRA, 2 pm]

The objective of this task is to develop QA procedures for the generation of SoK, assessing the appropriateness of the SoK generation process. For that purpose, with the support by the colleges, a QA plan is established, and revised and updated in several. The QA plan includes criteria, specifications, procedures for its implementation and control mechanisms. QA criteria reflect needs for end-users, including scientific excellence, inclusiveness, confidence levels and confidentiality levels. The GA approves the QA plan at the end of the second ProjectYear.

The QA plan will ensure that the SoK is balanced and inclusive, provides the basis for next generation of experts to enter the field, contains the scientific-technical state-of-the-art (SOTA) and is fit for purpose in the overall KM Programme. Furthermore, the QA plan will ensure that the SoK does not contain policy statements or other statements potentially compromising the interests of the WMOs, TSOs or REs (Deliverables 11.5 and 11.6)

Task 5 – Integration and preparation for the ongoing of the programme

Start date: Month 18 End Date; Month 24

Task Leader: [BGE, 3 pm]

The objective of this task is to prepare a results summary of the previous elaborated written specifications and documentation as well as the resulting technical implementation of SoK structure and content, QA Procedures, and Guidelines (Deliverable 11.7)

At the end of the second ProjectYear the decision is taken on how to proceed in the General Assembly. This could be done by a technical implementation tool which could be a single platform or a combination of different ones, making use of both existing ones (that possibly need adaptations) and new ones that need to be developed.

The tasks from month 25 to Month 60 will be developed in due time, as part of the 3rd Annual Work Programme

Participation per Partner

Partner number and short name	WP11 effort
1 - ANDRA	3.00
4 - BGE	25.00
6 - CIEMAT	0.75
15 - JUELICH	0.00
HZDR	24.00
40 - SSTC NRS	22.00
Total	74.75

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D11.1	Screening and review of existing/available knowledge management approaches and/or tools	15 - JUELICH	Report	Public	13
D11.2	List of selected demonstration cases, criteria for final selection, proposal and estimation of effort and resources	4 - BGE	Report	Public	9
D11.3	Outcomes of the demonstration cases	4 - BGE	Report	Public	22
D11.4	Procedures to Involve Knowledge providers	4 - BGE	Report	Public	13
D11.5	QA procedures for the generation of SoK demonstration cases	40 - SSTC NRS	Report	Public	4
D11.6	revised QA procedures	40 - SSTC NRS	Report	Public	19
D11.7	Results summary of WP11 during Year 1 and 2 and proposal for the for broad SoK	4 - BGE	Report	Public	24

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
	implementation in the following years				

Description of deliverables

- Deliverable 11.1 – Screening and review of existing/available knowledge management approaches and/or tools (Month: 13) : [JUELICH (HZDR)]
- Deliverable 11.2 – List of selected demonstration cases, criteria for final selection, proposal and estimation of effort and resources (Month 9) Lead: [BGE]
- Deliverable 11.3 – Outcomes of the demonstration cases (Month 22) Lead: [BGE]
- Deliverable 11.4 – Procedures to Involve Knowledge providers (Month 13) Lead: [BGE]
- Deliverable 11.5 – QA procedures for the generation of SoK demonstration cases (Month 4) Lead: [SSTC NRS]
- Deliverable 11.6 – revised QA procedures (Month 19) Lead: [SSTC NRS]
- Deliverable 11.7 – results summary of WP11 during Year 1 and 2 and proposal for the for broad SoK implementation in the following years (Month 24) Lead: [BGE]

D11.1 : Screening and review of existing/available knowledge management approaches and/or tools [13]

Screening and review of existing/available knowledge management approaches and/or tools

D11.2 : List of selected demonstration cases, criteria for final selection, proposal and estimation of effort and resources [9]

List of selected demonstration cases, criteria for final selection, proposal and estimation of effort and resources

D11.3 : Outcomes of the demonstration cases [22]

Outcomes of the demonstration cases

D11.4 : Procedures to Involve Knowledge providers [13]

Procedures to Involve Knowledge providers

D11.5 : QA procedures for the generation of SoK demonstration cases [4]

QA procedures for the generation of SoK demonstration cases

D11.6 : revised QA procedures [19]

revised QA procedures

D11.7 : Results summary of WP11 during Year 1 and 2 and proposal for the for broad SoK implementation in the following years [24]

Results summary of WP11 during Year 1 and 2 and proposal for the for broad SoK implementation in the following years

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	EURAD Kick-off meeting (General Assembly n°1)	1 - ANDRA	1	EURAD Kick-off meeting (General Assembly n°1)
MS7	KM SoK - launch of screening exercise (task 1)	15 - JUELICH	1	KM SoK - launch of screening exercise (task 1)
MS12	EURAD EJP Newsletters	1 - ANDRA	3	EURAD EJP Newsletters (Due date : M3 and then every quarter)

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS14	KM SoK - List of Demonstration cases	4 - BGE	7	KM SoK - List of Demonstration cases
MS15	KM SoK - list of criteria for selecting demonstration cases	4 - BGE	4	KM SoK - list of criteria for selecting demonstration cases
MS30	EURAD General Assembly n°2	1 - ANDRA	7	EURAD General Assembly n°2
MS42	EURAD Annual Work Plan 2	1 - ANDRA	9	EURAD Annual Work Plan 2
MS78	KM SoK - Initial draft QA plan	40 - SSTC NRS	4	KM SoK - Initial draft QA plan
MS79	KM SoK - proposal to the General Assembly for future work	4 - BGE	24	KM SoK - proposal to the General Assembly for future work
MS81	EURAD General Assembly n°3 + EURAD Annual Meeting 1	1 - ANDRA	13	EURAD General Assembly n°3 + EURAD Annual Meeting 1
MS85	EURAD Periodic Report 1	1 - ANDRA	14	EURAD Periodic Report 1
MS87	KM SoK - updated QA procedure documents	40 - SSTC NRS	19	KM SoK - updated QA procedure documents
MS93	KM SoK - start of broad SoK implementation	4 - BGE	25	KM SoK - start of broad SoK implementation
MS103	EURAD General Assembly n°4	1 - ANDRA	19	EURAD General Assembly n°4
MS112	EURAD Annual Work Plan 3	1 - ANDRA	21	EURAD Annual Work Plan 3
MS136	EURAD General Assembly n°5 + EURAD Annual Meeting 2	1 - ANDRA	25	EURAD General Assembly n°5 + EURAD Annual Meeting 2
MS140	EURAD Periodic Report 2	1 - ANDRA	26	EURAD Periodic Report 2
MS153	EURAD General Assembly n°6	1 - ANDRA	31	EURAD General Assembly n°6
MS162	EURAD Annual Work Plan 4	1 - ANDRA	33	EURAD Annual Work Plan 4
MS185	EURAD General Assembly n°7 + EURAD Annual Meeting 3	1 - ANDRA	37	EURAD General Assembly n°7 + EURAD Annual Meeting 3
MS189	EURAD Periodic Report 3	1 - ANDRA	38	EURAD Periodic Report 3
MS199	EURAD General Assembly n°8	1 - ANDRA	43	EURAD General Assembly n°8
MS206	EURAD Annual Work Plan 5	1 - ANDRA	45	EURAD Annual Work Plan 5
MS222	EURAD General Assembly n°9 + EURAD Annual Meeting 4	1 - ANDRA	49	EURAD General Assembly n°9 + EURAD Annual Meeting 4

Schedule of relevant Milestones

Milestone number¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS224	EURAD Periodic Report 4	1 - ANDRA	50	EURAD Periodic Report 4
MS234	EURAD General Assembly n°10	1 - ANDRA	55	EURAD General Assembly n°10
MS240	EURAD General Assembly n°11 + EURAD Annual Meeting 5	1 - ANDRA	60	EURAD General Assembly n°11 + EURAD Annual Meeting 5
MS241	EURAD Periodic Report 5	1 - ANDRA	60	EURAD Periodic Report 5 (Due date: 60+2)

Work package number ⁹	WP12	Lead beneficiary ¹⁰	42 - SÚRAO
Work package title	Guidance		
Start month	1	End month	60

Objectives

Objectives

The key objective of the KM Guidance WP is to develop a comprehensive suite of instructional Guidance Documents that can be used by Member-States with RWM programmes that are at an early stage of development with respect to their national RWM programme. The guidance will be focused on RD&D relating to planning and implementing a national radioactive waste management programme. It will be developed in such a way that it capitalises the experience and know-how gained by organisations having such responsibility in Member-States with advanced programmes.

The target end-user of the guidance will be primarily programme owners and managers (i.e. WMOs, and TSOs) responsible for planning and implementing RD&D at national level. Such guidance will also be of use and interest to other interested stakeholders, such as representatives of civil society and experts knowledgeable in governance and involvement of civil society.

The set of guidance developed shall be comprehensive for the purpose of the users, and unnecessary overlap shall be avoided, which includes complementary to existing IAEA, NEA and any other relevant documentation in the public domain.

Approach

The approach adopted for this WP consists of pursuing and complementing the work initiated previously with the PLANDIS Guide. This Guide was prepared at the request of the Commission in the context of the EURATOM coordination and support action SecIGD2 (Secretariat for IGD-TP). It provides a framework of broad programme activities and related RD&D activities at different stages of a waste disposal programme, from the view point of a WMO. PLANDIS will be used as the starting point for WP2. Thereby, in addition to establishing a broader framework for planning and operating an RD&D programme in support of geological disposal, the scope is widened to include relevant RD&D needs for pre-disposal, as well as disposal solutions tailored to smaller inventories. Other areas where the need for R&D is identified may be added along with implementation of the work programme.

Description of work and role of partners

WP12 - Guidance [Months: 1-60]

SÚRAO, JSI, JRC, PURAM, SSTC NRS, SURO

Task 1 - Updating the PLANDIS Guide and Quality Management Procedure

Start: Month 1 – End: Month 12 - Task Leader: [SÚRAO]

Task Contributors: [JSI (EIMV)] [PURAM] [SSTC NRS] [SURO,] [JRC] [EURAD Experts] [External experts, if required]

Total PM: 14

First step consists of updating the PLANDIS Guide in order to ensure consistency with EURAD Founding Documents (Vision, SRA, Roadmap). More precisely, the PLANDIS Guide will be revised, adjusted and complemented to be consistent with terminologies used in EURAD Founding Documents (Vision, Strategic Research Agenda, Roadmap) and to be aligned with EURAD SRA scientific themes/topics and with the successive phases of a RWM programme as elaborated in the Roadmap.

As PLANDIS was developed by the IGD-TP, it was focussed on the perspectives of implementation by a WMO, therefore a second important part of this update will be to include the perspectives of implementation from the TSOs. The outcome will be the updated version of the PLANDIS Guide “RD&D Planning for Radioactive Waste Management: Guidance for small and early-stage Programmes” (PLANMAN Guide) at the end of the first year, considering feedback from the first EURAD Annual Meeting (Deliverable 12.1).

The draft PLANMAN Guide will be previewed to the Bureau throughout development and the final form presented to the General Assembly in association with the 1st EURAD annual Workshop, requesting feedback during the special meeting and in the aftermath. Based on the feed-back, the final PLANMAN Guide will then be published at the end of the first year.

The development of the PLANMAN Guide will also include the drafting of a clear quality management procedure for how it has been developed, which can be used in subsequent years (and updated and modified to reflect learning) as future Guides are developed (Deliverable 12.2).

The substantial involvement of the WP organizations reflects the importance of the work, being the basis for the entire subsequent establishment of the detailed guidance. Additional involvement of experts from the Consortium and possibly external experts will ensure that all types of interest (especially small inventories, early stage programmes, particular waste inventory challenges, etc.) are considered.

Task 2 - Develop Prioritisation List and Schedule for Delineation of the PLANMAN Guide into more detailed Guidance Documents

Start: Month 4 – End: Month 12 - Task Leader: [PURAM]

Task Contributors: [JSI (EIMV)] [SÚRAO] [SSTC NRS] [SURO] [JRC]

Total PM: 8

The PLANMAN Guide is to be seen as an “umbrella document” that will need further more detailed guidance. Development of such more detailed guidance will commence in the second year. In order to plan and structure that work, a list of such guides is established together with implementation priorities and updated on an annual basis (Deliverable 12.3).

The KM Guidance WP Team together with the PMO propose on an annual basis (from Year 2) to the Bureau/ General Assembly the Guidance Documents’ Editorial Plan for the year to come, i.e. the specific Guidance Documents that shall be established and issued in priority., to be updated on an annual basis).

An important input to the editorial plan will be priorities identified by the competence/SoK/guidance mapping exercise to be completed by the PMO (see WP1) at initiation of the Joint Programme.

Another important preparation for Task 3 is development of the prototype guidance document as well as Quality management procedure and methodology for developing the detailed delineation guidance of PLANMAN (see below) (Deliverable 12.4).

Task 3 - Delineation of the PLANMAN Guide into more detailed Guidance Documents

Start: Month 13 – End: Month 60 - Task Leader: [SÚRAO]

Task Contributors: [JSI (EIMV)] [PURAM] [SSTC NRS] [SURO] [JRC] [EURAD Experts] [External experts, as required]

Total PM: 42

In accordance with the approved annual plans, the detailed Guidance drawing upon the PLANMAN Guide is developed by Editorial Board(s) composed of:

- Individuals experienced in RD&D planning in more advanced programmes;
- Representatives of early stage programmes and small inventory programmes, including representatives of the WP 12 Team organizations;
- Experts involved with the completion and delivery of RD&D plans for National Programmes;
- Target end-users of the Guide Documents, represented by experts working in organisations from countries with early-stage programmes and small inventory programmes.

Thereby, the efforts for the WP contributors to organize and coordinate the document development process is declared in the WP. The actual drafting and expert input is provided by the respective editorial boards. During the editorial process, preview of the draft Guide shall be performed by target end-users in order to obtain constructive feedback on content and usability. Peers of RD&D planning and implementation, especially from experienced programmes, shall provide review feedback of the draft Guidance Documents. EURAD Mandated Actors (especially WMOs, TSOs), shall provide endorsement of the Guidance Document prior to publication.

Dedicated workshops will be considered where beneficial for supporting the editorial process.

Delineation of PLANMAN is updated on an annual basis (Deliverable 12.5, updated annually)

Along with the workprogramme, the PLANMAN Guide and the subsequent detailed Guidance will be subject review and testing. Reporting on the outcome of this process will start after the third year, and be updated on an annual basis.

The delineation process shall not be finalized after EURAD first phase, but at the end of EURAD-1 there is one overall reporting on the generation of Guidance with the final status of the PLANMAN Guide, its detailed Guidance as achieved, and the processes for establishing the Guidance (Deliverable 12.6).

Participation per Partner

Partner number and short name	WP12 effort
22 - JSI	0.00
EIMV	10.00

Partner number and short name	WP12 effort
23 - JRC	3.50
35 - PURAM	13.30
40 - SSTC NRS	10.00
42 - SÚRAO	17.50
43 - SURO	10.00
Total	64.30

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D12.1	KM Guidance - PLANMAN Guide - Updated version of the PLANDIS Guide consistent with the EJP Roadmap and including perspectives of the TSOs needs (PLANMAN Guide)	42 - SÚRAO	Report	Public	12
D12.2	KM Guidance - Quality management procedure for PLANMAN development (incl. review and approval procedure)	42 - SÚRAO	Report	Public	12
D12.3	KM Guidance - Approved schedule for delineation of the PLANMAN Guide in-line with the PMO-developed competence matrix and approved Editorial Plan for Year 1	42 - SÚRAO	Report	Public	10
D12.4	KM Guidance - Quality management procedure and methodology for developing the detailed delineation guidance of PLANMAN	42 - SÚRAO	Report	Public	12
D12.5	KM Guidance - Delineated version of the PLANMAN Guide after Year 1	42 - SÚRAO	Report	Public	24
D12.6	KM Guidance - Final report on the PLANMAN Guide and the subsequent	42 - SÚRAO	Report	Public	60

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
	detailed Guidance, overall conclusions and recommendations				

Description of deliverables

Deliverable 12.1 - PLANMAN Guide - Updated version of the PLANDIS Guide consistent with EURAD Roadmap and including perspectives of the TSOs needs (PLANMAN Guide) (Month 12) Lead: [SÚRAO]

Deliverable 12.2 – Quality management procedure for PLANMAN development (incl. review and approval procedure) (Month 12) Lead: [SÚRAO]

Deliverable 12.3 – Approved schedule for delineation of the PLANMAN Guide in-line with the PMO-developed competence matrix and approved Editorial Plan for Year 1 (Month 10) Lead: [SÚRAO]

Deliverable 12.4– Quality management procedure and methodology for developing the detailed delineation guidance of PLANMAN (Month 12) Lead: [SÚRAO]

Deliverable 12.5 - Delineated version of the PLANMAN Guide after Year 1 (Month 24) Lead: [SÚRAO]

Deliverable 12.6 Final report on the PLANMAN Guide and the subsequent detailed Guidance, overall conclusions and recommendations (Month 60) Lead: [SÚRAO]

D12.1 : KM Guidance - PLANMAN Guide - Updated version of the PLANDIS Guide consistent with the EJP Roadmap and including perspectives of the TSOs needs (PLANMAN Guide) [12]

KM Guidance - PLANMAN Guide - Updated version of the PLANDIS Guide consistent with the EJP Roadmap and including perspectives of the TSOs needs (PLANMAN Guide)

D12.2 : KM Guidance - Quality management procedure for PLANMAN development (incl. review and approval procedure) [12]

KM Guidance - Quality management procedure for PLANMAN development (incl. review and approval procedure)

D12.3 : KM Guidance - Approved schedule for delineation of the PLANMAN Guide in-line with the PMO-developed competence matrix and approved Editorial Plan for Year 1 [10]

KM Guidance - Approved schedule for delineation of the PLANMAN Guide in-line with the PMO-developed competence matrix and approved Editorial Plan for Year 1

D12.4 : KM Guidance - Quality management procedure and methodology for developing the detailed delineation guidance of PLANMAN [12]

KM Guidance - Quality management procedure and methodology for developing the detailed delineation guidance of PLANMAN

D12.5 : KM Guidance - Delineated version of the PLANMAN Guide after Year 1 [24]

KM Guidance - Delineated version of the PLANMAN Guide after Year 1

D12.6 : KM Guidance - Final report on the PLANMAN Guide and the subsequent detailed Guidance, overall conclusions and recommendations [60]

KM Guidance - Final report on the PLANMAN Guide and the subsequent detailed Guidance, overall conclusions and recommendations

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	EURAD Kick-off meeting (General Assembly n°1)	1 - ANDRA	1	EURAD Kick-off meeting (General Assembly n°1)

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS10	KM Guidance - Editorial meeting for the update of PLANDIS	42 - SÚRAO	2	KM Guidance - Editorial meeting for the update of PLANDIS
MS12	EURAD EJP Newsletters	1 - ANDRA	3	EURAD EJP Newsletters (Due date : M3 and then every quarter)
MS30	EURAD General Assembly n°2	1 - ANDRA	7	EURAD General Assembly n°2
MS41	KM Guidance - Editorial Plan for PLANMAN Delineation Year 2	42 - SÚRAO	7	KM Guidance - Editorial Plan for PLANMAN Delineation Year 2
MS42	EURAD Annual Work Plan 2	1 - ANDRA	9	EURAD Annual Work Plan 2
MS80	KM Guidance - Editorial boards meetings for the PLANMAN delineation guides	42 - SÚRAO	13	KM Guidance - Editorial boards meetings for the PLANMAN delineation guides
MS81	EURAD General Assembly n°3 + EURAD Annual Meeting 1	1 - ANDRA	13	EURAD General Assembly n°3 + EURAD Annual Meeting 1
MS85	EURAD Periodic Report 1	1 - ANDRA	14	EURAD Periodic Report 1
MS103	EURAD General Assembly n°4	1 - ANDRA	19	EURAD General Assembly n°4
MS109	KM Guidance - Editorial Plan for PLANMAN Delineation Year 3	42 - SÚRAO	19	KM Guidance - Editorial Plan for PLANMAN Delineation Year 3
MS112	EURAD Annual Work Plan 3	1 - ANDRA	21	EURAD Annual Work Plan 3
MS136	EURAD General Assembly n°5 + EURAD Annual Meeting 2	1 - ANDRA	25	EURAD General Assembly n°5 + EURAD Annual Meeting 2
MS140	EURAD Periodic Report 2	1 - ANDRA	26	EURAD Periodic Report 2
MS153	EURAD General Assembly n°6	1 - ANDRA	31	EURAD General Assembly n°6
MS160	KM Guidance - Editorial Plan for PLANMAN Delineation Year 4	42 - SÚRAO	31	KM Guidance - Editorial Plan for PLANMAN Delineation Year 4
MS162	EURAD Annual Work Plan 4	1 - ANDRA	33	EURAD Annual Work Plan 4
MS185	EURAD General Assembly n°7 + EURAD Annual Meeting 3	1 - ANDRA	37	EURAD General Assembly n°7 + EURAD Annual Meeting 3
MS189	EURAD Periodic Report 3	1 - ANDRA	38	EURAD Periodic Report 3
MS199	EURAD General Assembly n°8	1 - ANDRA	43	EURAD General Assembly n°8

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS205	KM Guidance - Editorial Plan for PLANMAN Delineation Year 5	42 - SÚRAO	43	KM Guidance - Editorial Plan for PLANMAN Delineation Year 5
MS206	EURAD Annual Work Plan 5	1 - ANDRA	45	EURAD Annual Work Plan 5
MS222	EURAD General Assembly n°9 + EURAD Annual Meeting 4	1 - ANDRA	49	EURAD General Assembly n°9 + EURAD Annual Meeting 4
MS224	EURAD Periodic Report 4	1 - ANDRA	50	EURAD Periodic Report 4
MS234	EURAD General Assembly n°10	1 - ANDRA	55	EURAD General Assembly n°10
MS240	EURAD General Assembly n°11 + EURAD Annual Meeting 5	1 - ANDRA	60	EURAD General Assembly n°11 + EURAD Annual Meeting 5
MS241	EURAD Periodic Report 5	1 - ANDRA	60	EURAD Periodic Report 5 (Due date: 60+2)

Work package number ⁹	WP13	Lead beneficiary ¹⁰	38 - SCK•CEN
Work package title	Training & Mobility		
Start month	1	End month	60

Objectives

Objectives

The objectives of the Training and Mobility WP are:

- To compose a diverse portfolio of tailored basic and specialized training courses under the umbrella of a “School of Radioactive Waste Management”, newly created under EURAD-1, taking stock of and building upon already existing initiatives (i.e. IAEA and NEA) and creating new initiatives to bridge the identified gaps. The end-users are defined as professionals and potential new professionals at graduated and post-graduated level from EU and non-EU countries (via the IAEA and NEA programmes), and in particular the next generation of experts. Tasks under this WP will include improving access to existing training materials (e.g. training modules developed in association with past and ongoing RD&D projects and EURAD WPs), and providing new training courses and material, both aimed at acquiring both state-of-the-art scientific background and at accessing the vast amount of “tacit” knowledge available within EURAD-1 through targeted hands-on training.
- To organise a mobility programme which provides access to dedicated infrastructures associated with the Mandated Actors/Linked Third Parties within EURAD-1. These mobility actions can be seen either as a complementary action after one or more training course(s) (enabling hands-on training related to the experimental programme executed within EURAD-1) or can be part of the Continuous Personal Development (CPD) of experienced personnel involved in RWM.

Approach

Both the mobility initiative and the training course portfolio will be developed along two tracks, associated with the different needs identified within EURAD.

- In a first track, and following the efforts undertaken to identify knowledge requirements within the Roadmap, specific training/mobility initiatives are developed to suit the specific needs of the end-users at the various phases of RWM programmes according to the Roadmap and following a systematic approach in response to priorities agreed with the General Assembly. The portfolio will be composed of existing (and past) training initiatives that fit EURAD-1 needs and for which the original developer/organiser agrees to be put at the disposal of EURAD-1 portfolio (without losing its identity), and of learning actions specifically developed in the frame of this EURAD-1 to bridge the identified gaps in the existing landscape.

- In a second track, specific training/mobility initiatives will be developed serving the needs identified within the RD&D and SS WPs. The oversight performed by the Training WP will allow 1) to identify the training/mobility needs, scope and opportunities present within these RD&D and SS WPs, and 2) integration of the developed training materials and resources within the Knowledge Platform which will be developed in WP1.

Thereby, “The School of RWM” is an umbrella for the entire catalogue of training/mobility either

- linked to (i.e., organized and “owned” by third partners, could be EURAD Beneficiaries, and to which EURAD provides funding for participation), or
- developed in order to meet needs and fill gaps to what is already available.

With respect to the division into more general training, aimed in particular at next generation of experts, and targeted training aimed in particular at exchange and deepening skills and knowledge between existing experts:

- More general courses, especially those following from a gap analysis in the Roadmap are to be delivered within the frame of a “summer school”, and are scheduled to start after the first EURAD year,
- Targeted training courses making use of existing training from past and on-going EURATOM projects, are best integrated as specific modules at the “summer school”, and
- Targeted training courses, associated with the timing and tasks in the RD&D and SS WPs are to be organized depending on the interaction with, and input from these WPs. It could be organized back-to-back with a particular WP meeting, having all the involved experts gathered, nevertheless being open for participation for interested experts from beyond the specific WP. Such training should be aimed for already during the first EURAD year.

Description of work and role of partners

WP13 - Training & Mobility [Months: 1-60]

SCK•CEN, ANDRA, CIEMAT, JSI, JRC, SSTC NRS, SÚRAO, SURO

Task 1 - Identification of the training needs, scope and opportunities from the RD&D and SS WPs

Start: Month 1 – End: Month 3- Task Leader: [SCK•CEN]

Task Contributors: [JRC] [SÚRAO (CTU)] [SSTC NRS] [CIEMAT] [SURO]

Total PM: 2

Within the RD&D and Strategic Studies WPs, specific training needs are present. These training needs need to be identified at the early phase of EURAD initiation by interaction with the WP leaders and coordination teams (Deliverable 13.1). The identified needs should at least encompass 1) the scope of the training needed (basic vs specialised course), 2) the proposed training mode (classroom/hands-on, including mobility needs), 3) the timing of training. This interrogation, which can be done by an easy questionnaire, will allow to provide input for task 3: Training and Mobility Schedule & Priority List.

Task 2 - Improving access to historical and ongoing training modules

Start: Month 1 – End: Month 12- Task Leader: [SCK•CEN]

Task Contributors: [JRC] [SÚRAO (CTU)] [SSTC NRS] [CIEMAT]

Total PM: 4

Apart from the training developed within EURAD, we will also link with ongoing or expected training modules developed within ongoing EC H2020 EURATOM projects (like Modern2020, BEACON, MIND, CHANCE) and with existing training modules developed within past EURATOM projects (FP6 and FP7). Also existing initiatives from IAEA or NEA will be taken into account. This will both increase the amount of training materials (and therefore total portfolio) made available within the JP, and at the same time capitalise the efforts made in the past by integrating these efforts into a durable knowledge platform which will be developed within EURAD.

In order to achieve this goal, a mapping exercise will be performed within the first year of EURAD, in coordination with the PMO Task mapping exercise (Deliverable 13.2). The mapping will include (at least):

- Scope of the training course (including content, learning outcomes, duration, etc.)
- Course material availability (textbook, transparencies, exercises, etc.)
- Practical information (when was the course given, how many participants, feedback from the participants if available, etc.)

After the mapping, the generated info has to be translated to the Roadmap and the knowledge requirements identified therein. This will include how identified and available training material addresses knowledge requirements priorities (Deliverable 13.3), and whether changes or adaptations might be required in order to better suit the needs identified within the Roadmap.

Task 3 - Training and Mobility Schedule & Priority List

Start: Month 1 – End: Month 12 - Task Leader: [SCK•CEN]

Task Contributors: [Andra] [JRC] [SÚRAO (CTU)] [SSTC NRS] [CIEMAT] [SURO]

Total PM: 2

Drawing from the outputs of Task 1 and KM Coordination Work carried out by the PMO, an annual training schedule and priority list shall be developed to prioritise scope and resources within the Training WP. Such a priority list would indicate on an annual basis the resources allocated, the targeted audience and the trainers who will be involved (Deliverable 13.4).

Task 4 - Implementation of Training Courses

Start: Month 7 – End: Month 60 Task Leader: [SCK•CEN]

Task Contributors: [Andra] [SÚRAO (CTU)] [JRC] [SSTC NRS] [CIEMAT]

Total PM: 24

Different formats of training (classroom, distance learning, practical exercises in laboratories, URLs, ...) will be organised within EURAD-1, at appropriate levels targeting the needs of the end-users and having proper learning outcomes in line with the desired competence building. This includes:

- A first set of training modules envisages the basic relevant scientific and technical concepts supporting RWM applications. They intend to bring participants' knowledge and skills to a harmonized elementary level suitable for tackling the RD&D objectives brought forward within the R&D and Strategic Studies Work Packages and/or the knowledge requirements within the Roadmap. These training courses will include experts (Procured by the Knowledge Management Coordinator (PMO), from either the Organisations participating in EURAD or External Experts). Formats of training may include face-to-face courses, webinars or MOOCs (massive open online courses), depending on the audience, the training subject and the needs identified.
- Specialized training modules including hands-on training will connect those familiar with the basic scientific concepts with the state of the art in setting up experiments, achieving the maximum benefits out of experiments, and familiarising with modelling codes used to interpret and simulate experimental outcomes. These learning activities will be led by experts in the relevant domains and will aid in accessing the knowledge available outside existing documents and textbooks (referred to as “tacit”, “implicit” or “collective” knowledge). They will be conducted in a classroom

environment or at the work floor (laboratories, underground research facilities, ...). Distant training relying on available technology and tools can also be included (distant visual assistance, augmented learning, etc.).

The training programme within EURAD-1 will be developed taking into account the Systematic Approach to Training as defined by the IAEA (e.g., IAEA Guidebook on Nuclear Power Plant Personnel Training and its Evaluation, Technical Reports Series No. 380, 1996). This Approach consists of a cycled implementation with the following steps:

- Evaluation of functional scientific/technical competences required at the different phases and for the different themes identified within the Roadmap for implementation of a radioactive waste management RD&D programme, through to geological disposal (using the outputs of the Competency Matrix to be completed by the PMO at EURAD launch as key input).
- Design of a training programme based on a translation of competences into learning objectives.
- Development of training materials to meet learning objectives.
- Implementation of the training.
- Evaluation of the training effectiveness, which feeds back into step 1.

Quality criteria will be developed by which existing training initiatives can be appreciated in order to be taken up within the training portfolio of EURAD-1 (Deliverable 13.5).

For the training course (Deliverable 13.6) developed based on the needs identified within the RD&D Work Packages and the Strategic Studies Work Packages (see Task 1) a strong interaction is pursued, both in identifying suitable training courses which could strengthen and enforce the scientific community involved in the different scientific and technical themes addressed within these Work Packages, and in the preparation and execution of new training modules, where experts identified within EURAD Work Packages will be appointed to develop and deliver the training. The corresponding budgets will be allocated and made available to the organisations delivering training (additionally to the budgets already foreseen within these Work Packages).

All training modules developed or supported within EURAD-1 will be grouped under the umbrella of the “School of Radioactive Waste Management”, in order to provide a coherent and internally consistent portfolio which could substantially contribute in the short and long term to the maintenance of expert capacity in waste management and disposal. Trainings might be grouped into Summer or Winter Schools, possibly organised back-to-back with main conferences or workshops in the domains of EURAD-1.

Close interaction with KM WP1 is envisaged in order to align the training portfolio with the development of the State of Knowledge scope.

Task 5 - Implementation of Mobility Programme

Start: Month 7 – End: Month 60 Task Leader: [SURO]

Task Contributors: [Andra] [SÚRAO (CTU)] [JRC] [SSTC NRS] [CIEMAT]

Total PM: 28

With the mobility programme, EURAD aims to develop and share competences and knowledge beyond the academic pathways. It will contribute to transferring knowledge and skills related to infrastructure used and management between National Programmes at similar or close stages of development. It will also allow scientists and engineers from early-stage programmes to participate in tutored experimental efforts in laboratories of more advanced programmes. The mobility programme will target both professionals (as scientific visitor to contribute to the Continuous Professional Development) in order to increase their competences in a certain domain (learn by doing) and postgraduate students (by means of internship or thesis work).

The mobility programme will support access to dedicated infrastructure associated with EURAD-1. Such infrastructure is mainly present at the premises of EURAD Beneficiaries, and targets primarily underground research laboratories, as well as, on a secondary level, dedicated surface laboratories, specific analytical facilities, or computational infrastructure. Besides these “experimental” facilities and infrastructure, also more “desktop”-based interchanges or secondments can be envisaged to enable direct knowledge transfer from one organisation to another.

A first deliverable of the mobility task will be to generate a proposal for the mobility programme responding to the different needs identified within Task 1 and prioritised within Task 3 (Deliverable 13.7). The needs are then converted into mobility measures, specified with respect to target groups, hosting organizations and types of facilities, lengths of mobility engagement and competence and skills enhancement outcomes. For the latter, the mobility programme will identify the expectations and quality requirements for defining, monitoring and assessing the competences and skills acquired (“learning outcomes”, similar to training deliverable). Given the broad set of potential needs and the width of potential mobility measures, within the given boundary conditions the calls will be very open.

The mobility programme (Deliverable 13.8) will be developed in a spirit of complementarity with already existing initiatives (like the ENEN+ Mobility Fund or the NEA Nuclear Education, Skills and Technology (NEST) Framework) or to be developed projects (e.g. within current NFRP-2018-7) which also target facilitating access to dedicated infrastructures and promoting researcher’s mobility. This EURAD-1 focusses on professional end-users (from post-graduate onwards). However, a younger audience of students (MSc) is not to be neglected as they will populate

tomorrow's workforce in RWM. This task will explore the possibility to connect to existing initiatives primarily aiming at this target audience and will set up, if feasible, close collaborations with these initiatives or projects.

Participation per Partner

Partner number and short name	WP13 effort
1 - ANDRA	5.25
6 - CIEMAT	6.25
22 - JSI	0.00
EIMV	5.00
23 - JRC	5.75
38 - SCK•CEN	15.00
40 - SSTC NRS	5.75
42 - SÚRAO	0.00
CTU	5.75
43 - SURO	10.00
Total	58.75

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D13.1	KM Training - List of training needs from the RD&D and SS WPs	38 - SCK•CEN	Report	Public	3
D13.2	KM Training - Mapping of available course material	38 - SCK•CEN	Report	Public	8
D13.3	KM Training - Alignment of the available course material with the Roadmap	38 - SCK•CEN	Report	Public	12
D13.4	KM Training - Priority list and schedule for training/mobility	38 - SCK•CEN	Report	Public	12
D13.5	KM Training - Quality criteria and training specification as a reference guide of requirements and expectations of the training courses to be developed	38 - SCK•CEN	Report	Public	9

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D13.6	KM Training - Implementation of first training courses developed and implemented depending on the priorities identified and approved within the EJP	38 - SCK•CEN	Report	Public	13
D13.7	KM Training - Specification document of the content, material, and learning outcomes of mobility training e.g. in relation with a curricular of S/T knowledge acquisition targets	43 - SURO	Report	Public	12
D13.8	KM Training - Development of mobility programme	43 - SURO	Report	Public	13

Description of deliverables

Deliverable 13.1 - List of training needs from the RD&D and SS WPs - Month: 3 - Lead: [SCK•CEN].
 Deliverable 13.2 - Mapping of available course material Month 8) Lead: [SCK•CEN]
 Deliverable 13.3 - Alignment of the available course material with the Roadmap Month: 12) Lead: [SCK•CEN]
 Deliverable 13.4 - Priority list and schedule for training/mobility Month 12 Lead: [SCK•CEN]
 Deliverable 13.5 - Quality criteria and training specification as a reference guide of requirements and expectations of the training courses to be developed Month 9 Lead: [SCK•CEN]
 Deliverable 13.6 - Implementation of first training courses developed and implemented depending on the priorities identified and approved within EURAD Month 13+ Lead: [SCK•CEN]
 Deliverable 13.7 - Specification document of the content, material, and learning outcomes of mobility training e.g. in relation with a curricular of S/T knowledge acquisition targets (Month: 12) Lead: [SURO]
 Deliverable 13.8 - Development of mobility programme, depending on the priorities identified and approved within EURAD (see Task 3) (Month: 13+) Lead: [SURO]

D13.1 : KM Training - List of training needs from the RD&D and SS WPs [3]
 KM Training - List of training needs from the RD&D and SS WPs

D13.2 : KM Training - Mapping of available course material [8]
 KM Training - Mapping of available course material

D13.3 : KM Training - Alignment of the available course material with the Roadmap [12]
 KM Training - Alignment of the available course material with the Roadmap

D13.4 : KM Training - Priority list and schedule for training/mobility [12]
 KM Training - Priority list and schedule for training/mobility

D13.5 : KM Training - Quality criteria and training specification as a reference guide of requirements and expectations of the training courses to be developed [9]
 KM Training - Quality criteria and training specification as a reference guide of requirements and expectations of the training courses to be developed

D13.6 : KM Training - Implementation of first training courses developed and implemented depending on the priorities identified and approved within the EJP [13]
 KM Training - Implementation of first training courses developed and implemented depending on the priorities identified and approved within the EJP

D13.7 : KM Training - Specification document of the content, material, and learning outcomes of mobility training e.g. in relation with a curricular of S/T knowledge acquisition targets [12]
 KM Training - Specification document of the content, material, and learning outcomes of mobility training e.g. in relation with a curricular of S/T knowledge acquisition targets

D13.8 : KM Training - Development of mobility programme [13]
 KM Training - Development of mobility programme

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS1	EURAD Kick-off meeting (General Assembly n°1)	1 - ANDRA	1	EURAD Kick-off meeting (General Assembly n°1)
MS12	EURAD EJP Newsletters	1 - ANDRA	3	EURAD EJP Newsletters (Due date : M3 and then every quarter)
MS30	EURAD General Assembly n°2	1 - ANDRA	7	EURAD General Assembly n°2
MS42	EURAD Annual Work Plan 2	1 - ANDRA	9	EURAD Annual Work Plan 2
MS70	KM Training - School of RWM – portfolio gathering all training courses developed and implemented depending on the priorities identified and approved within the EJP; Founding of the School	38 - SCK•CEN	12	KM Training - School of Radioactive Waste Management – portfolio gathering all training courses developed and implemented depending on the priorities identified and approved within the EJP; Founding of the School
MS81	EURAD General Assembly n°3 + EURAD Annual Meeting 1	1 - ANDRA	13	EURAD General Assembly n°3 + EURAD Annual Meeting 1
MS85	EURAD Periodic Report 1	1 - ANDRA	14	EURAD Periodic Report 1
MS103	EURAD General Assembly n°4	1 - ANDRA	19	EURAD General Assembly n°4
MS112	EURAD Annual Work Plan 3	1 - ANDRA	21	EURAD Annual Work Plan 3
MS136	EURAD General Assembly n°5 + EURAD Annual Meeting 2	1 - ANDRA	25	EURAD General Assembly n°5 + EURAD Annual Meeting 2
MS140	EURAD Periodic Report 2	1 - ANDRA	26	EURAD Periodic Report 2
MS153	EURAD General Assembly n°6	1 - ANDRA	31	EURAD General Assembly n°6
MS162	EURAD Annual Work Plan 4	1 - ANDRA	33	EURAD Annual Work Plan 4

Schedule of relevant Milestones

Milestone number ¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification
MS185	EURAD General Assembly n°7 + EURAD Annual Meeting 3	1 - ANDRA	37	EURAD General Assembly n°7 + EURAD Annual Meeting 3
MS189	EURAD Periodic Report 3	1 - ANDRA	38	EURAD Periodic Report 3
MS199	EURAD General Assembly n°8	1 - ANDRA	43	EURAD General Assembly n°8
MS206	EURAD Annual Work Plan 5	1 - ANDRA	45	EURAD Annual Work Plan 5
MS222	EURAD General Assembly n°9 + EURAD Annual Meeting 4	1 - ANDRA	49	EURAD General Assembly n°9 + EURAD Annual Meeting 4
MS224	EURAD Periodic Report 4	1 - ANDRA	50	EURAD Periodic Report 4
MS234	EURAD General Assembly n°10	1 - ANDRA	55	EURAD General Assembly n°10
MS240	EURAD General Assembly n°11 + EURAD Annual Meeting 5	1 - ANDRA	60	EURAD General Assembly n°11 + EURAD Annual Meeting 5
MS241	EURAD Periodic Report 5	1 - ANDRA	60	EURAD Periodic Report 5 (Due date: 60+2)

Work package number ⁹	WP14	Lead beneficiary ¹⁰	1 - ANDRA
Work package title	Ethics requirements		
Start month	1	End month	60

Objectives

The objective is to ensure compliance with the 'ethics requirements' set out in this work package.

Description of work and role of partners

WP14 - Ethics requirements [Months: 1-60]

ANDRA

This work package sets out the 'ethics requirements' that the project must comply with.

List of deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D14.1	EPQ - Requirement No. 1	1 - ANDRA	Ethics	Confidential, only for members of the consortium (including the Commission Services)	12
D14.2	EPQ - Requirement No. 2	1 - ANDRA	Ethics	Confidential, only for members of the consortium (including the Commission Services)	12
D14.3	EPQ - Requirement No. 3	1 - ANDRA	Ethics	Confidential, only for members of the consortium (including the Commission Services)	12

Description of deliverables

The 'ethics requirements' that the project must comply with are included as deliverables in this work package.

D14.1 : EPQ - Requirement No. 1 [12]

7.1. Further information about the possible harm to the environment caused by the research and the measures that will be taken to mitigate the risks must be included in the grant agreement, kept on file, specified in the grant agreement. The proposal should consider potential hazards associated with the experimental work, particularly in underground laboratories. It is expected that these are all operated to high safety standards, but this should be confirmed and documentation related to health and safety should be made available on request of EC staff (depending on policy in this area). Such documentation should be stipulated in the grant agreement and produced for a facility before experiments for the project are performed.

D14.2 : EPQ - Requirement No. 2 [12]

7.2. Copies of authorisations for relevant facilities (e.g., security classification of laboratory) must be kept on file and specified in the grant agreement.

D14.3 : EPQ - Requirement No. 3 [12]

7.3. The applicant must demonstrate that appropriate health and safety procedures conforming to relevant local/national guidelines/legislation are followed for staff involved in this project. This must be confirmed in the grant agreement.

Schedule of relevant Milestones

Milestone number¹⁸	Milestone title	Lead beneficiary	Due Date (in months)	Means of verification

1.3.4. WT4 List of milestones

Milestone number ¹⁸	Milestone title	WP number ⁹	Lead beneficiary	Due Date (in months) ¹⁷	Means of verification
MS1	EURAD Kick-off meeting (General Assembly n°1)	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	1 - ANDRA	1	EURAD Kick-off meeting (General Assembly n°1)
MS2	ACED Kick-off meeting (WPM1)	WP2	38 - SCK•CEN	1	ACED Kick-off meeting (WPM1)
MS3	DONUT Kick off - WP Meeting 1	WP4	1 - ANDRA	1	DONUT Kick off - WP Meeting 1
MS4	FUTuRE Kick-off meeting (WPM1)	WP5	15 - JUELICH	1	FUTuRE Kick-off meeting (WPM1)
MS5	Kick-off GAS WP Meeting 1	WP6	32 - ONDRAF/NIRAS	1	Kick-off GAS WP Meeting 1
MS6	Kick-off HITEC WP Meeting 1	WP7	50 - VTT	1	Kick-off HITEC WP Meeting 1
MS7	KM SoK - launch of screening exercise (task 1)	WP11	15 - JUELICH	1	KM SoK - launch of screening exercise (task 1)
MS8	ACED Specifications of representative disposal cell systems and links with and between model approaches and expected experimental results M1.1.1	WP2	38 - SCK•CEN	2	ACED Specifications of representative disposal cell systems and links with and between model approaches and expected experimental results M1.1.1
MS9	ROUTES Kick-off meeting (ROUTES WPM1)	WP9	19 - IRSN	2	ROUTES Kick-off meeting (ROUTES WPM1)
MS10	KM Guidance - Editorial meeting for the update of PLANDIS	WP12	42 - SÚRAO	2	KM Guidance - Editorial meeting for the update of PLANDIS
MS11	ACED Task 2 workshop 1	WP2	38 - SCK•CEN	3	ACED Task 2 workshop 1
MS12	EURAD EJP Newsletters	WP1, WP10, WP11,	1 - ANDRA	3	EURAD EJP Newsletters (Due date : M3 and then every quarter)

Milestone number ¹⁸	Milestone title	WP number ⁹	Lead beneficiary	Due Date (in months) ¹⁷	Means of verification
		WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9			
MS13	ROUTES Questionnaire	WP9	19 - IRSN	3	ROUTES Questionnaire
MS14	KM SoK - List of Demonstration cases	WP11	4 - BGE	7	KM SoK - List of Demonstration cases
MS15	KM SoK - list of criteria for selecting demonstration cases	WP11	4 - BGE	4	KM SoK - list of criteria for selecting demonstration cases
MS16	ACED - note on the specific experimental conditions at the steel/clay material interface, parameters and modelling approaches	WP2	38 - SCK•CEN	6	ACED - note on the specific experimental conditions at the steel/clay material interface, parameters and modelling approaches with detailed information on set-ups and work flow, variables to measure and a dismantling and characterization plan. It will also define the link between the experiments and the model approaches (also input to general workshop 1, and MS31)
MS17	CORI Technical Report - Task 2 State-of-art report on organic degradation by radiolytic and hydrolytic processes	WP3	24 - KIT	6	CORI Technical Report - Task 2 State-of-art report on organic degradation by radiolytic and hydrolytic processes.
MS18	CORI Technical Report- Task 3 with (i) Final documentation of the systems to be studied and (ii) State-of-art summary on organic-cement-interactions	WP3	24 - KIT	6	CORI Technical Report- Task 3 with (i) Final documentation of the systems to be studied and (ii) State-of-art summary on organic-cement-interactions.
MS19	CORI Technical Report- Task 4 with (i) Final documentation of the systems to be studied and (ii)	WP3	24 - KIT	6	CORI Technical Report- Task 4 with (i) Final documentation of the systems to be studied and (ii) State-

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
	State-of-art summary on organic-cement-interactions				of-art summary on organic-cement-interactions
MS20	GAS Task 2.2 Experimental set-ups, geometries and boundary conditions	WP6	32 - ONDRAF/NIRAS	6	GAS Task 2.2 Experimental set-ups, geometries and boundary conditions
MS21	UMAN Draft D10.5 as input to Task 2, Task 4, Task 5 and other subtasks of Task 3	WP10	3 - BEL V	6	UMAN Draft D10.5 as input to Task 2, Task 4, Task 5 and other subtasks of Task 3
MS22	UMAN Preliminary list of uncertainties from UMAN subtask 3.3 as input to Subtask 4.2	WP10	3 - BEL V	6	UMAN Preliminary list of uncertainties from UMAN subtask 3.3 as input to Subtask 4.2
MS23	UMAN Preliminary list of uncertainties from subtask 3.4 as input to Subtask 4.2	WP10	3 - BEL V	6	UMAN Preliminary list of uncertainties from subtask 3.4 as input to Subtask 4.2
MS24	UMAN Identification of the different actors across the various programme phases including a first characterization of their roles and interests (Draft D10.10)	WP10	3 - BEL V	6	UMAN Identification of the different actors across the various programme phases including a first characterization of their roles and interests (Draft D10.10)
MS25	UMAN Composition of the pluralistic stakeholder group for Seminar 1	WP10	3 - BEL V	6	UMAN Composition of the pluralistic stakeholder group for Seminar 1
MS26	SOTA from RD&D CORI WP as input to UMAN T3.2	WP10, WP3	24 - KIT	6	SOTA from RD&D CORI WP as input to UMAN T3.2
MS27	SOTA from RD&D FUTuRE WP as input to UMAN T3.3	WP10, WP5	15 - JUELICH	6	SOTA from RD&D FUTuRE WP as input to UMAN T3.3
MS28	HITEC/GAS training n°1 on multi-physical coupling in geomechanics (especially THM and Gas coupling issues)	WP6, WP7	50 - VTT	6	HITEC/GAS training n°1 on multi-physical coupling in geomechanics (especially THM and Gas coupling issues)
MS29	SOTA from RD&D SFC WP as input to UMAN T3.5	WP10, WP8	39 - SKB	6	SOTA from RD&D SFC WP as input to UMAN T3.5
MS30	EURAD General Assembly n°2	WP1, WP10,	1 - ANDRA	7	EURAD General Assembly n°2

Milestone number ¹⁸	Milestone title	WP number ⁹	Lead beneficiary	Due Date (in months) ¹⁷	Means of verification
		WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9			
MS31	ACED Experimental data as a first input for modelling and information exchange towards other scales M1.1.2	WP2	38 - SCK•CEN	7	ACED Experimental data as a first input for modelling and information exchange towards other scales M1.1.2
MS32	ACED WP meeting 2 + Workshop 1	WP2	38 - SCK•CEN	7	ACED WP meeting 2 + Workshop 1
MS33	CORI Start of experimental RD&D programme (task 2, 3 and 4)	WP3	24 - KIT	7	CORI Start of experimental RD&D programme (task 2, 3 and 4)
MS34	DONUT WP Meeting 2	WP4	1 - ANDRA	7	DONUT WP Meeting 2
MS35	GAS WP Meeting 2	WP6	32 - ONDRAF/NIRAS	7	GAS WP Meeting 2
MS36	HITEC WP Meeting 2	WP7	50 - VTT	7	HITEC WP Meeting 2
MS37	ROUTES Workshop 1 on Radioanalytical characterisation of radioactive waste and waste with complex/toxic properties (T3.1)	WP9	19 - IRSN	7	ROUTES Workshop 1 on Radioanalytical characterisation of radioactive waste and waste with complex/toxic properties (T3.1)
MS38	ROUTES Workshop 1 on disposal options for SIMS (T5.1)	WP9	19 - IRSN	7	ROUTES Workshop 1 on disposal options for SIMS (T5.1)
MS39	ROUTES workshop on European experience in developing shared solutions for RWM	WP9	19 - IRSN	7	ROUTES workshop on European experience in developing shared solutions for RWM
MS40	UMAN Draft deliverable D10.2 as input to Tasks 4 and 5	WP10	3 - BEL V	7	UMAN Draft deliverable D10.2 as input to Tasks 4 and 5
MS41	KM Guidance - Editorial Plan for PLANMAN Delineation Year 2	WP12	42 - SÚRAO	7	KM Guidance - Editorial Plan for PLANMAN Delineation Year 2
MS42	EURAD Annual Work Plan 2	WP1, WP10,	1 - ANDRA	9	EURAD Annual Work Plan 2

Milestone number ¹⁸	Milestone title	WP number ⁹	Lead beneficiary	Due Date (in months) ¹⁷	Means of verification
		WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9			
MS43	ACED Identification of integration and upscaling strategies M1.1.3	WP2	38 - SCK•CEN	9	ACED Identification of integration and upscaling strategies M1.1.3
MS44	GAS State-of-the-art chapter on diffusion and gas sorption in clayey materials as an input to D6.1	WP6	32 - ONDRAF/NIRAS	9	GAS State-of-the-art chapter on diffusion and gas sorption in clayey materials as an input to D6.1
MS45	GAS State-of-the-art chapter on advective gas transport in clayey materials as an input to D6.1	WP6	32 - ONDRAF/NIRAS	9	GAS State-of-the-art chapter on advective gas transport in clayey materials as an input to D6.1
MS46	GAS State-of-the-art chapter on gas-induced impacts on barrier integrity including pathway closure and sealing processes as an input to D6.1	WP6	32 - ONDRAF/NIRAS	9	GAS State-of-the-art chapter on gas-induced impacts on barrier integrity including pathway closure and sealing processes as an input to D6.1
MS47	HITEC experimental progress report	WP7	50 - VTT	9	HITEC experimental progress report
MS48	HITEC Task 2.2 Experimental test plan	WP7	50 - VTT	9	HITEC Task 2.2 Experimental test plan
MS49	HITEC Selection of benchmark exercises for task 2.3	WP7	50 - VTT	9	HITEC Selection of benchmark exercises for task 2.3
MS50	FUTuRE Report on set-up of experiments – Task 2.1	WP5	15 - JUELICH	10	FUTuRE Report on set-up of experiments – Task 2.1
MS51	FUTuRE Report on set-up of experiments – Task 2.2	WP5	15 - JUELICH	10	FUTuRE Report on set-up of experiments – Task 2.2
MS52	FUTuRE Report on set-up of experiments – Task 2.3	WP5	15 - JUELICH	10	FUTuRE Report on set-up of experiments – Task 2.3

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
MS53	FUTuRE Report on set-up of experiments – Task 3	WP5	15 - JUELICH	10	FUTuRE Report on set-up of experiments – Task 3
MS54	UMAN Preliminary list of uncertainties from subtask 3.5 as input to Subtask 4.2	WP10	3 - BEL V	10	UMAN Preliminary list of uncertainties from subtask 3.5 as input to Subtask 4.2
MS55	ACED T3.1 - distribution of experimental samples to partners	WP2	38 - SCK•CEN	12	ACED T3.1 - distribution of experimental samples to partners
MS56	CORI First Annual WP Meeting (including technical meetings on Task level)	WP3	24 - KIT	12	CORI First Annual WP Meeting (including technical meetings on Task level)
MS57	CORI Technical Report- Task 4 (i) Radionuclide retention on CSH or CASH or AFm/AFt in the presence of organics, (ii) Radionuclide retention on HCP in the presence of organics	WP3	24 - KIT	12	CORI Technical Report- Task 4 (i) Radionuclide retention on CSH or CASH or AFm/AFt in the presence of organics, (ii) Radionuclide retention on HCP in the presence of organics.
MS58	GAS Task 3 – interim experimental design report comprising a revised detailed work programme of subtasks 3.1, 3.2 and 3.3	WP6	32 - ONDRAF/NIRAS	12	GAS Task 3 – interim experimental design report comprising a revised detailed work programme of subtasks 3.1, 3.2 and 3.3
MS59	GAS SOTA chapter on gas-induced impacts on model-based interpretation including a survey of previous research programmes and a screening of gas-related FEP lists as an input to D6.1	WP6	32 - ONDRAF/NIRAS	12	GAS State-of-the-art chapter on gas-induced impacts on model-based interpretation including a survey of previous research programmes and a screening of gas-related FEP lists as an input to D6.1
MS60	GAS SOTA chapter drawing an overview of the conceptualizations of gas migration through geological disposal systems and related processes, at the scale of a repository and how these can be translated into models	WP6	32 - ONDRAF/NIRAS	12	GAS State-of-the-art chapter drawing an overview of the conceptualizations of gas migration through geological disposal systems and related processes, at the scale of a repository and how these can be translated into models as an input to D6.1

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
MS61	GAS Technical Note defining a generic repository configuration, sets of parameters, conditions and relevant indicators	WP6	32 - ONDRAF/NIRAS	12	GAS Technical Note defining a generic repository configuration, sets of parameters, conditions and relevant indicators on which sub-task 4.2 will test various evaluation approaches
MS62	HITEC Task 2.1 Experimental test plan	WP7	50 - VTT	12	HITEC Task 2.1 Experimental test plan
MS63	HITEC Task 3.3 - Mathematical models – description of models and plan for improvements (Description of conceptual models and tools, plan for the models improvement)	WP7	50 - VTT	12	HITEC Task 3.3 - Mathematical models – description of models and plan for improvements (Description of conceptual models and tools, plan for the models improvement)
MS64	SFC Task 2.3 Characteristics of irradiated material to be characterised	WP8	39 - SKB	12	SFC Task 2.3 Characteristics of irradiated material to be characterised
MS65	ROUTES WPM2	WP9	19 - IRSN	12	ROUTES WPM2
MS66	ROUTES Workshop on Case studies on shared development and use of technologies and facilities	WP9	19 - IRSN	12	ROUTES Workshop on Case studies on shared development and use of technologies and facilities
MS67	UMAN Recommendations for future RD&D, strategic study and KM activities for the 2nd wave of EURAD-1	WP10	3 - BEL V	12	UMAN Recommendations for future RD&D, strategic study and KM activities for the 2nd wave of EURAD-1
MS68	Materials to be discussed in UMAN Seminar 1	WP10	3 - BEL V	12	Materials to be discussed in UMAN Seminar 1
MS69	UMAN Mapping of the stakes related to the outcomes of Task 2 and Subtask 3.1 from a civil society point of view for the 1st Task 5 seminar	WP10	3 - BEL V	12	UMAN Mapping of the stakes related to the outcomes of Task 2 and Subtask 3.1 from a civil society point of view for the 1st Task 5 seminar
MS70	KM Training - School of RWM – portfolio gathering all training courses developed and implemented	WP13	38 - SCK•CEN	12	KM Training - School of Radioactive Waste Management – portfolio gathering all training courses developed and implemented

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
	depending on the priorities identified and approved within the EJP; Founding of the School				depending on the priorities identified and approved within the EJP; Founding of the School
MS71	Methodology for ICS activities assessment	WP1, WP10, WP9	19 - IRSN	12	Methodology for ICS activities assessment
MS72	ACED Workshop 2 – Joint workshop with GAS and DONUT	WP2	38 - SCK•CEN	13	ACED Workshop 2 – Joint workshop with GAS and DONUT (Month 13 - 18)
MS73	FUTuRE WPM2	WP5	15 - JUELICH	13	FUTuRE WPM2
MS74	UMAN WP meeting 1	WP10	3 - BEL V	13	UMAN WP meeting 1
MS75	UMAN Draft D10.3 as input to Task 3	WP10	3 - BEL V	13	UMAN Draft D10.3 as input to Task 3
MS76	UMAN Draft D10.7 as input to Task 4 and 5	WP10	3 - BEL V	13	UMAN Draft D10.7 as input to Task 4 and 5
MS77	UMAN Seminar 1	WP10	3 - BEL V	13	UMAN Seminar 1
MS78	KM SoK - Initial draft QA plan	WP11	40 - SSTC NRS	4	KM SoK - Initial draft QA plan
MS79	KM SoK - proposal to the General Assembly for future work	WP11	4 - BGE	24	KM SoK - proposal to the General Assembly for future work
MS80	KM Guidance - Editorial boards meetings for the PLANMAN delineation guides	WP12	42 - SÚRAO	13	KM Guidance - Editorial boards meetings for the PLANMAN delineation guides
MS81	EURAD General Assembly n°3 + EURAD Annual Meeting 1	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	1 - ANDRA	13	EURAD General Assembly n°3 + EURAD Annual Meeting 1
MS82	ICS Workshop 1	WP1, WP10, WP9	19 - IRSN	13	ICS Workshop 1
MS83	GAS WP Meeting 3 jointly organised with the WP HITEC	WP6, WP7	32 - ONDRAF/NIRAS	13	GAS WP Meeting 3 jointly organised with the WP HITEC

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
MS84	HITEC WP Meeting 3 jointly organised with the WP GAS	WP6, WP7	50 - VTT	13	HITEC WP Meeting 3 jointly organised with the WP GAS
MS85	EURAD Periodic Report 1	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	1 - ANDRA	14	EURAD Periodic Report 1
MS86	CORI Technical Report- Task 3 (i) Organic retention on cement hydrates (AFm, AFt, CSH/CASH), (ii) Organic retention on hardened cement pastes (HCP), (iii) Effect of iron on organic sorption in cementitious systems	WP3	24 - KIT	14	CORI Technical Report- Task 3 (i) Organic retention on cement hydrates (AFm, AFt, CSH/CASH), (ii) Organic retention on hardened cement pastes (HCP), (iii) Effect of iron on organic sorption in cementitious systems
MS87	KM SoK - updated QA procedure documents	WP11	40 - SSTC NRS	19	KM SoK - updated QA procedure documents
MS88	ROUTES up-to-date overview per country on the use of waste acceptance criteria (WAC) in Member-States, hereby focusing on the use of WAC as a tool for waste cycle management	WP9	19 - IRSN	15	ROUTES up-to-date overview per country on the use of waste acceptance criteria (WAC) in Member-States, hereby focusing on the use of WAC as a tool for waste cycle management
MS89	UMAN Compiled and reviewed information about possible management options for site and geosphere related uncertainties as input to Subtask 4.3	WP10	3 - BEL V	15	UMAN Compiled and reviewed information about possible management options for site and geosphere related uncertainties as input to Subtask 4.3
MS90	ROUTES Workshop 2 on Radioanalytical characterisation of radioactive waste and	WP9	19 - IRSN	16	ROUTES Workshop 2 on Radioanalytical characterisation of radioactive waste and waste with

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
	waste with complex/toxic properties (T3.1)				complex/toxic properties (T3.1)
MS91	ROUTES Workshop 2 on disposal options for SIMS (T5.1)	WP9	19 - IRSN	16	ROUTES Workshop 2 on disposal options for SIMS (T5.1)
MS92	UMAN Preliminary list of uncertainties from subtask 3.2 as input to Subtask 4.2	WP10	3 - BEL V	16	UMAN Preliminary list of uncertainties from subtask 3.2 as input to Subtask 4.2
MS93	KM SoK - start of broad SoK implementation	WP11	4 - BGE	25	KM SoK - start of broad SoK implementation
MS94	ACED - GAS - DONUT Joint Workshop - 1	WP2, WP4, WP6	32 - ONDRAF/NIRAS	16	ACED - GAS - DONUT Joint Workshop
MS95	ACED Task 2 workshop 2	WP2	38 - SCK•CEN	18	ACED Task 2 workshop 2
MS96	ACED T4.1 - Simulation results as basis for ACED T4.2 and T4.3	WP2	38 - SCK•CEN	18	ACED T4.1 - Simulation results as basis for ACED T4.2 and T4.3
MS97	CORI Technical Report - Task 2 Hydrolytic/radiolytic degradation of organics: description of first results on hydrolytic and radiolytic organic degradation and identification of released species	WP3	24 - KIT	18	CORI Technical Report - Task 2 Hydrolytic/radiolytic degradation of organics: description of first results on hydrolytic and radiolytic organic degradation and identification of released species
MS98	CORI Technical Report- Task 4 (i) Radionuclide transport in HCP in the presence of organics, (ii) Radionuclide speciation under alkaline conditions in presence of organics	WP3	24 - KIT	18	CORI Technical Report- Task 4 (i) Radionuclide transport in HCP in the presence of organics, (ii) Radionuclide speciation under alkaline conditions in presence of organics.
MS99	GAS - Task 2.1 Experimental progress report	WP6	32 - ONDRAF/NIRAS	18	GAS Task 2.1 Experimental progress report
MS100	GAS Task 2.2 - Experimental progress report	WP6	32 - ONDRAF/NIRAS	18	GAS Task 2.2 Experimental progress report
MS101	UMAN Draft D10.8 as input to Task 4 and 5	WP10	3 - BEL V	18	UMAN Draft D10.8 as input to Task 4 and 5

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
MS102	Composition of the pluralistic stakeholder group for UMAN Seminar 2	WP10	3 - BEL V	18	Composition of the pluralistic stakeholder group for UMAN Seminar 2
MS103	EURAD General Assembly n°4	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	1 - ANDRA	19	EURAD General Assembly n°4
MS104	ACED WP meeting 3	WP2	38 - SCK•CEN	19	ACED WP meeting 3
MS105	DONUT WP Meeting 3	WP4	1 - ANDRA	19	DONUT WP Meeting 3
MS106	GAS WP Meeting 4	WP6	32 - ONDRAF/NIRAS	19	GAS WP Meeting 4
MS107	HITEC WP Meeting 4	WP7	50 - VTT	19	HITEC WP Meeting 4
MS108	UMAN Workshop 1 on management options and preferences of different actors regarding site and geosphere related uncertainties	WP10	3 - BEL V	19	UMAN Workshop 1 on management options and preferences of different actors regarding site and geosphere related uncertainties
MS109	KM Guidance - Editorial Plan for PLANMAN Delineation Year 3	WP12	42 - SÚRAO	19	KM Guidance - Editorial Plan for PLANMAN Delineation Year 3
MS110	ROUTES Workshop 3 on Radioanalytical characterisation of radioactive waste and waste with complex/toxic properties (T3.1) +Workshop 1 on Characterization and segregation of legacy waste (T3.2)	WP9	19 - IRSN	20	ROUTES Workshop 3 on Radioanalytical characterisation of radioactive waste and waste with complex/toxic properties (T3.1) +Workshop 1 on Characterization and segregation of legacy waste (T3.2)
MS111	UMAN Draft D10.9 as input to Task 4 and 5	WP10	3 - BEL V	20	UMAN Draft D10.9 as input to Task 4 and 5
MS112	EURAD Annual Work Plan 3	WP1, WP10, WP11, WP12,	1 - ANDRA	21	EURAD Annual Work Plan 3

Milestone number ¹⁸	Milestone title	WP number ⁹	Lead beneficiary	Due Date (in months) ¹⁷	Means of verification
		WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9			
MS113	UMAN Compiled and reviewed information about possible management options for uncertainties related to the human aspects as input to Subtask 4.3	WP10	3 - BEL V	21	UMAN Compiled and reviewed information about possible management options for uncertainties related to the human aspects as input to Subtask 4.3
MS114	DONUT Intermediate report describing numerical method improvement and their transferability in numerical tools	WP4	1 - ANDRA	22	DONUT Intermediate report describing numerical method improvement and their transferability in numerical tools
MS115	DONUT Intermediate report describing numerical method improvement and their transferability in numerical tools.	WP4	1 - ANDRA	22	DONUT Intermediate report describing numerical method improvement and their transferability in numerical Tools.
MS116	DONUT Intermediate report describing improvement and implementation of scale transition methods improvement and their application for multiscale simulations	WP4	1 - ANDRA	22	DONUT Intermediate report describing improvement and implementation of scale transition methods improvement and their application for multiscale simulations
MS117	DONUT Intermediate report describing numerical developments realized to treat uncertainty	WP4	1 - ANDRA	22	DONUT Intermediate report describing numerical developments realized to treat uncertainty
MS118	UMAN Compiled and reviewed information about possible management options for uncertainties related to spent fuel as input to Subtask 4.3	WP10	3 - BEL V	23	UMAN Compiled and reviewed information about possible management options for uncertainties related to spent fuel as input to Subtask 4.3

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
MS119	ACED T4.3 - Definition of calculation cases and parameter ranges	WP2	38 - SCK•CEN	24	ACED T4.3 - Definition of calculation cases and parameter ranges
MS120	CORI Second Annual WP Meeting (including technical meetings on Task level)	WP3	24 - KIT	24	CORI Second Annual WP Meeting (including technical meetings on Task level)
MS121	CORI Technical Report - Task 2 Identification/ quantification of soluble organic species generated by degradation of organic matter	WP3	24 - KIT	24	CORI Technical Report - Task 2 Identification/ quantification of soluble organic species generated by degradation of organic matter: description and discussion of results acquired about identification of soluble species generated by radiolysis/hydrolysis.
MS122	GAS Task 2.1 Modelling progress report.	WP6	32 - ONDRAF/NIRAS	24	GAS Task 2.1 Modelling progress report
MS123	GAS Task 2.2 Modelling progress report	WP6	32 - ONDRAF/NIRAS	24	GAS Task 2.2 Modelling progress report
MS124	GAS Tasks 3.1 and 3.2 experimental progress report	WP6	32 - ONDRAF/NIRAS	24	GAS Tasks 3.1 and 3.2 experimental progress report
MS125	GAS Task 3 – Progress report describing Modelling / concepts, codes and validation workflows	WP6	32 - ONDRAF/NIRAS	24	GAS Task 3 – Progress report describing Modelling / concepts, codes and validation workflows
MS126	SFC Task 2.1 Workshop – 24	WP8	39 - SKB	24	SFC Task 2.1 Workshop – 24
MS127	ROUTES WPM3	WP9	19 - IRSN	24	ROUTES WPM3
MS128	Materials to be discussed in UMAN Seminar 2	WP10	3 - BEL V	24	Materials to be discussed in UMAN Seminar 2
MS129	Mapping of the stakes related to the outcomes of UMAN Tasks 2, 3 and 4 from a civil society point of view for the 2nd Task 5 seminar	WP10	3 - BEL V	24	Mapping of the stakes related to the outcomes of UMAN Tasks 2, 3 and 4 from a civil society point of view for the 2nd Task 5 seminar
MS130	HITEC Task 3.3 - Modelling benchmarks – description	WP4, WP7	50 - VTT	24	HITEC Task 3.3 -Modelling benchmarks – description (Description of calibration

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
	(Description of calibration case, verification cases and benchmarks selected for T3.3 in cooperation with DONUT)				case, verification cases and benchmarks selected for T3.3 in cooperation with DONUT
MS131	FUTuRE WPM3	WP5	15 - JUELICH	25	FUTuRE WPM3
MS132	ROUTES Workshop on waste management with/without WAC available (T4.2)	WP9	19 - IRSN	25	ROUTES Workshop on waste management with/without WAC available (T4.2)
MS133	UMAN WP meeting 2	WP10	3 - BEL V	25	UMAN WP meeting 2
MS134	UMAN Workshop 2 on management options and preferences of different actors regarding human aspects related uncertainties	WP10	3 - BEL V	25	UMAN Workshop 2 on management options and preferences of different actors regarding human aspects related uncertainties
MS135	UMAN Seminar 2	WP10	3 - BEL V	25	UMAN Seminar 2
MS136	EURAD General Assembly n°5 + EURAD Annual Meeting 2	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	1 - ANDRA	25	EURAD General Assembly n°5 + EURAD Annual Meeting 2
MS137	ICS Workshop 2	WP1, WP10, WP9	19 - IRSN	25	ICS Workshop 2
MS138	GAS WP Meeting 5 jointly organised with the WP HITEC	WP6, WP7	32 - ONDRAF/NIRAS	25	GAS WP Meeting 5 jointly organised with the WP HITEC
MS139	HITEC WP Meeting 5 jointly organised with the WP GAS	WP6, WP7	50 - VTT	25	HITEC WP Meeting 5 jointly organised with the WP GAS
MS140	EURAD Periodic Report 2	WP1, WP10, WP11, WP12, WP13, WP2, WP3,	1 - ANDRA	26	EURAD Periodic Report 2

Milestone number ¹⁸	Milestone title	WP number ⁹	Lead beneficiary	Due Date (in months) ¹⁷	Means of verification
		WP4, WP5, WP6, WP7, WP8, WP9			
MS141	CORI Technical Report- Task 3 (i) Organic transport in HCP, (ii) Update on organic retention studies on cementitious materials including iron/calcium effect	WP3	24 - KIT	26	CORI Technical Report- Task 3 (i) Organic transport in HCP, (ii) Update on organic retention studies on cementitious materials including iron/calcium effect
MS142	CORI Technical Report. Update on radionuclide retention studies on cementitious materials in the presence of organics	WP3	24 - KIT	26	CORI Technical Report. Update on radionuclide retention studies on cementitious materials in the presence of organics.
MS143	UMAN Draft 10.6 as input to Task 4 and 5	WP10	3 - BEL V	26	UMAN Draft 10.6 as input to Task 4 and 5
MS144	ROUTES summary of Task 4.2 workshop outcomes on Sharing experience on waste management with/ without WAC available	WP9	19 - IRSN	28	ROUTES summary of Task 4.2 workshop outcomes on Sharing experience on waste management with/without WAC available
MS145	UMAN Compiled and reviewed information about possible management options for uncertainties related to waste inventory as input to Subtask 4.3	WP10	3 - BEL V	28	UMAN Compiled and reviewed information about possible management options for uncertainties related to waste inventory as input to Subtask 4.3
MS146	UMAN Workshop 3 on management options and preferences of different actors regarding waste inventory related uncertainties	WP10	3 - BEL V	28	UMAN Workshop 3 on management options and preferences of different actors regarding waste inventory related uncertainties
MS147	Composition of the pluralistic stakeholder group for UMAN Seminar	WP10	3 - BEL V	29	Composition of the pluralistic stakeholder group for UMAN Seminar
MS148	ACED Task 2 workshop 3	WP2	38 - SCK•CEN	30	ACED Task 2 workshop 3

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
MS149	ACED T4.1 - Simulation results as a basis for ACED T4.2 and T4.4	WP2	38 - SCK•CEN	30	ACED T4.1 - Simulation results as a basis for ACED T4.2 and T4.4
MS150	ACED Workshop 4 – Joint workshop with GAS and DONUT	WP2	38 - SCK•CEN	30	ACED Workshop 4 – Joint workshop with GAS and DONUT (Month 30 - 37)
MS151	ROUTES Workshop predisposal routes for the disposal options for SIMS (T5.2)	WP9	19 - IRSN	30	ROUTES Workshop predisposal routes for the disposal options for SIMS (T5.2)
MS152	Last input from ROUTES to UMAN	WP10, WP9	19 - IRSN	30	Last input from ROUTES to UMAN
MS153	EURAD General Assembly n°6	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	1 - ANDRA	31	EURAD General Assembly n°6
MS154	ACED WP meeting 4 + Workshop 3	WP2	38 - SCK•CEN	31	ACED WP meeting 4 + Workshop 3
MS155	ACED Updated experimental data, model concepts and parameters as input for modelling and for information transfer towards other scales including update upscaling approach M1.1.4	WP2	38 - SCK•CEN	31	ACED Updated experimental data, model concepts and parameters as input for modelling and for information transfer towards other scales including update upscaling approach M1.1.4
MS156	DONUT WP Meeting 4	WP4	1 - ANDRA	31	DONUT WP Meeting 4
MS157	GAS WP Meeting 6	WP6	32 - ONDRAF/NIRAS	31	GAS WP Meeting 6
MS158	HITEC WP Meeting 6	WP7	50 - VTT	31	HITEC WP Meeting 6
MS159	UMAN Input to Task 5 on management options and preferences of different actors regarding site and geosphere and human	WP10	3 - BEL V	31	UMAN Input to Task 5 on management options and preferences of different actors regarding site and geosphere and human aspects related uncertainties

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
	aspects related uncertainties				
MS160	KM Guidance - Editorial Plan for PLANMAN Delineation Year 4	WP12	42 - SÚRAO	31	KM Guidance - Editorial Plan for PLANMAN Delineation Year 4
MS161	ROUTES Workshop 2 on Characterization and segregation of legacy waste (T3.1)	WP9	19 - IRSN	32	ROUTES Workshop 2 on Characterization and segregation of legacy waste (T3.1)
MS162	EURAD Annual Work Plan 4	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	1 - ANDRA	33	EURAD Annual Work Plan 4
MS163	ROUTES Workshop on identification of R&D needs and opportunities of collaboration related to the management of challenging wastes (T4.3)	WP9	19 - IRSN	33	ROUTES Workshop on identification of R&D needs and opportunities of collaboration related to the management of challenging wastes (T4.3)
MS164	UMAN Workshop 4 on management options and preferences of different actors regarding SF-related uncertainties	WP10	3 - BEL V	33	UMAN Workshop 4 on management options and preferences of different actors regarding SF-related uncertainties
MS165	ACED - GAS - DONUT Joint Workshop	WP2, WP4, WP6	32 - ONDRAF/NIRAS	33	ACED - GAS - DONUT Joint Workshop
MS166	Composition of the pluralistic stakeholder group for UMAN Seminar 4	WP10	3 - BEL V	35	Composition of the pluralistic stakeholder group for UMAN Seminar 4
MS167	ACED T3.2 - Synthesis note on concepts and effective parameters for approximation of chemical evolution of waste packages on disposal cell scale	WP2	38 - SCK•CEN	36	ACED T3.2 - Synthesis note on concepts and effective parameters for approximation of chemical evolution of waste packages on disposal cell scale (input to milestone M1.1.5)

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
	(input to milestone M1.1.5)				
MS168	ACED T3.3 - Synthesis note on concepts and effective parameters for approximation of chemical evolution of waste packages on disposal cell scale (input to milestone M1.1.5)	WP2	38 - SCK•CEN	36	ACED T3.3 - Synthesis note on concepts and effective parameters for approximation of chemical evolution of waste packages on disposal cell scale (input to milestone M1.1.5)
MS169	ACED T4.2 - Demonstration of simulation results with abstracted models	WP2	38 - SCK•CEN	36	ACED T4.2 - Demonstration of simulation results with abstracted models
MS170	CORI Third Annual WP Meeting (including technical meetings on Task level)	WP3	24 - KIT	36	CORI Third Annual WP Meeting (including technical meetings on Task level)
MS171	CORI Technical Report - Task 2 Update of soluble organics species generated by degradation of organic matter: update of results on the identification of soluble organic species generated by radiolysis/hydrolysis	WP3	24 - KIT	36	CORI Technical Report - Task 2 Update of soluble organics species generated by degradation of organic matter: update of results on the identification of soluble organic species generated by radiolysis/hydrolysis
MS172	GAS Task 2.1 Experimental progress report	WP6	32 - ONDRAF/NIRAS	36	GAS Task 2.1 Experimental progress report
MS173	GAS Task 2.2 Experimental progress report	WP6	32 - ONDRAF/NIRAS	36	GAS Task 2.2 Experimental progress report
MS174	GAS Task 4.2 progress report on modelling and evaluation approaches applied to the generic repository derived from the conceptualizations of gas migration through geological disposal systems and related processes, at the scale of a repository	WP6	32 - ONDRAF/NIRAS	36	GAS Task 4.2 progress report on modelling and evaluation approaches applied to the generic repository derived from the conceptualizations of gas migration through geological disposal systems and related processes, at the scale of a repository
MS175	SFC Task 2.2 Workshop – 36	WP8	39 - SKB	36	SFC Task 2.2 Workshop – 36

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
MS176	ROUTES WPM4	WP9	19 - IRSN	36	ROUTES WPM4
MS177	ROUTES Workshop on the feasibility of developing further European shared solutions for waste management from cradle to grave (T6.3)	WP9	19 - IRSN	36	ROUTES Workshop on the feasibility of developing further European shared solutions for waste management from cradle to grave (T6.3)
MS178	Materials to be discussed in UMAN Seminar 3	WP10	3 - BEL V	36	Materials to be discussed in UMAN Seminar 3
MS179	Mapping of the stakes related to the outcomes of UMAN Tasks 2, 3 and 4 from a civil society point of view for the 3rd Task 5 seminar	WP10	3 - BEL V	36	Mapping of the stakes related to the outcomes of UMAN Tasks 2, 3 and 4 from a civil society point of view for the 3rd Task 5 seminar
MS180	ACED Final freeze of data and models mainly for transfer towards other scales M1.1.5	WP2	38 - SCK•CEN	37	ACED Final freeze of data and models mainly for transfer towards other scales M1.1.5
MS181	FUTuRE WPM4	WP5	15 - JUELICH	37	FUTuRE WPM4
MS182	UMAN WP meeting 3	WP10	3 - BEL V	37	UMAN WP meeting 3
MS183	UMAN Input to Task 5 on management options and preferences of different actors regarding waste inventory and SF related uncertainties	WP10	3 - BEL V	37	UMAN Input to Task 5 on management options and preferences of different actors regarding waste inventory and SF related uncertainties
MS184	UMAN Seminar 3	WP10	3 - BEL V	37	UMAN Seminar 3
MS185	EURAD General Assembly n°7 + EURAD Annual Meeting 3	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	1 - ANDRA	37	EURAD General Assembly n°7 + EURAD Annual Meeting 3
MS186	ICS Workshop 3	WP1, WP10, WP9	19 - IRSN	37	ICS Workshop 3

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
MS187	GAS WP Meeting 7 jointly organised with the WP HITEC	WP6, WP7	32 - ONDRAF/NIRAS	37	GAS WP Meeting 7 jointly organised with the WP HITEC
MS188	HITEC WP Meeting 7 jointly organised with the WP GAS	WP6, WP7	50 - VTT	37	HITEC WP Meeting 7 jointly organised with the WP GAS
MS189	EURAD Periodic Report 3	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	1 - ANDRA	38	EURAD Periodic Report 3
MS190	CORI Technical Report- Task 3Update on organic transport studies in HCP	WP3	24 - KIT	38	CORI Technical Report- Task 3Update on organic transport studies in HCP
MS191	CORI Technical Report. Update on radionuclide transport studies in HCP in the presence of organics.	WP3	24 - KIT	38	CORI Technical Report. Update on radionuclide transport studies in HCP in the presence of organics
MS192	ROUTES Note on identification, per country, of R&D needs with respect to the management of challenging wastes	WP9	19 - IRSN	40	ROUTES Note on identification, per country, of R&D needs with respect to the management of challenging wastes
MS193	ACED Task 2 workshop 4	WP2	38 - SCK•CEN	42	ACED Task 2 workshop 4
MS194	ACED T4.2 - Updated simulation results with abstracted models	WP2	38 - SCK•CEN	42	ACED T4.2 - Updated simulation results with abstracted models
MS195	ACED T4.3 - Simulation results and integration towards T1.2	WP2	38 - SCK•CEN	42	ACED T4.3 - Simulation results and integration towards T1.2
MS196	CORI End of experimental RD&D programme (Task 2, 3 and 4)	WP3	24 - KIT	42	CORI End of experimental RD&D programme (Task 2, 3 and 4)

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
MS197	Materials to be discussed in UMAN Seminar 4	WP10	3 - BEL V	42	Materials to be discussed in UMAN Seminar 4
MS198	Mapping of the stakes related to the outcomes of UMAN Tasks 2, 3 and 4 from a civil society point of view for the 4th Task 5 seminar	WP10	3 - BEL V	42	Mapping of the stakes related to the outcomes of UMAN Tasks 2, 3 and 4 from a civil society point of view for the 4th Task 5 seminar
MS199	EURAD General Assembly n°8	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	1 - ANDRA	43	EURAD General Assembly n°8
MS200	ACED WP meeting 5 + Workshop 6	WP2	38 - SCK•CEN	43	ACED WP meeting 5 + Workshop 6
MS201	DONUT WP Meeting 5	WP4	1 - ANDRA	43	DONUT WP Meeting 5
MS202	GAS WP Meeting 8	WP6	32 - ONDRAF/NIRAS	43	GAS WP Meeting 8
MS203	HITEC WP Meeting 8	WP7	50 - VTT	43	HITEC WP Meeting 8
MS204	UMAN Seminar 4	WP10	3 - BEL V	43	UMAN Seminar 4
MS205	KM Guidance - Editorial Plan for PLANMAN Delineation Year 5	WP12	42 - SÚRAO	43	KM Guidance - Editorial Plan for PLANMAN Delineation Year 5
MS206	EURAD Annual Work Plan 5	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	1 - ANDRA	45	EURAD Annual Work Plan 5

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
MS207	HITEC Final Workshop on Influence of temperature on clay-based material behaviour	WP7	50 - VTT	46	HITEC Final Workshop on Influence of temperature on clay-based material behaviour
MS208	Recommendations of UMAN for future RD&D, strategic study and KM activities for future EURAD implementation phase	WP10	3 - BEL V	46	Recommendations of UMAN for future RD&D, strategic study and KM activities for future EURAD implementation phase
MS209	HITEC/GAS training n°2 on multi-physical coupling in geomechanics (especially THM and Gas coupling issues)	WP6, WP7	50 - VTT	46	HITEC/GAS training n°2 on multi-physical coupling in geomechanics (especially THM and Gas coupling issues)
MS210	ACED Closure meeting	WP2	38 - SCK•CEN	48	ACED Closure meeting
MS211	CORI Fourth and Final WP Meeting (including technical meetings on Task level)	WP3	24 - KIT	48	CORI Fourth and Final WP Meeting (including technical meetings on Task level)
MS212	CORI Electronic data deposit	WP3	24 - KIT	48	CORI Electronic data deposit
MS213	CORI Conclusive Technical Meeting of Task 2 (integrated into the Fourth Annual CORI WP Meeting). Preparation of technical	WP3	24 - KIT	48	CORI Conclusive Technical Meeting of Task 2 (integrated into the Fourth Annual CORI WP Meeting). Preparation of technical
MS214	CORI Conclusive Technical Meeting on Task 3 (integrated into the Fourth Annual CORI WP Meeting). Preparation of technical Deliverable	WP3	24 - KIT	48	CORI Conclusive Technical Meeting on Task 3 (integrated into the Fourth Annual CORI WP Meeting). Preparation of technical Deliverable. (48).
MS215	FUTuRE WPM5	WP5	24 - KIT	48	FUTuRE WPM5
MS216	GAS Task 2.1 Modelling progress report	WP6	32 - ONDRAF/NIRAS	48	GAS Task 2.1 Modelling progress report
MS217	GAS Task 2.2 Modelling progress report.	WP6	32 - ONDRAF/NIRAS	48	GAS Task 2.2 Modelling progress report
MS218	SFC Task 2.4 Workshop – 48	WP8	39 - SKB	48	SFC Task 2.4 Workshop – 48
MS219	ROUTES WPM5	WP9	19 - IRSN	48	ROUTES WPM5

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
MS220	GAS Chapter on pathway closure and sealing processes of the WP thematic report on barrier integrity as input to D6.8 (in common with HITEC WP)	WP6, WP7	32 - ONDRAF/NIRAS	48	GAS Chapter on pathway closure and sealing processes of the WP thematic report on barrier integrity as input to D6.8 (in common with HITEC WP)
MS221	GAS WP Meeting 9	WP6	32 - ONDRAF/NIRAS	49	GAS WP Meeting 9
MS222	EURAD General Assembly n°9 + EURAD Annual Meeting 4	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	1 - ANDRA	49	EURAD General Assembly n°9 + EURAD Annual Meeting 4
MS223	ICS Workshop 4	WP1, WP10, WP9	19 - IRSN	49	ICS Workshop 4
MS224	EURAD Periodic Report 4	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	1 - ANDRA	50	EURAD Periodic Report 4
MS225	GAS Update of the State-of-the-art chapter on diffusion and gas sorption in clayey materials as an input to D6.2	WP6	32 - ONDRAF/NIRAS	52	GAS Update of the State-of-the-art chapter on diffusion and gas sorption in clayey materials as an input to D6.2
MS226	GAS Update of the State-of-the-art chapter on advective gas transport in clayey materials as an input to D6.2	WP6	32 - ONDRAF/NIRAS	52	GAS Update of the State-of-the-art chapter on advective gas transport in clayey materials as an input to D6.2

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
MS227	GAS Chapter on diffusion and retention processes of the WP thematic report on gas transport mechanisms as input to D6.7	WP6	32 - ONDRAF/NIRAS	54	GAS Chapter on diffusion and retention processes of the WP thematic report on gas transport mechanisms as input to D6.7
MS228	GAS Chapter on advective gas transport of the WP thematic report on gas transport mechanisms as input to D6.7	WP6	32 - ONDRAF/NIRAS	54	GAS Chapter on advective gas transport of the WP thematic report on gas transport mechanisms as input to D6.7
MS229	GAS Chapter on gas induced impact of the WP thematic report on barrier integrity as input to D6.8	WP6	32 - ONDRAF/NIRAS	54	GAS Chapter on gas induced impact of the WP thematic report on barrier integrity as input to D6.8
MS230	GAS Chapter on model-based interpretation and synthesis of results of the WP thematic report on barrier integrity as input to D6.8	WP6	32 - ONDRAF/NIRAS	54	GAS Chapter on model-based interpretation and synthesis of results of the WP thematic report on barrier integrity as input to D6.8
MS231	GAS Update of the State-of-the-art chapter on model-based interpretation including a survey of previous research programmes and a screening of gas-related FEP lists as an input to D6.2	WP6	32 - ONDRAF/NIRAS	54	GAS Update of the State-of-the-art chapter on model-based interpretation including a survey of previous research programmes and a screening of gas-related FEP lists as an input to D6.2
MS232	GAS Chapter of the WP thematic report on conceptualisation and evaluation at repository scale	WP6	32 - ONDRAF/NIRAS	54	GAS Chapter of the WP thematic report on conceptualisation and evaluation at repository scale presenting the gas storyboards and the testing of various approaches for the evaluation of gas impact at repository scale in a performance assessment context (as an input to D6.9)
MS233	GAS Update of the State-of-the-art chapter drawing an overview on the conceptualizations of gas migration through geological disposal	WP6	32 - ONDRAF/NIRAS	54	GAS Update of the State-of-the-art chapter drawing an overview on the conceptualizations of gas migration through geological disposal systems and related processes, at the scale of a

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
	systems and related processes, at the scale of a repository				repository and how these can be translated into models as an input to D6.2
MS234	EURAD General Assembly n°10	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	1 - ANDRA	55	EURAD General Assembly n°10
MS235	ICS Workshop 5	WP1, WP10, WP9	19 - IRSN	55	ICS Workshop 5
MS236	GAS WP Meeting 10	WP6	32 - ONDRAF/NIRAS	56	GAS WP Meeting 10
MS237	GAS Workshop on “Mechanistic understanding of gas transport in clay-based materials”	WP6	32 - ONDRAF/NIRAS	56	GAS Workshop on “Mechanistic understanding of gas transport in clay-based materials”
MS238	GAS Chapter of the WP thematic report 4 on conceptualisation and evaluation at repository scale comparing modelling and evaluation approaches (as an input to D6.9)	WP6	32 - ONDRAF/NIRAS	57	GAS Chapter of the WP thematic report 4 on conceptualisation and evaluation at repository scale comparing modelling and evaluation approaches (as an input to D6.9)
MS239	ROUTES WPM6	WP9	19 - IRSN	60	ROUTES WPM6
MS240	EURAD General Assembly n°11 + EURAD Annual Meeting 5	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	1 - ANDRA	60	EURAD General Assembly n°11 + EURAD Annual Meeting 5
MS241	EURAD Periodic Report 5	WP1, WP10,	1 - ANDRA	60	EURAD Periodic Report 5 (Due date: 60+2)

Milestone number¹⁸	Milestone title	WP number⁹	Lead beneficiary	Due Date (in months)¹⁷	Means of verification
		WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9			

1.3.5. WT5 Critical Implementation risks and mitigation actions

Risk number	Description of risk	WP Number	Proposed risk-mitigation measures
1	Risk: Poor communication, non-adherence to PMO good practice, or lack of quality control results in a negative impact to EURAD progress and timely implementation of safe radioactive waste management Risk consequence: Lack of confidence or loss of credibility in EURAD	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	Risk actioner: PMO Mitigation measure: PMO includes clear ToR, range of competence with individuals experienced in scientific coordination, who hold a good overview of RWM, and who represent and understand the views of different Actor perspectives
2	Risk: Lack of understanding of contractual agreements, liabilities, or roles and responsibilities between the EC, Mandated Organisations (Beneficiaries) or Linked 3rd parties results in dispute or negative impact to EURAD Risk consequence: Lack of confidence or loss of credibility in EURAD	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	Risk actioner: PMO Mitigation measure: Clear consortium agreement, ToR (and governance scheme) and financial reporting procedures (in accordance with good practice for procurement and financial project management)
3	Risk: Delay in getting information/data/ contributions from team (internal contributions) or inputs from Actors, interested stakeholders or expert reviewers (external contributions). Lack of support from Task contributors due to illness/holidays/competing requirements. Lack of communication and progress updates. Risk consequence: Delay to work or inefficient working	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	Risk actioner: WP Leaders Mitigation measure: Clear ToR and follow good practice with respect to project management and progress reporting
4	Risk: Delay in getting information/data/ contributions from team (internal contributions) or inputs from Actors, interested stakeholders or expert reviewers (external contributions). Lack of support from Task contributors due to illness/holidays/competing requirements. Lack of communication and progress updates. Risk consequence:	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	Risk actioner: Task Leaders Mitigation measure: Clear ToR and follow good practice with respect to project management and progress reporting

Risk number	Description of risk	WP Number	Proposed risk-mitigation measures
	Delay to work or inefficient working		
5	Risk: Mis-use of EURAD IP (data, systems, tools, documents, knowledge). Risk consequence: Potential loss of public confidence	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	Risk actioner: All Mitigation measure: Adherence to quality management system procedures, adopt good practice with respect to data management, quality and version control and apply industry standard security measures (for example, security marking documents appropriately if commercial in confidence and/or draft)
6	Risk: Lack of support from personnel due to illness/holiday/competing requirements Risk consequence: Delays in programme schedule	WP1, WP10, WP11, WP12, WP13, WP2, WP3, WP4, WP5, WP6, WP7, WP8, WP9	Risk actioner: All Mitigation measure: Regular dialogue across EURAD teams, including PMO, Bureau, and other boards. Management teams will promote a culture of open and transparent working and provide opportunities to obtain constructive feedback to continuously improve EURAD based on experience and community feedback.

1.3.6. WT6 Summary of project effort in person-months

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	WP10	WP11	WP12	WP13	WP14	Total Person/ Months per Participant
1 - ANDRA	100	11.80	10.40	2.50	2	15	13.70	0	5.40	7.90	3	0	5.25		176.95
· BRGM	0	19.60	13.40	34.50	30.50	0	16.70	0	0	0	0	0	0	0	114.70
2 - ARAO	0	0	0	0	0	0	0	0	1.20	0	0	0	0		1.20
3 - BEL V	0	4	0	0	0	0	0	0	0.30	11	0	0	0		15.30
4 - BGE	0	0	0	0	0	3.58	13.70	0	0	5.80	25	0	0		48.08
5 - CEA	0	56	35.40	0	23	0	15	10.90	0	0	0	0	0		140.30
· EDF	0	6.50	0	9.50	0	9.50	10.50	0	0	0	0	0	0	0	36
· Orano	0	0	0	0	0	0	0	0	6.30	0	0	0	0	0	6.30
6 - CIEMAT	0	19.50	44.40	0	53	26	37	160.27	6.60	3.50	0.75	0	6.25		357.27
· UPC	0	0	0	0	0	19	48.50	0	0	0	0	0	0	0	67.50
· CSIC	0	0	30	0	0	0	0	0	0	0	0	0	0	0	30
· IDOM	0	0	0	0	0	0	0	14.21	0	0	0	0	0	0	14.21
· UPM	0	0	0	0	0	0	0	48	0	0	0	0	0	0	48
· UAM	0	31	0	0	0	0	6	0	0	0	0	0	0	0	37
7 - ChRDI	0	0	0	0	0	0	0	4.50	0	0	0	0	0		4.50
· KIPT	0	0	0	0	0	0	48	0	0	0	0	0	0	0	48
· SHIGNASU	0	0	0	0	0	0	21	0	0	0	0	0	0	0	21
8 - CNRS	7.50	14	44	39	86	15.30	50	71.10	0	0	0	0	0		326.90
· ULorraine	0	6	0	0	0	50.70	33	0	0	0	0	0	0	0	89.70
· UOrléans	0	0	16	0	0	0	0	0	0	0	0	0	0	0	16
· UNice	0	0	0	6	0	0	0	0	0	0	0	0	0	0	6
· UGrenoble	0	0	0	0	31	39.70	0	0	0	0	0	0	0	0	70.70
· ULille	0	0	0	31	0	0	0	0	0	0	0	0	0	0	31

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	WP10	WP11	WP12	WP13	WP14	Total Person/ Months per Participant
· UMontpellier	0	0	0	0	0	0	0	8	0	0	0	0	0	0	8
· UPoitiers	0	0	0	0	7	35.20	0	0	0	0	0	0	0	0	42.20
· IMT Atlantique	0	12	0	0	0	0	0	0	0	3.50	0	0	0	0	15.50
9 - COVRA	0	10.50	0	0.60	0	2.75	0	0	4	1.50	0	0	0		19.35
· TU Delft	0	0	0	0	0	17.50	0	0	0	0	0	0	0	0	17.50
10 - FTMC	0	0	20	0	0	0	0	3.83	3.10	2	0	0	0		28.93
11 - CV REZ	0	0	12	0	0	0	0	0	0	0	0	0	0		12
12 - Dekom	0	0	0	0	0	0	0	0	2	0	0	0	0		2
13 - EEAE	0	0	0	0	0	0	0	0	3.10	0	0	0	0		3.10
14 - ENRESA	0	1	0	4.80	0	0	2.10	2.39	0	2.50	0	0	0		12.79
15 - JUELICH	0	10.80	19	17	31	0	0	0	6	0	0	0	0		83.80
· HZDR	0	0	8	14.50	48	0	0	36	0	3.30	24	0	0	0	133.80
· UFZ	0	10	0	27.50	0	12	0	0	0	0	0	0	0	0	49.50
16 - GRS	0	0	0	18.70	10.40	11	0	0	2	4.30	0	0	0		46.40
17 - IAE	0	0	0	0	0	0	0	0	1.10	0	0	0	0		1.10
18 - INCT	0	0	0	0	0	0	0	0	5.60	0	0	0	0		5.60
19 - IRSN	3	26	0	24	0	40	0	0	9.10	5.50	0	0	0		107.60
· MINES ParisTech	0	22	0	0	0	0	0	0	0	0	0	0	0	0	22
· MUTADIS	4.10	0	0	0	0	0	0	0	0	10.80	0	0	0	0	14.90
· NTW	10.70	0	0	0	0	0	0	0	4.90	2.90	0	0	0	0	18.50
20 - IST	0	0	0	0	0	0	0	0	4.40	0	0	0	0		4.40
21 - IST ID	0	0	0	0	0	0	0	0	4.40	0	0	0	0		4.40
22 - JSI	0	0	26.40	0	0	0	0	10.80	1.50	1.50	0	0	0		40.20
· ZAG	0	38	0	0	0	0	0	0	0	0	0	0	0	0	38
· EIMV	2.20	0	0	0	0	0	0	0	6.90	5.30	0	10	5	0	29.40

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	WP10	WP11	WP12	WP13	WP14	Total Person/ Months per Participant
23 - JRC	15	0	0	0	0	0	0	63.48	0	0	0	3.50	5.75		87.73
24 - KIT	0	0	47.90	0	47	0	0	19.34	0	2.50	0	0	0		116.74
· AMPHOS 21	0	0	21.40	0	0	0	0	0	0	0	0	0	0	0	21.40
· PEL	0	0	0	0	0	0	0	2.10	0	0	0	0	0	0	2.10
· Uni Mainz	0	0	24	0	25	0	0	0	0	0	0	0	0	0	49
· BAM	0	0	0	0	0	0	0	30	0	0	0	0	0	0	30
· Uni Potsdam	0	0	12	0	0	0	0	0	0	0	0	0	0	0	12
· Uni Clausthal	0	0	0	0	0	0	0	0	0	5.50	0	0	0	0	5.50
· BGR	0	0	0	0	0	13	9	0	0	0	0	0	0	0	22
25 - LEI	0	11	0	5	0	6.50	10	7	1.90	3.50	0	0	0		44.90
26 - MTA EK	0	11	0	0	21	0	0	22	0	0	0	0	0		54
· SORC	0	0	0	12	0	0	0	0	0	0	0	0	0	0	12
27 - NAGRA	0	0	0	0	0	9	3.40	8.84	0	3.50	0	0	0		24.74
· ZHAW	0	0	0	0	0	12	0	0	0	0	0	0	0	0	12
· UBERN	0	54	0	0	0	0	0	0	0	0	0	0	0	0	54
· EPFL	0	0	0	0	0	32	0	0	0	0	0	0	0	0	32
· CIMNE	0	0	0	0	0	34	0	0	0	0	0	0	0	0	34
28 - NCSR	0	0	0	0	0	0	0	0	4.90	0	0	0	0		4.90
· DMT	0	0	0	0	0	0	0	0	7.60	0	0	0	0	0	7.60
29 - NES	0	0	0	0	0	0	0	0	4.90	0	0	0	0		4.90
30 - NJF	0	0	0	0	0	0	0	0	1.50	0	0	0	0		1.50
31 - NRG	0	20	0	5	0	0	0	0	0.30	3.80	0	0	0		29.10
32 - ONDRAF/ NIRAS	0	0	0	0	0	6.50	0	0	5.50	2.30	0	0	0		14.30
· EURIDICE	0	0	0	0	0	0	4.90	0	0	0	0	0	0	0	4.90

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	WP10	WP11	WP12	WP13	WP14	Total Person/ Months per Participant
· ULiège	0	0	0	0	0	45.80	40.50	0	0	0	0	0	0	0	86.30
33 - POSIVA	0	0	0	0	0	0	2.50	0	0	0	0	0	0		2.50
· Envirocase	0	0	0	0	0	0	0	0	0	3	0	0	0	0	3
34 - PSI	0	18	13	18	81.95	24	0	30.10	0	1.50	0	0	0		186.55
· EMPA	0	0	11	0	0	0	0	0	0	0	0	0	0	0	11
35 - PURAM	0	0	0	0	0	0	0	0	0	0	0	13.30	0		13.30
36 - RATEN	0	0	17	0	22	0	0	0	3	7.30	0	0	0		49.30
37 - RWM	7.50	0	0	0	0	3.50	10.90	0	0	3	0	0	0		24.90
38 - SCK•CEN	0	33.50	18.30	26	12.25	31.40	0	15.54	1.30	4	0	0	15		157.29
39 - SKB	0	0	0	0	0	0	9	0	1.70	0	0	0	0		10.70
· UU	0	0	0	0	0	0	0	54.72	0	0	0	0	0	0	54.72
40 - SSTC NRS	0	0	0	0	0	0	0	3.12	9.40	4.80	22	10	5.75		55.07
41 - STUBA	0	0	0	0	0	0	0	0	3.20	1.50	0	0	0		4.70
42 - SÚRAO	0	1.50	4.60	6.50	1	4.50	11	0	1.90	3.50	0	17.50	0		52
· CU	0	0	0	19	0	0	45	0	0	0	0	0	0	0	64
· CTU	0	0	40	35	0	36	54	0.44	0	0	0	0	5.75	0	171.19
· ÚJV	0	41.50	42	10	31	12.50	10	0	0	0	0	0	0	0	147
· TUL	0	0	0	45	0	0	0	0	0	0	0	0	0	0	45
· IGN	0	0	0	64	0	0	0	0	0	0	0	0	0	0	64
43 - SURO	0	0	0	0	0	0	0	0	6.70	3	0	10	10		29.70
44 - TNO	0	0	0	0	14	0	0	0	0	0	0	0	0		14
45 - TS Enercon	0	0	0	20	0	0	0	0	0.30	1.20	0	0	0		21.50
46 - TUS	0	0	0	4	0	0	0	16.97	4.90	4.80	0	0	0		30.67
47 - UCyprus	0	0	4	0	0	0	0	0	0.90	0	0	0	0		4.90
48 - UHelsinki	0	0	0	0	18	0	28	0	0	0	0	0	0		46

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	WP10	WP11	WP12	WP13	WP14	Total Person/ Months per Participant
· JYU	0	0	0	0	0	0	28	0	0	0	0	0	0	0	28
· TUT	0	0	0	20	0	0	0	0	0	0	0	0	0	0	20
· Aalto	0	0	0	0	0	6	0	0	0	0	0	0	0	0	6
· GTK	0	0	0	0	0	0	6	0	0	0	0	0	0	0	6
49 - UKRI	0	0	0	0	0	107.77	84.80	0	0	0	0	0	0		192.57
50 - VTT	0	27	0	0	0	0	28.50	10	0	1.50	0	0	0		67
· GSL	0	0	0	0	0	0	0	0	7.50	2.50	0	0	0	0	10
51 - VUJE	0	0	0	0	0	0	0	0	2	0	0	0	0		2
Total Person/Months	150	516.20	534.20	519.10	595.10	681.70	700.70	653.65	147.30	134	74.75	64.30	58.75		4829.75

1.3.7. WT7 Tentative schedule of project reviews

No project reviews indicated

1. Project number

The project number has been assigned by the Commission as the unique identifier for your project. It cannot be changed. The project number **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

2. Project acronym

Use the project acronym as given in the submitted proposal. It can generally not be changed. The same acronym **should appear on each page of the grant agreement preparation documents (part A and part B)** to prevent errors during its handling.

3. Project title

Use the title (preferably no longer than 200 characters) as indicated in the submitted proposal. Minor corrections are possible if agreed during the preparation of the grant agreement.

4. Starting date

Unless a specific (fixed) starting date is duly justified and agreed upon during the preparation of the Grant Agreement, the project will start on the first day of the month following the entry into force of the Grant Agreement (NB : entry into force = signature by the Commission). Please note that if a fixed starting date is used, you will be required to provide a written justification.

5. Duration

Insert the duration of the project in full months.

6. Call (part) identifier

The Call (part) identifier is the reference number given in the call or part of the call you were addressing, as indicated in the publication of the call in the Official Journal of the European Union. You have to use the identifier given by the Commission in the letter inviting to prepare the grant agreement.

7. Abstract

8. Project Entry Month

The month at which the participant joined the consortium, month 1 marking the start date of the project, and all other start dates being relative to this start date.

9. Work Package number

Work package number: WP1, WP2, WP3, ..., WPn

10. Lead beneficiary

This must be one of the beneficiaries in the grant (not a third party) - Number of the beneficiary leading the work in this work package

11. Person-months per work package

The total number of person-months allocated to each work package.

12. Start month

Relative start date for the work in the specific work packages, month 1 marking the start date of the project, and all other start dates being relative to this start date.

13. End month

Relative end date, month 1 marking the start date of the project, and all end dates being relative to this start date.

14. Deliverable number

Deliverable numbers: D1 - Dn

15. Type

Please indicate the type of the deliverable using one of the following codes:

R	Document, report
DEM	Demonstrator, pilot, prototype
DEC	Websites, patent filings, videos, etc.
OTHER	
ETHICS	Ethics requirement
ORDP	Open Research Data Pilot
DATA	data sets, microdata, etc.

16. Dissemination level

Please indicate the dissemination level using one of the following codes:

- PU Public
- CO Confidential, only for members of the consortium (including the Commission Services)
- EU-RES Classified Information: RESTREINT UE (Commission Decision 2005/444/EC)
- EU-CON Classified Information: CONFIDENTIEL UE (Commission Decision 2005/444/EC)
- EU-SEC Classified Information: SECRET UE (Commission Decision 2005/444/EC)

17. Delivery date for Deliverable

Month in which the deliverables will be available, month 1 marking the start date of the project, and all delivery dates being relative to this start date.

18. Milestone number

Milestone number: MS1, MS2, ..., MSn

19. Review number

Review number: RV1, RV2, ..., RVn

20. Installation Number

Number progressively the installations of a same infrastructure. An installation is a part of an infrastructure that could be used independently from the rest.

21. Installation country

Code of the country where the installation is located or IO if the access provider (the beneficiary or linked third party) is an international organization, an ERIC or a similar legal entity.

22. Type of access

- VA if virtual access,
- TA-uc if trans-national access with access costs declared on the basis of unit cost,
- TA-ac if trans-national access with access costs declared as actual costs, and
- TA-cb if trans-national access with access costs declared as a combination of actual costs and costs on the basis of unit cost.

23. Access costs

Cost of the access provided under the project. For virtual access fill only the second column. For trans-national access fill one of the two columns or both according to the way access costs are declared. Trans-national access costs on the basis of unit cost will result from the unit cost by the quantity of access to be provided.

Table of history of changes from proposal

Part A

Description of the change	Impacted	Date
WP1, the work plan has been revised to enhance <i>PMO task 2 - Overall scientific and technical coordination/integration/evaluation of impacts</i> with extended information about the evaluation of impacts (additional deliverable) Key Performance Indicators and Risk Register.	WP1	26/04/2019
WP1, WP7, WP8 the work plan has been revised to remove interaction with Civil Society description has been revised in order to address evaluators' recommendations.	WP1, WP7 and WP8	08/03/2019
WP11 the work plan has been revised according to recommendation n°17	WP11	08/03/2019
WP13, the work plan has been revised to alleviate restrictions to end-users	WP13	08/03/2019
List of deliverables and milestones updated accordingly to modifications of the plan		08/03/2019

Part B

Page	Description of the change	Date
pp. 5-6	Section 1.2 has been revised with extended information about Key Performance Indicators and Risk Register.	26/04/2019
p.15	Section 1.4.4 has been revised to indicate that strong synergies with IAEA and any other international organisations shall be established for joint development and implementation of actions related to Knowledge Management and Strategic Studies with subsequent Memorandum of Understanding.	26/04/2019
p.6, 15, 41 and 42	Section 1.1.4, section 1.4.4 and section 3.2 have been revised in order to clarify the definition and role of the CS group and the CS experts and the procedures and criteria for selection of representatives from the CSOs should be defined.	03/05/2019
p.22	Section 3 (introduction), it is now specified that specific attention/emphasis on Strategic Studies shall be paid for the second wave.	26/04/2019
p.42	Section 3.2 has been revised to reinforce the strong scientific/technical leader with recognized high level contribution in the field of radioactive waste management.	26/04/2019
p.47	Section 3.4.2 – it has been clarified that the distribution of EC contribution between the different types of activities shall not be capped. It can be subject to modification after approval by the General Assembly	26/04/2019
p.3	Section 1, reference to EURAD Sciences network added p.3	08/03/2019
p.12	Section 1.4.3 has been revised to clarify that the IAEA phases plus the added phase 0 used in the Roadmap are of a general nature and are each applicable to several waste streams and waste types.	08/03/2019

pp.13-14	Section 1.4.4 has been revised: - To mention that SOTA reports will be completed in-line with international good practice (incl. communication of the existing knowledge gaps in the context of safety). This will be done in a general or generic way, without direct reference to specific safety assessments, safety cases or national programmes. - To remove reference to KM platform (recommendation 17) - To revise Interaction with Civil Society in RD&D WPs	08/03/2019
p.18	Section 2.2.1: reference to KM platform removed (recommendation 17)	08/03/2019
pp.22-28	Section 3: has been complemented with statements that explain in a concise manner ‘what’ and ‘why’ paragraphs for each of the RD&D and SS WPs and to explicitly demonstrate the link with EURAD Roadmap/SRA. It has also been revised to take into account the modification in the interactions with CS.	08/03/2019
p.28	Sections 3.1.d has been revised to address recommendation n°20	08/03/2019
p.39	Section 3.3 has been revised to indicate that regulators’ representatives (through WENRA, ENSREG) will be invited to join the EAB, to address recommendation	08/03/2019

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1. Excellence

Following decades of research, development and demonstration (RD&D) in support of the safe management and disposal of radioactive waste, and building on the preparatory work of the recent EC JOPRAD project, a European Joint Programme on Radioactive Waste Management (EURAD) is now proposed to coordinate activities on agreed priorities of common interest between European Waste Management Organisations (WMOs), Technical Support Organisations (TSOs) and Research Entities (REs).

Such Joint Programming will complement National RD&D Programmes, by jointly establishing and carrying out activities jointly where there is added value at the European level. It is the logical next step in deepening collaboration between European actors in the field of radioactive waste management (RWM). It builds on existing and emerging networks of European actors (IGD-TP, SITEX and EuradSciences), preceding coordination and support actions (in particular, SecIGD2, SITEX-II project and JOPRAD).

The vision of the European Joint Programme on Radioactive Waste Management (EURAD) is to achieve:

“A step change in European collaboration towards safe radioactive waste management (RWM), including disposal, through the development of a robust and sustained science, technology and knowledge management programme that supports timely implementation of RWM activities and serves to foster mutual understanding and trust between Joint Programme participants”.

By step-change we mean the next step in deepening of research-cooperation between Member-States with long lasting impacts, and with a significantly more effective and efficient public RD&D funding in Europe.

We will implement a Joint Programme of strategic research and knowledge management activities at the European level, bringing together and complementing national EU Member State programmes of various magnitudes and at various states of advancement in order to ensure cutting edge knowledge creation and preservation in view of delivering safe, sustainable and socially acceptable solutions for the management of radioactive waste across Europe now and in the future.

1.1. Objectives

The Joint Programme will generate and manage knowledge to support EU Member-States with their implementation of the Directive 2011/70/Euratom ([Waste Directive](#)), taking into account the different magnitudes and stages of advancement of member state National Programmes. This will encompass:

- Supporting Member-States in developing and implementing their national RD&D programmes for the safe long-term management of their full range of different types of radioactive waste through participation in the RWM Joint Programme; in particular:
- Consolidating existing knowledge for the safe start of operation of the first geological disposal facilities for spent fuel, high-level waste, and other long-lived radioactive waste, and supporting optimization linked with the stepwise implementation of geological disposal; and
- Enhancing knowledge management and transfer between organisations, Member-States and generations.

From this, these high-level objectives, the Joint Programme has established the following specific objectives:

- a) Develop, maintain and consolidate the scientific and technical basis of safe radioactive waste management;
- b) Address important and complex issues and enable expert networking;
- c) Enhance knowledge management and transfer between organisations, Member-States and generations; and
- d) Engage with Civil Society.

These are each described further below.

1.1.1. Develop, maintain and consolidate the scientific and technical basis of radioactive waste management

The research, development and demonstration (RD&D) carried out in support of safe radioactive waste management (RWM), including disposal, is considered a key component of each National Programme. Given the long timescales and socio-political dimension, RD&D provides primarily the scientific basis for implementing safe RWM solutions, whilst also contributing to building stakeholder trust, public acceptance, and training for next generations of experts.

EURAD consists of collaboratively developing, maintaining and consolidating at the European level the scientific and technical basis of RWM, including disposal.

The scope of EURAD includes scientific and technical activities on RWM from cradle to grave:

- Radioactive waste characterisation and processing (incl. treatment, conditioning and packaging);
- Interim storage of radioactive waste; and
- Disposal solutions – Mainly geological disposal of spent fuel, high-level waste (HLW) and long-lived intermediate level waste (ILW).

Specific RD&D required for near-surface or surface disposal and low-level waste (LLW), will be addressed, and is encompassed within the RD&D needs identified for waste characterisation and processing, interim storage and geological disposal of radioactive waste. Nuclear facility dismantling and decommissioning activities are however excluded, although interfaces, and particularly aspects that impacts final disposal will be considered.

EURAD scope is organised at a strategic level by 7 scientific themes. Each theme is further split into a list of topics and sub-topics (mostly collaborative RD&D, and relevant strategic studies or knowledge management activities), that in-part, or in-full, contribute to the overall European effort to address remaining challenges of RWM, including disposal.

The Joint Programme implements in a collaborative way those aspects of RD&D activities required within national research RWM programmes as well as associated activities where synergy at European level has been identified. The prioritised scope identified is described more fully in the Strategic Research Agenda and will support achievement of the EURAD Vision.

1.1.2. Address important and complex issues and enable expert networking

Complementary to RD&D and in support to the implementation of the Member-States' National Programmes, the Joint Programme shall give the opportunity to participants and expert contributors to network on methodological and strategic issues and challenges that are common to various National Programmes and in direct links with scientific and technical issues:

- Share knowledge and discuss common methodological and strategical challenging issues (strategic studies) that are in close link with scientific, technical and societal aspects on RWM and that are common to various National Programmes;
- Identify the contribution of past and on-going RD&D projects to the resolution of these issues;
- Identify any emerging topics for collaboration that could be addressed within the Joint Programme;
- Take into account emerging science and technology as well as research priorities originating from other programmes (for example results from Horizon 2020 projects or IAEA outputs).

1.1.3. Enhance knowledge management and transfer between organisations, Member-States and generations

It is essential to implement an efficient and integrated Knowledge Management programme at EU level in order to establish, capitalize and transfer the state of scientific and technical knowledge in the field of RWM. Objectives are to:

- Preservation/capitalisation of generated knowledge - Make sure that the publicly financed knowledge generated over the past, ongoing and future RD&D activities is preserved and made accessible.
- Transfer of knowledge towards Member-States with early-stage RWM programmes - Make sure that Member-States with National Programmes at an early-stage of implementation can take advantage of existing knowledge and know-how from the Member-States with advanced National Programmes, primarily to access state of the art, and second to ease access to knowledge developed during previous EC supported RD&D projects.
- Transfer of knowledge between generations - Ensure that the necessary expertise and skills are maintained through generations of experts in view of the long lead-times and operational time-spans (several decades) for RWM, including disposal, by providing training and mobility for researchers.
- Dissemination of knowledge – Disseminate and demonstrate progress, results and added-value of the European Joint Programme to a wider audience.

1.1.4. Engage with Civil Society

The successful implementation of RWM National Programmes relies on both scientific and technical aspects for a sound safety strategy and scientific and engineering excellence and societal (social, legal, ethical, political) aspects.

Civil Society Organisations (CSOs) are not research organisations but have a specific concern on RWM safety and are involved in the perspective of the implementation of the UNECE Aarhus Convention which reinforces the requirements of access to information, public participation in decision-making and access to justice in environmental matters. European programmes therefore undertake work to address these requirements through local and national stakeholder engagement activities to enable Civil Society (representative organisations, e.g. Non-Government Organizations, Local Community Partnerships, etc.) to participate in defining their national RD&D programmes and the evaluation of RD&D results in the perspective of safety.

Interacting with Civil Society is important in this perspective and therefore one objective of the Joint Programme is to allow interactions between WMOs, TSOs, Res and Civil Society Organisations. These interactions will facilitate the translation of scientific/technical results and create the conditions for Civil Society Organisations to express their expectations or views. Such interactions shall improve the mutual understanding on the RD&D needed to develop safe acceptable solutions in the processing and disposal of radioactive waste. It shall also contribute to developing ideas, propositions and methodologies on how to interact with Civil Society on scientific and technical results, how to deal with uncertainties (inherently linked to the long timeframes and numerous processes considered for geological disposal), and on how to interact with Civil Society stakeholders in order to promote mutual benefit of the available knowledge, based on cooperation and sharing.

1.2. Evaluation of objectives

Section 6.2 of the Founding Documents describes the processes planned for Evaluation.

At the WP level - To assess EURAD outputs, early affects and long-term impacts, monitoring and evaluation criteria will be constructed that will serve as the basis for the development of a set of key performance indicators (KPI). Such KPIs shall help measuring outcomes and impacts towards the phases of the Roadmap and in terms which can also be assessed by decision makers (EC, Programme Owners). These KPIs are built

in close consultation and collaboration with the Joint Programme participants and will align with objectives within the scientific Themes, and prioritized RD&D, strategic studies and knowledge management activities presented in the Strategic Research Agenda. This will be managed by the PMO, together with each work package. The set of KPI will be included in the Quality Management Plan (Deliverable 1.1).

At the Programme level – By mandating organisations to participate, Member-States demonstrate that EURAD has an EU-added value beyond their National Programme. As the Joint Programme is not working in direct support for implementation of RWM operations or geological disposal, it is the responsibility of the National Programmes to evaluate outputs and results with respect to their own needs (towards implementation). As part of this, towards the end of EURAD-1, the PMO shall prepare a tool (e.g. questionnaire aligned to the Waste Directive) for getting the views from national programme owners on EURAD impacts during phase 1.

Assessment of quality and scientific excellence can however be shared, and will represent a primary criterion for the evaluation of EURAD results and achievements, and assumes over-riding importance in the first 5-year implementation plan.

The scope of criteria for evaluating the overall Joint Programme (and the individual Work Packages) will include:

- The Joint Programme/Work Package must articulate the overall research vision. To enhance the potential of achieving it, a world-class team of complementary expertise shall have been brought together.
- The Joint Programme/Work Package shall be ambitious, creative, innovative, and address key research challenges. It shall also be sustainable beyond the lifetime of the programme itself.
- A strong scientific case for support must be demonstrated by the Joint Programme/Work Package with the proposed research set into the context of the current state of knowledge and other work under way in the field.
- The outputs of the Joint Programme/Work Package shall result in a major impact on the research area beyond the immediate project, resulting in an appreciable raise in the international profile of European radioactive waste RD&D.
- The Joint Programme/Work Package shall clearly demonstrate the methods intended to be used to attain the stated objectives and describe clearly how appropriate they are for the planned activity and their scientific or technical feasibility. Where there is not a detailed methodological plan for the whole period of the implementation plan, the proponents shall explain how the research objectives for the latter years will be identified.
- The Joint Programme/Work Package shall identify the most significant challenges to achieving the stated objectives and explain how these will be addressed.
- The Joint Programme/Work Package must show clearly how meaningful, independent peer review will be integrated on a timely basis within the overall implementation plan.

In addition, the PMO will actively maintain and monitor a Risk Register to document those risks identified within each Work Package that may impact the overall performance of the EJP. With respect to the WPs that require significant coordination and strategic oversight to ensure consistency and continued support by each College), it is anticipated that a key risk will be raised that relates to meeting the needs of safety assessment end-users with a focus on generic methodologies (exact wording to be agreed). This risk will be managed through identified mitigation measures to be developed and continuously monitored together with the WP Leader, Key WP Contributors from each College, and the PMO.

1.3. Relation to the work programme

EURAD falls into EURATOM WP2018 – Topic NFRP-2018-6, that calls for the establishment of a European Joint Research Programme in the field of radioactive waste management in order to complement the national efforts in view of delivering safe, sustainable and publicly acceptable solutions for the management of radioactive waste across Europe now and in the future.

By fostering and strengthening RD&D collaboration and by making existing knowledge easily available to end users, EURAD shall enable cutting-edge knowledge creation and preservation and effective use of resources and shall help the RWM community facing the following challenges over the coming years:

- The implementation of the first geological disposal facilities by the more advanced programmes;
- The harmonisation of practices fostered by European initiatives such as [WENRA](#), EC [Waste Directive](#), EC [Nuclear Safety Directive](#), and [Aarhus Convention](#), etc.;
- The development and update of early stage programmes to start a disposal siting and licensing process, taking benefit of the experience gained by advanced programmes;
- The establishment of the State-of-Knowledge and its transfer to end users;
- The availability of competencies, research infrastructures and programmes to accompany the implementation and contribute to optimizing the management, including the disposal, of radioactive waste; and
- The necessity of creating a multi-decennial research and knowledge management perspective, considering the more than 100 years process between siting, licensing, operation and closure of a typical geological disposal programme.

1.4. Concept and methodology

The proposed overall concept described in this section is based on the EURAD Founding Documents that deliver the common Vision, Strategic Research Agenda (including Knowledge Management), Roadmap, Deployment Plan and Governance Scheme that will guide cooperative research and investments in the field over the coming decades in Europe. See EURAD ‘Founding Documents’ that are attached as an Appendix to the Part B.

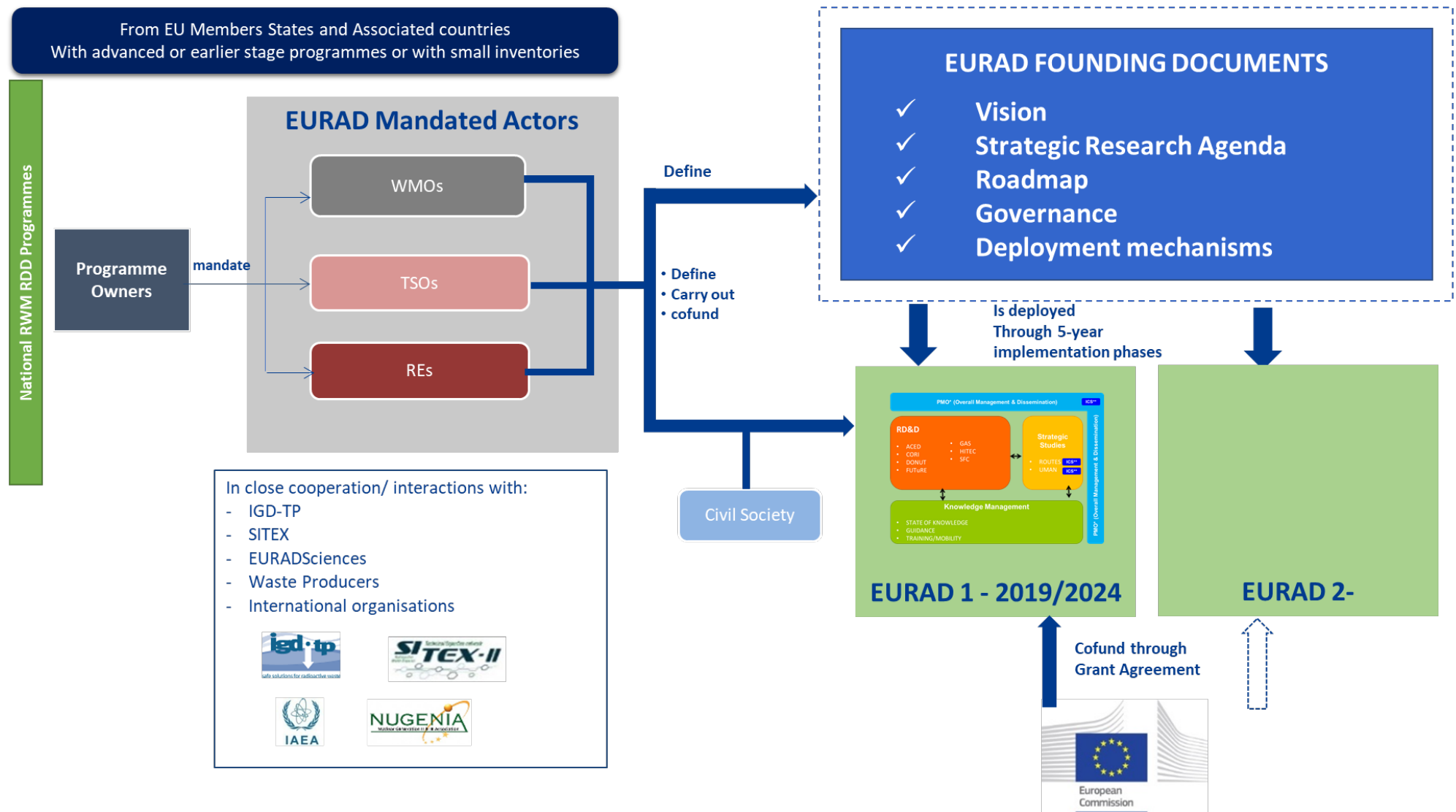


Figure 1– Overall scheme of the European Joint Programme on Radioactive Waste Management (EURAD)

1.4.1. Participants

EURAD participants are those organisations with scientific and technical responsibilities and a national mandate for RD&D and innovation programmes in the field of radioactive waste management that endorse EURAD Vision and that are willing to share the EURAD Founding Documents (Vision, Strategic Research Agenda, Roadmap, Deployment Plan and Governance - added as an Appendix to this Part B) and positively support its implementation.

After extensive consultation of the Member-States National Programmes and the research community, the EURATOM JOPRAD project identified three distinct categories of organisation with scientific and technical responsibilities and a national mandate for research in RWM:

- **Waste Management Organisations (WMOs)** whose mission covers the management and disposal of radioactive waste,
- **Technical Support Organisations (TSOs)** carrying out activities aimed at providing the technical and scientific basis for notably supporting the decisions made by a national regulatory body and
- **Research Entities (REs)** which are involved in RD&D in RWM under the responsibility of Member-States

Participants can call for Linked Third Parties to carry out part of the work plan. A Linked Third Party is an organisation to which a Participant has a pre-existing legal relationship (options are: Memorandum of Understanding, agreement, contract, affiliation, joint research unit...) which is not based on a contract for the purchase of goods works or services.

For full details on EURAD Consortium, see Section 3.6.

1.4.2. Strategic Research Agenda

EURAD Strategic Research Agenda (SRA) has been developed in a stage-wise manner, Step 1 - taking over entirely the scope developed within the Programme Document developed under EC JOPRAD Project [¹] and Step 2 – enhanced with a small number of additional needs identified by ongoing EC projects and approved for inclusion between the key contributors of the JP.

The SRA is set up as a dynamic and living document that shall be updated periodically in order to integrate outcomes of RD&D activities as well as any emerging collaboration needs identified by the RWM community during the implementation phases of the Joint Programme.

We anticipate that there will be regular ‘soft’ updates to make minor edits and additions. This will be consolidated and extended by periodic extensive updates to coincide with future Work Package developments (for example during identification and prioritisation of the scope of future EURAD implementation phase) where it is anticipated that significant changes may result to take account of learning from EURAD-Phase 1. Thereby, the SRA, Roadmap and Work Package scope and methodologies may align with experience feedback, particularly with respect to the JP governance scheme and how criteria are used to identify evolving needs of the Member-States, and how the WMOs, TSOs and REs contribute to this process.

¹ [JOPRAD - Towards a Joint Programming on Radioactive Waste Disposal](#): EC project that completed initial preparatory work for the potential setting up of Joint Programme on radioactive waste management and disposal. JOPRAD identified the scientific and technical basis of a future joint Programme in the [D4.4 Programme Document](#) together with considerations for a financing and governance scheme, published in the [D3.2 Conditions for Implementing a Joint Programme](#).

The SRA provides a description of scientific and technical activities and knowledge management needs of common interest between the Joint Programme participants. These activities are grouped into a number of scientific themes and based upon the scope established by the EC JOPRAD Project. The SRA Themes, are illustrated below in Figure 2. Although all technical in nature, Theme 1 is an overarching theme, Themes 2-5 are predominantly focussed on fundamental science, engineering, and technology, and Themes 6 and 7 include aspects more of an applied science and integration focus. Each Theme is also summarised below.

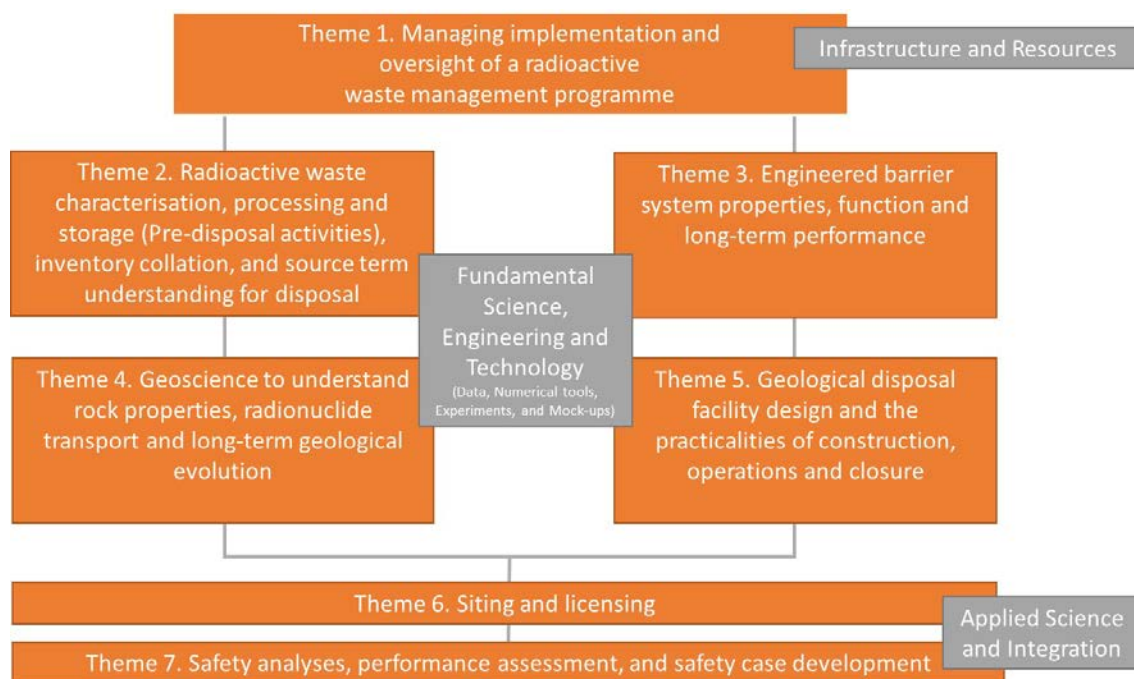


Figure 2 - The 7 Scientific Themes of the Joint Programme

Theme 1: Managing implementation and oversight of a radioactive waste management programme

Implementation of a national radioactive waste management programme, including geological disposal, requires a strong technical foundation of national policy to provide a legal framework, a long term vision, appropriate regulatory oversight, funding, organisational infrastructure and sound management systems and processes and frequent exchange among stakeholders. For programmes in the early phase of establishing national policy or developing a waste management programme, there is international entities support (IAEA, NEA) and EU-wide good practice and lessons learned that can be used to facilitate implementation of suitable organisational structures and strategic decision making.

Theme 2: Radioactive waste characterisation, processing and storage (Pre-disposal activities), and source term understanding for disposal.

This involves characterizing the various waste types (requiring activation calculations, evaluation of contamination carry-over, development of waste treatment and packing technology, etc.), evolution of waste matrix properties during extended interim storage times, developing waste acceptance criteria and developing model predictions about future waste. This also includes development of sufficient interim storage capacity. Source term and radionuclide release mechanisms need to be assessed for different waste forms/waste packages considering the interaction of the various interfaces with the disposal environment. In this broad area of work much information is already available or can be acquired through co-operation. Where remaining issues remain, they are often site and design specific.

Theme 3: Engineered barrier system properties, function and long-term performance.

Engineered barriers (overpack, buffer, backfill, seals, etc.) are in a broad sense comparable in many programmes and much basic information is already available today as there have been many European and international project to-date. Existing needs can be further developed through continued co-operation, which includes the provision of utilising available Underground Research Laboratories (URL) to conduct large-scale demonstration and verification testing. However, at a National Programme level some specific development work is often necessary to improve the understanding of the system of engineered barriers, optimise it or adapt it to the specific situation at hand. Remaining research issues concern in particular cementitious and to a lesser degree clay-based materials.

Theme 4: Geoscience to understand rock properties, radionuclide transport and long-term geological evolution.

Geoscience focussing on host rocks representative of the broad range of geologies to understand long-term geological evolution (and stability), and on the detailed understanding of the relevant properties and behaviour of different types of host rocks. This includes the transport properties of radionuclides and fluids, redox phenomena, coupled phenomena to address facility-induced disturbances, and the impact of gases). This also includes the demonstration and verification that the important coupled geomechanical, thermal, hydrological and chemical phenomena are sufficiently well understood to allow for long term assessment of void space closure, fluid movement and behaviour of the material interfaces, in some cases through full scale experiments in an URL. The broad area of geoscience will require significant activities that are specific to each country (especially regional geology but also the details of specific rocks), but with respect to the properties of rocks, much can be learned from other programmes working on similar rocks and may involve co-operative projects in URLs.

Theme 5: Facility design and the practicalities of construction, operations and closure.

Facility design (covering early conceptual design during early programme phases, right through to detailed design for construction, operation and closure). In the area of geomechanics and excavation, much can be learned from the tunnelling and mining industries and the corresponding science and technology developments. The current focus is on the demonstration of waste transport and engineered barrier emplacement techniques, and to perform demonstration tests under real 1:1 scale and active conditions. URLs and/or rock characterisation facility experiments, incl. monitoring activities often focus on demonstrating that technical aspects of facility construction and operation are suited for their purpose.

Theme 6: Siting and licensing.

The selection of a site (or sites) and licensing for a geological disposal facility is clearly the most important challenge to the successful implementation of long-term management of radioactive wastes. Site characterisation (exploration of geometrical aspects, rock layers, structures, and characterisation of key rock properties), acquiring site parameters through the use of geophysical techniques, hydraulic and geochemical measurements in boreholes and seismic investigations will contribute to the selection of the preferred site. As part of the full development of the selected site, underground testing will be required to allow detailed in-situ confirmation (and/or refinement) of some of the critical data on rock properties and state parameters before and during the construction of the repository. Site selection policies and procedures, regulatory arrangements and licensing requirements vary between Member-States, reflecting inter alia the socio-political context, geological factors, and the waste inventory. In this broad area of work a large part is of national focus and much can be learned from science and technology e.g. developed for hydro-carbon exploration, but also the wealth of information available from radioactive waste management programmes and from previously existing URLs must be considered. For URL-experiments, significant technology developments have been made (testing tools, sensors, etc.) that are essential for underground testing at repository sites. This area is very much suited for co-operation.

Theme 7: Performance assessment, safety analyses and safety case development.

For safety analyses (methodology, numerical tools, compiling all the information and data, drawing the conclusions), a wealth of information is already available. The development of the safety case and the task of integrating all the necessary information will always be specific to the system evaluated and thus, in this area, each country must develop its own capabilities in interaction with the various local stakeholders, however, confidence building requires often international exchange and the help of experienced experts from elsewhere. Common issues include typically the exchange on the treatment of uncertainties. There is a need to recognise the need for independence between those supporting and managing safety case development and those supporting or managing the regulatory review and scrutiny of a safety case, this applies to all the SRA Themes, but especially relevant to Theme 7.

1.4.3. Roadmap

The SRA is further complemented by a Roadmap that describes the totality of scope of the Joint Programme and its relevance to radioactive waste management (including disposal) programmes at different stages of maturity. The Roadmap effectively provides a framework upon which to organise the scientific and technical activities of the SRA, enabling programmes to ‘click-in’, and to access active work or future plans. It also provides a framework for future periodic assessment of the Joint Programme, and to evaluate future priorities and new work packages as new knowledge is acquired or as new needs are identified.

A Roadmap, with clear objectives, linking the Joint Programme activities (as listed in the SRA) to milestones typical of different phases of a radioactive waste management (RWM) programme has been developed (focussed on those planning for disposal). The Roadmap relates to Joint Programme Founding Documents (and was not addressed by the preparatory work carried out in the EC JOPRAD project). It draws from the IAEA work (see, [IAEA Planning and Design Considerations for Geological Repository Programmes of Radioactive Waste](#)). The IAEA definitions of recognised phases of a waste disposal programme (and their associated major objectives) are used to provide the Roadmap framework:

- Phase 0: Policy, framework and programme establishment*;
- Phase 1: Site evaluation and site selection;
- Phase 2: Site characterisation;
- Phase 3: Facility construction;
- Phase 4: Facility operation and closure;
- Phase 5: Post-closure.

*Note that the IAEA phases used in the Roadmap are of a general nature and are each applicable to several waste streams and waste types. Furthermore, phase 0 was not covered by IAEA-TECDOC-1755, but added to capture pre-disposal (waste treatment and processing) and interim storage and to recognise the needs of Member-States who are in the process of establishing a waste management programme.

The Roadmap demonstrates the totality of scope of the Joint Programme and its relevance to waste management and disposal programmes at different stages of maturity. The Roadmap effectively provides a framework upon which to organise the scientific priorities of the SRA, enabling users and programmes to ‘click-in’, and to access existing knowledge and active work or future plans. It also provides a framework for future periodic assessment of the Joint Programme, and to evaluate future priorities and new work packages as new knowledge is acquired or as new needs are identified.

The Roadmap comprises 7 theme-specific tables showing how identified activities of the Joint Programme SRA relate to different Phases of implementation and typical Waste Management Programme objectives for each theme. The SRA tasks are flagged (🟡) to illustrate those being addressed in-part or in-full by scope of active EC-funded projects, including those of the Joint Programme. Tasks that will be addressed in future work of the Joint programme are also flagged (🔵).

The Roadmap tables will be used throughout the Joint Programme as a tool to support the management of the SRA in reviewing progress, updating on how new work should be prioritised (importance and urgency) and communicating completed, ongoing and future work activities to those interested in our work.

1.4.4. Deployment Mechanisms

Deployment activities

EURAD Vision, SRA and Roadmap will be delivered through **5-year implementation phases** according to the EJP Cofund Instrument. The Work Plan of an implementation phase is broken down into a set of Work Packages, Tasks and Sub-Tasks. To deliver against EURAD objectives, four different types of Work Package (WP) have been adopted, as well as specific cross-cutting tasks - interactions with Civil Society and providing access to knowledge/results – that will be directly embedded in specific WPs. These are each described below.

Table 1: Deployment Mechanisms to be used by the EURAD

Type of WP	Type of actions	Type of deliverables
Collaborative RD&D WPs	Activities aiming at developing and consolidating scientific and technical knowledge. Activities shall be a balance between those with a direct link to operational RD&D (direct links with implementation of deep geological disposal or other waste management route as well as safety concerns) and prospective RD&D (short and long-term experiment and/or modelling works to demonstrate the robustness of the waste management concepts, to increase understanding and predictability of the impact of fundamental processes and their couplings or to maintain scientific excellence and competences throughout the stepwise long-term management of radioactive waste).	State-of-the-art ² (initial and update), S/T deliverables, reports, demonstrator, pilot, prototype, plan designs, software, technical diagram...
Strategic Studies WPs	Actions consisting of enabling experts and specialists to network on methodological/ strategic issues and advance significant challenges that are common to various National Programmes and that are in direct link with scientific and technical issues.	Position paper (e.g. emerging needs for future RD&D/Strategic Studies/KM activities), report on generic methodologies, best practices...
Knowledge Management WPs	Actions consisting of developing State of Knowledge; developing descriptive methodological guidance and developing/delivering Training modules and mobility measure.	State-of-knowledge documents; Guidance documents, Training delivery and materials...
Programme Management Office WP	Day-to-day administrative, financial and legal management, reporting exercises, interactions with EC, communication and dissemination activities, administration of JP website, Extranet, Scientific and technical coordination/integration of the overall JP (monitoring EURAD progress)	Management tools, Periodic reports, financial statements, website, platforms...

² SOTA reports, where specified for all EURAD WPs, will be completed in-line with international good practice. This will include communication of the existing knowledge gaps in the context of safety. This will be done in a general or generic way, without direct reference to specific safety assessments, safety cases or national programmes. It is the responsibility of the National Programmes to evaluate outputs and results with respect to their own needs (towards implementation) as specified in Section 6.2 of the EURAD Founding Documents and section 1.2 of the Part B.

Synergies with international organisations

Strong synergies with IAEA and any other international organisations shall be established for joint development and implementation of actions related to Knowledge Management and Strategic Studies with subsequent Memorandum of Understanding.

Interaction with Civil Society – cross cutting component

As described in the Vision Document, one objective of EURAD is to allow innovative ways for close interactions between experts from WMOs, TSOs and REs and Civil-Society (CS) Organisations. Based on model of pluralistic interactions between them developed and tested under previous projects (SITEX-II, JOPRAD, Modern2020), EURAD proposes a framework for interaction with CS that consists in:

- Translating scientific/technical results for communication to CS group at the annual workshops CS and by extension to the public;
- Gathering CS views on future EURAD activities;
- Improve the mutual understanding on the RD&D needed to develop safe acceptable solutions in the processing and disposal of radioactive waste ;
- Develop propositions on how to interact with CS on scientific and technical results, how to deal with uncertainties (inherently linked to the long timeframes and numerous processes considered for geological disposal), and on how to interact with CS stakeholders in order to promote mutual benefit of the available knowledge, based on cooperation and sharing.

To do so, the EURAD has the ambition to establish interaction activities with a group of representatives of civil society organisations (**the CS group**). The composition of the CS group³ will be launched at inception of EURAD via an open call relayed by EURAD consortium to CS organisations such as local communities having interest in RWM (local association, local Committee of Information, local partnership), national or European CS Organisations taking part in interactions in the field of RWM at national or European level. The candidates shall demonstrate evidence of a standing engagement in the follow-up of RWM activities. Each participant of the CS group will approve the principle of participating in EURAD ICS activities as described in the EURAD Terms of Reference.

The interactions with the CS group will be facilitated by Civil Society facilitators (**the CS experts**), working for Linked Third Parties to mandated actors in the Joint Programme, having a long-term engagement on RWM and/or having skills/experience on the involvement of Civil Society in scientific and technical issues. The CS experts will interact with the institutional experts from the WMOs, TSOs and REs in order to understand the field of study and to prepare interactions with the CS group. The process will enable CS group to express their views on the RD&D needed to develop safe solutions in the processing and disposal of radioactive waste. The CS experts will work in an organised process together with representatives from WMOs, TSOs and REs.

1.5. Ambition

The ambition of EURAD is to establish an inclusive, transparent, leading edge scientific and goal oriented, entirely new approach on European collaboration towards safe and timely implementation of radioactive waste management, including disposal. This will, foster mutual understanding and trust between Joint Programme participants as well as other stakeholders.

A cornerstone is the development of a robust and sustained **state-of-the-art science and technology programme**, established to complement National R&D programmes, and to carry out activities of high common interest between WMOs, TSOs and REs where there is added value at the European level. Such Joint programme will allow improved integration of the fundamental scientific understanding for all concepts

³ Each candidate shall demonstrate evidence of a standing engagement in the follow-up of RWM activities (for a period of at least 3 years in the RWM field). Each participant should be willing to attend (at least twice a year) a programme of meetings where facilitated interactions with the JP participants will be organised.

related to the safe and environmentally sound disposal of long-lived radioactive waste and spent nuclear fuel in geological disposal sites within Europe, including corresponding pre-disposal activities. It supports research needs of advanced and early stage programmes and will assure access to advanced research infrastructure for coordinated implementation within scientific excellence and leading edge research on basic components and generic processes and their couplings and upscaling, oriented towards site-specific complex systems understanding of long-term repository evolution and safety. The EURAD Strategic Research Agenda, originating from research needs of high common interest established by the EC JOPRAD project, contains a broad spectrum of scope and prioritised activities that will lead to an improved scientific basis for geological disposal, and the safe treatment, packaging and storage of radioactive waste across Europe.

As disposal programmes across Europe advance, and move from conceptual studies to industrialisation and operations, research will continue. Given the inherent long timescales involved, with both licensing of a facility (decades), and the operation of facilities up to closure (centuries), scientific understanding will evolve and technology will advance. It is therefore necessary that any waste management programme remains founded at any given moment on rapidly evolving leading edge science. Our research approach will enable programmes to cope with this fast evolving scientific and technological landscape, regardless of stage of advancement, and allow the waste management concepts to remain credible and strongly efficient throughout the very long phase (>30 yr) between siting and closure of a repository.

Beyond the state-of-the-art, an important, novel and ambitious component of EURAD is to **consolidate efforts across Member-States on Knowledge Management** – this includes access to existing Knowledge (State-of-Knowledge), guiding the development of capability in line with core competencies (Guidance and Training), and improving access to quality tools, resources and communities of practice to share and learn from each other (Dissemination).

As radioactive waste management programmes across Europe are varied, particularly with respect to their level of advancement, a key consideration is ensuring that the right knowledge is available to the right people at the right time. Therefore, within the Joint Programme, we plan to use the Roadmap that has been established to provide a framework for mapping Knowledge requirements at different stages of a waste management programme. It is intended that the Roadmap will serve as a key tool for identifying, structuring, prioritising and managing all Knowledge Management activities in the Joint Programme. This will include future expansion with the required competencies in relation to what is needed to support disposal programme implementation, so that it may be used to determine critical training and guidance needs and as a tool for managing people development. This will enable the Joint Programme Knowledge Management efforts to focus initially on the most critical Knowledge required for Early Stage Programmes (i.e. State of Knowledge, Guidance and Training to support Programme Managers working in support of a National Programme that is at an early stage of development with respect to implementing radioactive waste management) and which can benefit from preparatory work undertaken previously by the IGD-TP SecIGD2 and JOPRAD Projects to understand KM.

Joint Programme Objectives on Knowledge Management are to:

- Develop an approach to comprehensive accessibility to publicly financed knowledge generated over the past, ongoing and future RD&D activities is preserved and made accessible
- Make sure that Member-States with National Programmes at an early-stage of implementation can take advantage of existing knowledge and know-how from the Member-States with advanced National Programmes, primarily to access state of the art, and second to ease access to knowledge developed during previous EC supported RD&D projects .
- In view of the long lead-times and operational time-spans for RWM, provide support to ensuring that the necessary expertise and skills are maintained through generations of experts for ongoing project.
- Disseminate and demonstrate progress, results and added-value of the European Joint Programme to a wider audience.

In addition to generating and managing expertise and scientific-technical knowledge, EURAD will **elaborate upon complex issues and identify new and emerging ones by bringing together all interested actors to**

jointly conduct Strategic Studies. Strategic studies are initiated in order to agree upon needs for future activities, including further specific thematic studies or RD&D. This may also be referred to as ‘think-tank’ activities to determine if there is a RD&D need on an emerging issue, if there is a need of a position paper or if it is considered mature and suitable for knowledge management activities.

As part of EURAD-1, there is one Strategic Study on the understanding of uncertainty, risk and safety amongst different actors, including how uncertainty transforms into risk, and how this translates into “safety” for different actors. This Strategic Study contributes to a common understanding of these phenomena amongst the different actors, including identifying research and innovation that could further bring forward this area.

Another Strategic Study is elaborating upon the need for R&I in order to deal with all the different types of waste in Europe, also “exotic” ones for which there presently is not mature solution available. One specific aspect within this study is R&I needs for dealing with small national inventories, where existing solutions may be inadequate and/or prohibitively expensive, and rely on human and financial resources found in countries with larger programmes. By these initial Strategic Studies, EURAD meets the expectation of extending the areas of activities to identification of R&I needs well beyond the community addressed in former EURATOM framework programmes, namely the strong community of advanced programmes developing geological disposal for spent fuel and high-level waste.

EURAD intends to maintain and **deepen the interaction/cooperation** that have been established since JOPRAD and during the preparation phase of EURAD proposal:

- **Waste Producers**

Waste Producers and those with a pre-disposal waste management remit are engaged via the Nuclear Generation II & III Association (NUGENIA). Although not direct contributors or participants of the Joint Programme, continued engagement via dissemination and consultation will ensure NUGENIA and their dedicated R&D on nuclear fission technologies and predisposal activities, will set a foundation for future collaboration in projects influencing the waste form for final disposal. Waste Producers and Waste Management Organisations /Implementers at a national level are often well-connected and have existing cooperation activities that should support the integration of Waste Producers RD&D needs (that impact disposal), via the WMOs. Waste Producers are often responsible for contributing to financing of disposal facilities.

- **International Organisations**

It is recognised that the scientific basis and public acceptance of RWM solutions, including geological disposal, is a global effort, and that new opportunities may emerge to link to worldwide RD&D efforts. Already the Joint Programme has established close links with the International Atomic Energy Agency (IAEA) from inception to avoid duplication of effort and resources. Such co-operation will continue, e.g. with the establishment of a Memorandum of Understanding, and extend to other organisations, including the Organisation for Economic Co-operation and Development – Nuclear Energy Agency (OECD-NEA), to strategically direct and offer clear added-value to the Joint Programme objective.

2. Impact

2.1. Expected impacts

EURAD will generate and manage knowledge to support EU Member-States with their implementation of the Directive 2011/70/Euratom ([Waste Directive](#)), and more specifically with the development and implementation of their national RD&D programmes for the safe long-term management (including disposal) of their full range of different types of radioactive waste. More specifically, EURAD will:

1. **Support compliance with European regulations** – by supporting Member-States in implementing RD&D, developing skills and providing for transparency in order to develop solutions for their radioactive waste (see, Waste Directive articles 8, 10 and 12.1(f));
2. **Support passive safety of radioactive waste** – by contributing to the responsible and safe management of radioactive waste in Europe, including the safe start of operation of the first geological disposal facilities for high-level and long-lived radioactive waste / spent nuclear fuel as well as improvement, innovation and development of science and technology for the management and disposal of other radioactive waste categories;
3. **Help to gain or maintain public confidence and awareness in radioactive waste management** - by fostering transparency, credibility and scientific excellence;
4. **Support radioactive waste management innovation and optimisation** – by supporting the development of solutions for different waste streams and types and continuously improving and optimising waste management routes and disposal solutions, including identifying needs specific to small inventory programmes with their particular challenges with respect to access to critical mass of expertise and developing appropriate disposal options;
5. **Contribute to addressing scientific/technical challenges and evolving regulatory concerns** – by prioritising activities of high common interest, and creating conditions for cross fertilization, interaction and mutual understanding between different Joint Programme contributors and participants;
6. **Enhance knowledge transfer to early stage programmes** – by providing an opportunity for less advanced programmes, and in particular those in an early stage of geological disposal programme implementation, to benefit from the cross-European integration in radioactive waste management;
7. **Foster efficient use of the RD&D resources at the EU level** - by sharing and advancing existing knowledge, facilities and infrastructure rather than repeating and duplicating efforts; and
8. **Foster a better transfer of knowledge across generations of experts** – by helping to bridge the risk of shortage of the skilled, multidisciplinary human resources and critical infrastructure needed to develop, assess, license and operate RWM facilities, in view of the long lead-times and the intergenerational operational time-spans.

2.2. Measures to maximise impact

2.2.1. Dissemination and exploitation of results

At the inception of EURAD, one of the first task of the Programme Management Office (WP1 Task 6) will be to develop a plan for the dissemination and exploitation of the EURAD results. Such plan for the dissemination and exploitation (PDER) will be a key deliverable that will describe in a concrete and comprehensive manner, the area in which we expect to make an impact, who are the potential users of the results and how we plan to maximise EURAD impacts/results. It should also describe appropriate channels of dissemination and interaction with potential users. This PDER will be agreed between EURAD participants and will be submitted at month 3. It will be then regularly updated during the implementation of EURAD, as Beneficiaries are required to report periodically to the European Commission the concrete dissemination and exploitation activities carried out. At the end of the first implementation phase of EURAD, the final report should include the final version of the PDER that will allow the European Commission to assess the impacts of EURAD activities.

Dissemination shall be based upon:

- **EURAD Annual Meetings;**
- **Peer-reviewed scientific open access publications** in internationally recognized scientific journals;
- **Presenting EURAD scientific-technical results and achievements at scientific-technical conferences/ workshops /forums** addressing the scientific-technical expert community;

- **Presenting EURAD objectives, scope, work programme and main achievements at events where broader stakeholder community and/or decision maker presence**, with the aim of providing confidence in the scientific-technical basis and enhancing awareness of the well-founded progress in the field and its time-horizons;
- **Presenting, at events of inter-European and international platforms, organizations and fora**, exchanging on the EJP and promoting coherent messages and developments within the broader context;
- **Exchanging the scientific-technical basis, the objectives, scope, work planning and achievements with civil society and their representatives**, resulting in out-reach beyond the involved expert community to these key actors for advancement of National Programmes and for policy decision-making.
- **Training/Mobility Programme to be developed as part of EURAD KM Programme of activities**

Within KM Programme of activities, a **diverse portfolio of tailored basic and specialized training courses** will be composed under the umbrella of a “School of Radioactive Waste Management”, newly created under EURAD-1, taking stock of and building upon already existing initiatives (i.e. IAEA and NEA) and creating new initiatives to bridge the identified gaps. The end-users are defined as professionals and potential new professionals at graduated and post-graduated level associated with the organisations participating within EURAD-1, and in particular the next generation of experts. Access to existing training materials (e.g. training modules developed in association with past and ongoing RD&D projects and EURAD WPs) will be improved and new training courses and material provided, both aimed at acquiring both state-of-the-art scientific background and at accessing the vast amount of “tacit” knowledge available within EURAD-1 through targeted hands-on training.

Furthermore, a **mobility programme** shall provide access to dedicated infrastructures associated with the organisations participating within EURAD-1. These mobility actions can be seen either as a complementary action after one or more training course(s) (enabling hands-on training related to the experimental programme executed within EURAD-1) or can be part of the Continuous Personal Development (CPD) of experienced personnel involved in RWM.

The key-mechanism for exploitation of the results are based on the Joint Programme as a facilitator for the different Actors to generate the value that they exploit:

- The EJP contributing by developing and making available knowledge, promoting common understanding with respect to decision-making and policy amongst actors across Europe, promoting mobile cross-European expertise, and providing Guidance on how to implement R&D programmes and knowledge management;
- National decision-makers making use for avoiding unnecessary delay in establishing and implementing the required policy;
- Industry and other involved actors to implement science and technology in a safe and cost-effective manner, making use of knowledge and expertise available across Europe;
- Industry making use of their front-runner position to sell know-how and technology also outside of Europe.

2.2.2. Access policy and Intellectual Property Rights (IPR)

The management of intellectual property generated within EURAD will be regulated by the Consortium Agreement that all partners (Beneficiaries/Linked Third parties) have agreed to finalise before the Grant Agreement is signed.

The Consortium Agreement will set out the rules on IPR matters, including identification of background, access rights and patent issues and its stipulations will be complemented in the dissemination plan that

addresses also the exploitation of results. Results generated by EURAD shall be the property of the participants (Beneficiaries/Linked Third parties) generating it. Each participant, duly owner of Results will have to consider its interest and to determine whether to apply for a patent or not.

Any software developed in the framework of EURAD shall be accessible on a royalty-free basis to all EURAD participants (Beneficiaries/Linked Third Parties) for the needs of EURAD implementation, for non-commercial internal research activities and/or its non-commercial industrial activities.

All WP deliverables are made freely available to all participants. Participants, on the other hand, will take care in not revealing information with a potential commercial interest to third parties.

The data (excluding patents and software) arising from the deliverables will be public and will be considered as open-access literature.

Any type of industrialization is not yet the primary goal of EURAD, but the feasibility and reliability demonstrations also provide results that are needed as input for the next step of the innovation cycle towards the industrial scale of processes and tools, such as conditioning, treatment, monitoring..., needed for implementing safe management of radioactive waste..

2.2.3. Communication activities

In parallel of the Dissemination and Exploitation Plan, a Communication Plan will be developed in order to describe the targeted communication measures that will be implemented for promoting EURAD itself and its mains results and findings and demonstrating to a large public how EU funding contributes to tackle scientific/technical and societal challenges in the field of radioactive waste management.

Several communication channels/tools will be developed within EURAD WP1-Programme Management Office:

- A dedicated **EURAD website** that will provide initial information on EURAD Vision, Roadmap, Strategic Research Agenda. It will present EURAD participants, ongoing projects (Work Packages for a wide audience. The website will be regularly updated with on-going activities, public reports, publications, it will also publicised EURAD Annual Meetings, scientific/technical workshops organised within the different WPs, as well as training/mobility programme.
- A **newsletter** that will be regularly published and will aim to keep all interested parties informed on EURAD ongoing activities and main findings, results and outcomes.
- **Communication tools, such as flyer, brochures, posters, rollups, synthesis, video etc.** that may be displayed and/or distributed during workshops, conferences or congresses will be also developed within WP1.
- Publication of articles in non-scientific and non-peer-reviewed publication
- EURAD participants will be encouraged to provide short information about EURAD on their own website with a link towards the official EURAD website.

All communication and dissemination activities will acknowledge support of the HORIZON2020 Euratom programme by displaying the EU emblem and by including the following text: This project has received funding from Euratom research and training programme 2014-2018 under grant agreement No [847593]”.

Figure 3 –EURAD-1 overall structure of the work plan (‘first wave’)

This EURAD-1 overall work plan (“first wave”) is the result of a collaborative process between WMOs, TSOs and REs that is fully described in the Annex 3 of the EURAD Founding Documents (see Appendix).

During the preparation phase of EURAD, the WMOs, TSOs and REs collaboratively established the RD&D/Strategic Studies WPs to be launched as a first wave of EURAD-1, respecting the following boundary conditions:

- Each WP shall be in line with EURAD Vision and the JOPRAD Programme Document (Basis of EURAD Strategic Research Agenda). Specifically, each WP has to address mainly topics of high or medium level of common interest from the JOPRAD Programme Document.
- The WPs shall be of common interest by the different categories of actors: REs, TSOs and WMOs.
- The WPs shall avoid (i) duplication of existing international activities (e.g. from NEA or IAEA) and (ii) re-doing what has been done in the past (at national or European level).
- The WPs shall address topics which are not currently addressed by ongoing EC projects. The ongoing EC projects are given on the following figure. The different topics addressed in ongoing EC projects are the following: monitoring (Modern2020), microorganisms (MIND), concrete alteration (Cebama), non-destructive assay methods (CHANCE), waste thermal treatment (THERAMIN), bentonite mechanical evolution (Beacon) and characterization of dismantling waste (INSIDER). The aim of this is to wait for feedback from these ongoing projects before launching any follow up WP within EURAD-1.

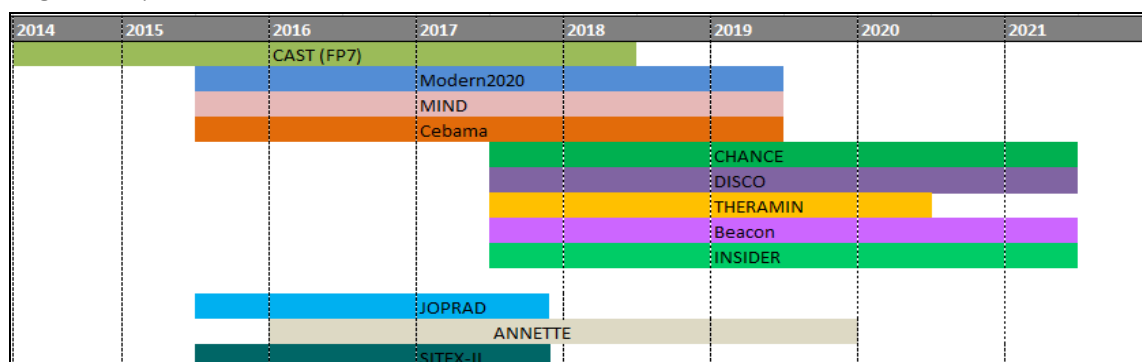


Figure 4 – Overview of ongoing EC EURATOM projects

3.1.1. Work breakdown structure

EURAD 1 Work Packages (2019-2024)		Indicative Budget	EURAD Strategic Research Objectives	EURAD Beneficiaries				
		Total Cost (EC + Beneficiary Contributions)		How the Work Package will address objectives, priorities and activities of high common interest in the EURAD Strategic Research Agenda	WMOs	TSOs	REs	Coordinator
					◆ = Beneficiary Organisation; ◆ = Coordinating Beneficiary Organisation			
Programme Management Office		7%						
WP1	Administration, Scientific Coordination, Communication and Dissemination	€2.7 M		◆◆	◆	◆◆	ANDRA (France)	
Collaborative RD&D		75%						
WP2	Assessment of Chemical Evolution of ILW and HLW Disposal Cells (ACED)	€5.1 M	Multiscale approach and process integration to improve long-term modelling and assessments .	◆◆◆◆◆	◆◆◆◆◆	◆◆◆◆◆ ◆◆◆	SCK-CEN (Belgium)	
WP3	Cement-Organics-Radionuclide-Interactions (CORI)	€4.7 M	Improved understanding of the role of organics (either naturally occurring or as introduced in the wastes) and their influence on radionuclide migration in cement based environments.	◆◆	◆◆◆	◆◆◆◆◆ ◆◆◆◆◆	KIT (Germany)	
WP4	Development and Improvement of Numerical Methods and Tools for Modelling Coupled Processes (DONUT)	€3.7 M	Improved understanding of the upscaling of THMC modelling for coupled hydro-mechanical-chemical processes in time and space.	◆◆◆◆	◆◆◆◆◆	◆◆◆◆◆ ◆◆◆	ANDRA - BRGM (France)	
WP5	Fundamental Understanding of Radionuclide Retention (FUTURE)	€4.6 M	Quantification of long-term entrapment of key radionuclides in solid phases to inform reactive transport models and the influence of redox.	◆◆	◆◆◆◆◆	◆◆◆◆◆ ◆◆◆	FZJ (Germany)	
WP6	Mechanistic Understanding of Gas Transport in Clay Materials (GAS)	€5.6 M	To increase understanding and predictability of gas migration in different host rocks.	◆◆◆◆◆ ◆◆	◆◆◆	◆◆◆◆◆ ◆◆◆◆◆	ONDRAF/NIRAS (Belgium)	
WP7	Influence of Temperature on Clay-based Material Behaviour (HITEC)	€5.3 M	Improved THM description of clay based materials at elevated temperatures.	◆◆◆◆◆ ◆◆◆◆◆	◆◆	◆◆◆◆◆◆◆	VTT (Finland)	
WP8	Spent Fuel Characterisation and Evolution Until Disposal (SFC)	€5.8 M	Reduce uncertainties in spent fuel properties in predisposal phase.	◆◆◆◆◆	◆◆◆◆◆	◆◆◆◆◆ ◆◆◆◆◆	SKB-UU (Sweden)	
Strategic Studies to Address Complex Issues and Expert Networking		10%						
WP9	Waste management routes in Europe from cradle to grave (ROUTES) *	€1.7 M	Waste Management Routes across Europe considering different waste types and their specified endpoints.	◆◆◆◆◆ ◆◆◆◆◆ ◆◆	◆◆◆◆◆◆◆ ◆◆◆◆◆◆◆ ◆◆◆	◆◆◆◆◆◆◆ ◆◆◆◆◆◆◆ ◆	IRSN (France)	
WP10	Uncertainty Management multi-Actor Network (UMAN) *	€1.7 M	Further refinement of methods to make sensitivity and uncertainty analyses and the development of a multi-actor network for uncertainty management.	◆◆◆◆◆ ◆◆◆◆◆ ◆◆◆◆◆	◆◆◆◆◆◆◆ ◆◆◆◆◆◆◆ ◆◆◆◆◆◆◆	◆◆◆◆◆◆◆ ◆◆◆◆◆◆◆ ◆◆◆◆◆◆◆	BelV (Belgium)	
Knowledge Management		8%						
WP11	KM State-of-Knowledge (SoK)	€1.4 M	To maintain information, knowledge and records over the long lead- and implementation-timelines of geological disposal programmes, from pre-licensing through to the post-operational phase.	◆◆	◆◆	◆◆	BGE (Germany)	
WP12	Guidance	€0.5 M	To identify RD&D and knowledge transfer needs in support of defining pre-licensing activities that can support success in the siting and licensing phase/process.	◆◆	◆◆◆		SURAO (Czech Republic)	
WP13	Training & Mobility	€0.6 M	Training and competence maintenance of skills and expertise to support safe radioactive waste management including disposal.	◆◆	◆◆◆	◆◆	SCK-CEN (Belgium)	

* Interactions with Civil Society

a. Programme Management Office (Management and Dissemination)

• **WP1 – Programme Management Office**

During EURAD-1, and in addition to its responsibility of administrative, legal and financial management and the coordination of the overall scientific and technical coordination/integration/evaluation of impacts (RD&D, Strategic Studies and KM, the PMO shall support EURAD General Assembly in the exercise that consists of **extending/updating the SRA and the Roadmap**. During EURAD-1, the following extension/updates are anticipated:

- [Year 1] **Roadmap Extension** - Complete EURAD Roadmap with a **Competency Matrix**, to identify competencies for different Actors (WMOs, TSOs and REs) and to **map existing/available SoK, Guidance and Training material** (open access) against Themes of EURAD SRA for different phases of implementation of a RWM programme. This shall support identification of the key need-gaps, which will then be used to prioritise the scope of each of the main KM WPs. This task will be undertaken by the PMO, with inputs from participants of the KM WPs and with oversight and guidance by the appointed Joint Programme Fellows/Experts
- [Year 2] **‘Soft’ update of the SRA/Roadmap** in view of the preparation of the 2nd wave of RD&D and Strategic Studies WPs where it is anticipated that minor edits and additions should be made, e.g. assessing the level of common interest of topics that emerged lately in the process of developing the SRA; identification of emerging RD&D needs and assess level of common interest.
- [Year 4-5] **‘Extensive’ update** of the SRA/Roadmap (exact timing to be adjusted in order to be in line with Euratom work programme) to coincide with preparation and prioritisation of the scope of the potential EURAD2. During this extensive update, it is anticipated that significant changes may result to take account of learning from EURAD-1 and align the Vision, SRA, Roadmap and RD&D, Strategic Studies and KM Work Packages scope and methodologies with how things evolve, particularly with respect to the JP governance scheme and how the criteria used to identify needs of the WMOs, TSOs and REs.

See WP1-PMO description for full details, included related Deliverables.

b. Collaborative RD&D WPs

For the first wave of EURAD-1, the following RD&D WPs have been collaboratively established:

WP2 - Assessment of Chemical Evolution of ILW and HLW Disposal Cells (ACED);

Multiscale approach and process integration to improve long-term modelling and assessments

‘What’

This WP improves the methodology to integrate knowledge on the geochemical processes in and between the materials in a disposal cell for ILW and HLW waste in order to understand and assess the long-term evolution of such complex system. A multi-process and multi-scale modelling framework will enable the assessment of the chemical evolution at various materials interfaces and thermal, hydraulic and/or chemical gradients from the microscale to the disposal cell scale (ILW, HLW) considering the near field environment and the host rock for larger temporal scales. Starting from small-scale process understanding, it seeks to which detail geochemical processes need to be included for representative assessments of the chemical evolution in view of the needs in repository design and safety assessment.

‘Why’

The WP ACED is included already in the first EJP EURAD as it covers an important number of high priority items of the roadmap of EURAD. These are in particular the EBS systems understanding in phase 1 and 2:

- Improved understanding of the interactions occurring at the interfaces between waste packages and different barriers in the disposal system

- Improved description of the spatial and temporal evolution and transformations affecting the porous media and degrading materials in the near field of HLW and ILW disposal systems
- And concerns also the high priority item for phase 1 in performance assessment and systems models
- Improved understanding of the role of physical/chemical processes at different scales and linking bottom-up and top-down approaches in performance assessment

More concrete: the work will allow identifying to which detail and complexity these processes should be incorporated in models for different type of safety and performance related studies. The information gained through study of the more generic but European representative HLW and ILW disposal cells can later be used and adapted for more specific, national disposal cell designs.

The outcomes will impact the safety case in different ways such as with respect to material specifications and establishment of requirements for deposition scenarios. The representative designs are set for ILW and HLW in both crystalline and sedimentary rock types, representing prevailing designs of the WMOs as end-users. The clear interest of the mandated actors in this WP is demonstrated by the fact that the WP work is carried out by a large number of partners, with a good balance between WMO, TSO and RE representatives.

WP3 - Cement-Organic-Radionuclide interactions (CORI);

Improved understanding of the role off organics (either naturally occurring or as introduced in the wastes and their influence on radionuclide migration in cement based environments)

‘What’

This WP aims to develop an in-depth understanding of the interaction of cementitious materials with omnipresent organic matter and with radionuclides. Organic materials are present in some nuclear waste and as admixtures in cement-based materials and can potentially influence the performance of a geological disposal system, especially in the context of low and intermediate level waste disposal. The potential accelerating effect of organic molecules on radionuclide migration is related to the formation of complexes in solution with some radionuclides of interest (actinides and lanthanides) which can (i) increase the radionuclide solubility and (ii) decrease the radionuclide sorption. The WP’s raison d’être is to quantify the organic release issues which can accelerate the radionuclide migration in the context of the post closure phase of geological repositories for ILW and LLW/VLLW, including surface/shallow disposal.

‘Why’

The thematic represented by the WP Cori has been selected for the first phase of the EJP as “improved understanding of the role of organics (either naturally occurring or introduced by the wastes) and their influence on radionuclide migration” was identified as an important subject in theme 4 (Geoscience to understand rock properties, radionuclide transport and long-term geological evolution) phase 1 and 2 of the roadmap. Due to the potential degradation of organic matter, this subject is particularly challenging in cementitious environments. Due to the importance of this subject in national programs, various mandated actors are working already since long time on the issues addressed by this WP (see for instance the meetings of the former TSWG in May 2013, Ghent, Belgium, leading to CEBAMA, or the latter extended discussion on CORI at the IGD-TP EF 6 (2015) in London, UK). Over this entire period, partners were eager to join forces for a strong improvement in scientific understanding allowing assessing long term radionuclide mobility in organic rich cementitious waste disposal environments.

WP4 - Development and Improvement Of Numerical methods and Tools for modelling coupled processes (DONUT);

Improved understanding of the upscaling THMC modelling for coupled hydro-mechanical-chemical processes in time and space

‘What’

This WP will develop and improve specific numerical methods and tools that allow efficient modelling coupled processes, considering (i) the versatility of numerical methods with regards to the various tools used by “end-users”; and (ii) a demonstration of robustness and added-value of developments by benchmark of the methods and tools on representative test cases at large repository time and space scales.

‘Why’

The DONUT WP has been selected for the first phase of EURAD as it will address the following activities identified as a high or medium level of common interest in Theme 7 “Performance assessment, safety case development and safety analyses” of the Roadmap:

- Improved understanding of the upscaling of THMC modelling for coupled hydromechanical-chemical processes in time and space (Phase 1 of the Roadmap).
- Improved understanding and models for the impact of THMC on the behaviour of the host rock and the buffer materials (Phase 2 of the Roadmap).
- Improved multi-scale reactive transport models (Phase 2 of the Roadmap)
- Improved performance assessment tools (Phases 0 and 1 of the Roadmap).
- Further refinement of methods to make sensitivity and uncertainty analyses (Phases 2 and 3 of the Roadmap)
- Improved computing (Phases 3 and 4 of the Roadmap).

Furthermore, by improving the numerical methods and tools that are able to manage multi-physicals coupled processes, the work conducted in this WP is relevant for better description of site evolution and design optimization. Both can be applied to deep geological and near surface radioactive waste disposal. Finally, by providing efficient numerical means for analysis, DONUT will, contribute to abstraction for safety case (quantification of safety margins, detailed assessment of safety functions allocated to components...).

WP5 - Fundamental understanding of radionuclide retention (FUTURE)

Quantification of long-term entrapment of key radionuclides in solid phases to inform reactive transport models and the influence of redox

‘What’

This WP aims at realizing a step change in quantitative mechanistic understanding of radionuclide retention in the repository barrier system, the key mission of any repository for radioactive waste. In consequence, the *raison d’être* of this WP concerns the identification of constraints and the increase in predictability of RN migration properties in “real” clay and crystalline rocks, quantifying the influence of key parameters of the heterogeneous rock/water system such as rock structure, redox interfaces, water saturation, reversibility etc. with the goal to develop multicomponent mechanistic sorption models, fracture and/or pore scale simulations of radionuclides transport in both in crystalline clay rock considering the combined analysis of reactivity, structure, flow field, and RN mobility/retention.

‘Why’

“Radionuclide mobility” has been identified by the mandated actors of WMO, TSO and RE as one of the key themes (4) of the EJP, the SRA and its concretization in the roadmap. It is a key theme in all radioactive waste management countries in Europe, a cornerstone for any proof of safety of nuclear waste disposal concepts. Hence, it was evident to all actors that this theme should also be part of the first EJP, acknowledging that there has been research on the various topics of radionuclide migration for more than 30 years, often funded by the European Commission, but realizing as well that various key themes have not been addressed in previous European projects (e.g. FUNMIG, SKIN, RECOSEY) with sufficient depth and with sufficient potential for applicability on the real repository systems in clay or crystalline rock. The results of the project are expected to reduce uncertainties and over-conservatism of current approaches and improve the scientific basis, the realism and credibility for the safety case of deep geological disposal in clay and crystalline rock.

WP6 - Mechanistic understanding of gas transport in clay materials (GAS);

To increase understanding and predictability of gas migration in different host rocks

‘What’

This WP will provide data and develop process-level models to improve mechanistic understanding of transport processes in natural and engineered clay materials, including couplings with mechanical behaviour and impact on the clay properties. Experimental work will determine, for each identified gas transport regime, the conditions under which that regime is possible, in clay materials representative of host rock and clay EBS components. Data will be obtained that are pertinent for low (diffusion) to high (advection) gas transport rates.

Work will also show how knowledge gained from lab and in situ experiments is integrated in the conceptualisation of gas transport through different components of a repository system and how gas could affect (or not) the performance of the system. This will involve (i) development of phenomenological descriptions of gas transport and of its likely consequences at the relevant scale and (ii) testing different approaches to represent the effects of gas at repository scale and bounding its consequences in terms of repository performance.

‘Why’

Theme 4 of the EURAD Roadmap (Geoscience to understand rock properties, radionuclide transport and long-term geological evolution), increasing the understanding of gas migration is a high priority topic. Gas generation and transport is a key issue as it is possible that gas could be generated at a faster rate than it can be removed through clay host rocks (and clay EBS components – Theme 3) without creating discrete, gas-specific pathways through these low-permeability components. In several disposal concepts, the potential for migration of free gas containing radionuclides to the biosphere is an important issue. Consequently, the *raison d’être* of this WP is to answer two key end-users questions:

- How can gas migrate within the repository and which water soluble and volatile radionuclides could be associated with it?
- How and to what extent could the hydro-mechanical perturbations induced by gas affect barrier integrity and performance?

This WP will build on the outcomes of FORGE. Experiments in FORGE revealed complex mechanisms and emphasized the importance of the mechanical control exerted by the porous material on gas transport. It was suggested that this complexity can be addressed as long as one can bound the effects of these mechanisms using simple and robust descriptions for evaluation purposes (e.g. two-phase flow models for gas transient representation at repository scale, identified as a medium priority under Theme 4). A necessary condition for this is that the scientific bases are integrated properly, in a traceable way throughout the system conceptualisation process. Hence, the structure of this WP follows this process, imposing interactions at each step to ensure close cooperation between experimentalists, process modellers and those involved in evaluation of system performance. This should allow the development of robust evaluation approaches that support the expert judgement formulated at the end of FORGE that gas is not a feasibility challenging issue for geological disposal but more a challenge of managing uncertainties.

WP7 - Influence of temperature on clay-based material behaviour (HITEC); and

Improved THM description of clay based materials at elevated temperatures

‘What’

This WP aims to develop and document improved THM understanding of clay based materials (host rock and buffer) exposed to elevated temperatures (>100°C) for extended durations. The WP’s *raison d’être* is to evaluate whether or not elevated temperature limits (of 100-150°C) are feasible and safe for a variety of geological disposal concepts for high heat generating wastes (HHGW).

HITEC will study clay host rock formations (<120°C) and establish the possible extent of elevated temperature damage in the near or far field (e.g. from over pressurisation) and also the consequences of any such damage. The WP will also look at buffer bentonite and determine if temperature influences the

buffer swelling pressure, hydraulic conductivity, erosion or transport properties (i.e. inhibits buffer safety functions).

‘Why’

The HITEC WP has been selected for the first phase of EURAD as the activity “Characterise bentonite/clay-based material evolution under specific conditions to provide data on hydro-mechanical, thermal and chemical behaviour” was identified as a high priority subject in theme 3 (EBS properties, function and long-term performance) phases 1-3 of the roadmap. Furthermore, the theme 4 (Geoscience to understand rock properties, radionuclide transport and long-term geological evolution) topic of “Improved understanding of the influence of temperature on radionuclide migration and representation of effects in geochemical models” was also rated as a medium priority activity.

For the disposal of HHGW it is important to understand the consequences of the heat produced on the properties (and their long term performance) of the natural and engineered clay barriers. Most safety cases (for disposal concepts that involve clay) currently involve a temperature limit of 100°C. Being able to tolerate higher temperature, whilst still ensuring an appropriate safety standard, would have significant advantages (e.g. shorter above ground cooling times, more efficient packaging, fewer disposal containers, fewer transport operations, smaller facility footprints etc.).

This WP has the potential to effectively integrate with the parallel SFC RD&D WP (i.e. interrogate the validity of the currently applied thermal limits and also the accuracy of the assumed waste source term).

WP8 - Spent Fuel characterisation and evolution until disposal (SFC);

Reduce uncertainties in spent fuel properties in predisposal phase

‘What’

This WP will develop and document an experimentally verified procedure to accurately determine the source term of irradiated spent fuels. It will also develop characterisation techniques that will allow us to more fully understand the physiochemical evolution of irradiated spent fuels (pellets and cladding) under normal and credible accident scenarios following reactor discharge (i.e. during interim storage (wet and dry), transport to and emplacement in a GDF).

‘Why’

Accurately determining the source term (see “...management of inventory data and uncertainty treatment”) and evolving condition (see “Improved understanding of the impacts of extended storage...”) of spent fuel is fundamental to safety assessment. This is reflected in the fact that both of these Roadmap theme 2 activities are shared high priorities. Parameters such as decay heat and nuclear reactivity (fissile content) need to be known to decide how much fuel can be safely loaded into a disposal container and how closely disposal containers can be emplaced at disposal. In the absence of accurate knowledge there is a risk that these parameters could be too conservatively estimated. Conservatisms would then percolate through container loadings and facility layouts, potentially resulting in substantially more containers than necessary, more transport operations and ultimately a larger facility footprint. This scenario has safety and cost ramifications. Conversely, the alternative is also possible (i.e. optimistic parameters are estimated), which could then be detrimental to safety, i.e. inadvertently breach a thermal or criticality safety limit.

WMOs are particularly interested in the possibility of an NDA technique that could allow swift and accurate corroboration of spent fuel records, prior to fuel containerisation (i.e. potential waste acceptance criteria (WAC), such as a fuel burn-up measurement or a thermal limit acceptance check). WAC is a key thematic area under theme 2 of the EURAD Roadmap and is typically of most interest to more advanced stage programmes (Phase 2 onwards).

This has potential to effectively integrate with the parallel HITEC RD&D WP (i.e. scrutinise actual thermal output and also the validity of currently applied thermal limits).

c. Strategic Studies WPs

For the first wave of EURAD-1, the following Strategic Studies WPs have been collaboratively established. These two WPs consist of enabling experts and specialists to network on these methodological/ strategic issues and advance significant challenges that are common to various National Programmes and that are in direct link with scientific and technical issues. Initiated in order to agree upon and define in some detail the

needs for future activities, including further specific thematic studies or RD&D at the forefront of science. This may also be referred to as ‘think-tank’ or networking activities to determine if there is a RD&D need on an emerging issue, if there is a need of a position paper or if it is considered mature and suitable for knowledge management activities.

- **WP9 - Waste Management routes in Europe from cradle to grave (ROUTES); and**

Share experience and knowledge on RWM routes between WMOS, TSOs and REs from different countries, with programmes at different stages of development, with different amounts and types of radioactive waste to manage

‘What’

This WP will describe and compare the different approaches to characterisation, treatment and conditioning and to long-term waste management routes between MS (member states). The interested organisations are from different countries, with programmes at different stages of development, with different amounts and types of radioactive waste to manage. In this WP, will be Identified the safety-relevant issues and their R&D needs associated with the waste management routes (cradle to grave), including the management routes of legacy and historical waste. The WP will consider past and present EU projects on the topics of interest and other initiatives carried out at international level such as IAEA, NEA in order not to duplicate the work. The aim of this WP is to identify relevant R&D topics which could be collaboratively launched in the second wave of EURAD.

‘Why’

As noted under the EURAD Roadmap Theme 2 - Radioactive waste characterisation, processing and storage (Pre-disposal activities), and source term understanding for disposal - the pre-disposal activities including radioactive waste characterization, treatment and conditioning as well as storage are considered as high priorities. Moreover, as highlighted in the Roadmap, a sufficient knowledge of the radionuclide and chemical content of the waste is a prerequisite for the development of the complete waste management route.

The common interests addressed in the ROUTES strategic studies are identified in the Roadmap and related to the Theme 2: Inventory collation and forecasting (3.5), the Methodology to define radionuclides inventories (3.6), understanding of the potential for Long-term storage as a management option for disused sealed radioactive sources (3.10), the Management of damaged waste packages and methods for reprocessing aged waste (1.2.4), the Waste acceptance criteria (2.1.6). All these subtopics are related to Roadmap Phase 0 (Policy, Framework & Programme Establishment), except the subtopic WAC which is related to Phase 2 (Site Characterisation) and Phase 3 (Facility Construction).

Consequently, the raison d’être of this WP is to provide an opportunity to the organisations of the Member-States to share their experience and to identify common R&D interest on such topics. To this aim, safety-relevant issues and R&D needs associated with the waste management routes (cradle to grave) will be identified, considering waste characterisation, the development of waste acceptance criteria (WAC) prior to the availability of disposal facilities, options for disposal of small waste inventories. In addition to providing an overview of good practices for different steps in radioactive waste management and guidance for research activities, the work package will provide an opportunity to consider sharing of technology and facilities.

- **WP10 - Understanding of uncertainty, risk and safety (UMAN).**

Further refinement methods to make sensitivity and uncertainty analyses and the development of multi-actor network for uncertainty management

‘What’

This WP is dedicated to the management of uncertainties potentially relevant to the safety of different radioactive waste management stages and programmes. It includes various activities such as exchanges

on views, practices and uncertainty management options and the review of existing strategies, approaches and tools. Interactions between different types of actors including civil society are central to this WP. These interactions are aimed at meeting the shared objective of fostering a mutual understanding of uncertainty management strategies, approaches and preferences. A particular focus is put on uncertainties in direct link with RD&D WPs and with a high (and where relevant medium) priority subdomain of the SRA for which exchanges of information and experiences and strategic studies have been identified as beneficial by the JP actors themselves. The WP will consider past and present EU projects on the topics of interest and other initiatives carried out at international level such as IAEA and NEA so as to avoid duplicating existing work. The WP will allow identifying the contribution of past and on-going RD&D projects to the overall management of uncertainties as well as remaining and emerging issues associated with uncertainty management that could be addressed in subsequent waves of EURAD.

‘Why’

Decisions associated with radioactive waste management programmes are made in the presence of irreducible and reducible uncertainties. Several choices made on the basis of limited information in early programme phases may also have to be confirmed before or during the construction and operation of the facility. At the end of the process, uncertainties will inevitably remain but it should be demonstrated that these uncertainties do not undermine safety arguments. Hence, the management of uncertainties is a key issue when developing and reviewing the safety case of waste management facilities and, in particular, of waste disposal facilities due to the long-time scales during which the radiotoxicity of the waste remains significant.

As noted under the EURAD Roadmap Theme 1 - Managing implementation and oversight of a radioactive waste management programme - a clear strategy and commitment to involvement of stakeholders is essential to the decision-making process at all stages of a waste management programme. It is also explained that scientific activities associated with a waste management programme (site characterisation, process modelling, safety assessment etc.) are evolving over time leading to new view points and sometimes new uncertainties and they are less predictable in the outcome, duration or resources that may eventually be required. Accounting for such uncertainty has thus become a key part of successful programme planning, and would benefit from continued sharing of methodologies and experience.

Therefore, uncertainty is a cross-cutting issue of the different themes and stages identified in the Roadmap. The term “uncertainty” is also explicitly mentioned in the title of several activities of common interest considered as having a medium or a high priority: Inventory uncertainty (1.1.1), Site uncertainty treatment (3.1), Geological Uncertainties (1.6.2), Uncertainty treatment (2.1.3). Furthermore, RD&D activities are aimed at improving the state-of-knowledge and thus are expected to reduce uncertainties. Understanding the contribution of these activities to the overall uncertainty management is important for the different actors involved in the decision-making process as well as for the identification of future EURAD priorities and activities.

Consequently, the *raison d’être* of this WP is to provide an opportunity to the organisations and different actors of the Member-States to share their experience and views on uncertainty management and to identify emerging needs associated with this topic. The WP will also contribute to understanding the added value of RD&D activities for the safety case and the decision-making process. It also contributes to the vision of EURAD by fostering mutual understanding and trust between Joint Programme participants.

d. Knowledge Management WPs

Under EURAD-1, Knowledge Management is enabled by three permanent WPs that derive directly from EURATOM expectations under WP2018:

- **WP11 - State of Knowledge** - Activities under this WP consist of developing a systematic approach of establishing the state-of-knowledge in the field of RWM research. This shall be done on a stepwise basis: i) establishing of procedures to document the SoK; ii) testing and improving these procedures on a few demonstration topics/sub-topics (of the Roadmap); iii) performing a review on

existing tools/platforms and evaluating the added-value of establishing such a platform dedicated to provide access to SoK developed in EURAD.

- **WP12 - Methodological guidance** - Activities under this WP consist of developing a comprehensive suite of instructional guidance documents that can be used by Member-States with RWM programmes that are at an early stage of development with respect to their national RWM programme. Such WP shall pursue and complement the work initiated with the [PLANDIS Guide](#).
- **WP13- Training/mobility** - Activities under this WP consist of developing a diverse portfolio of tailored basic and specialised training courses under the umbrella of a “School of Radioactive Waste Management”, taking stock of and building upon already existing initiatives (i.e. IAEA and NEA) and creating new initiatives to bridge the identified gaps. The end-users are defined as professionals and potential new professionals at graduated and post-graduated level from EU and non-EU countries (via the IAEA and NEA programmes), and in particular the next generation of experts This WP will also organise a mobility programme to provide access to dedicated infrastructures associated with the Mandated Actors/Linked Third Parties within EURAD. This work will be carried out in close interaction with European networks having a recognised experience in training/mobility in the field of RW

e. Contribution from Civil Society

For the first wave of the EURAD-1, the two Strategic Studies Work Packages have been selected for specific contribution from civil society because they are focusing on generic aspects of radioactive waste management and are of interest for civil society in EU countries:

- SS WP9 - Waste Management routes in Europe from cradle to grave (ROUTES); and
- SS WP10- Understanding of uncertainty, risk and safety (UMAN).

In close collaboration with the WP Boards (WP Leader and task leaders) the role of **CS Experts** (in charge of translating the WP work content and results to the CS group as described in [Section 1.1.4](#)) is to:

- Sketch out and map the key stakes related to the work performed in the different tasks/subtasks of the WPs from a CS point of view in order to translate the work content and the results to the broader CS group and gather its feedback at annual workshops;
- Contribute to the work performed in the tasks/subtasks of the selected WPs and participate in key working meetings of these tasks;
- Raise awareness from the broader CS group on the scientific/technical research issues for radioactive waste management solutions by preparing and animating a specific session dedicated to the selected WPs in the CS annual workshop of EURAD (see above).

Furthermore, under the PMO WP, a **dedicated coordination task** is established to coordinate, support and integrate at the programme level all the interactions activities with Civil Society. This coordination task will consist of providing methodological support for CS interactions with RWM stakeholders: elaboration of material, methodologies, processes and sessions to prepare EURAD participants and CS representatives in order facilitate fruitful interactions, as well as the assessment of the on-going experimental model of Interaction between EURAD participants and Civil Society. This coordination work will also consist notably of organizing yearly a workshop involving the participants of the CS group, the CS Experts together with a panel of experts from WMOs, TSOS and REs participants in EURAD.

3.1.2. Timing of the different work packages and their components

WP1- Programme Management Office (PMO), including Dissemination

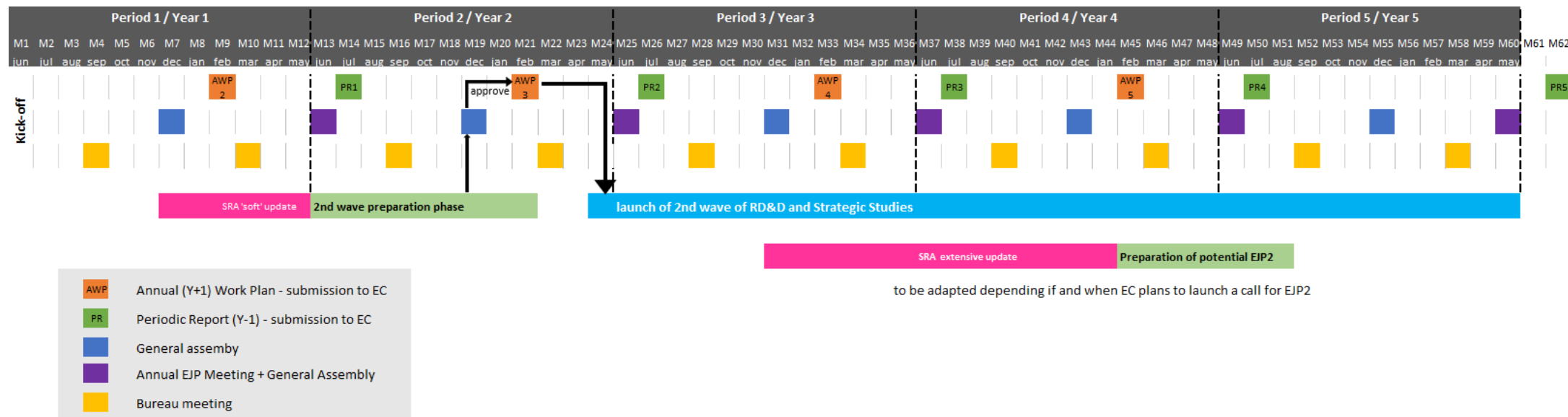
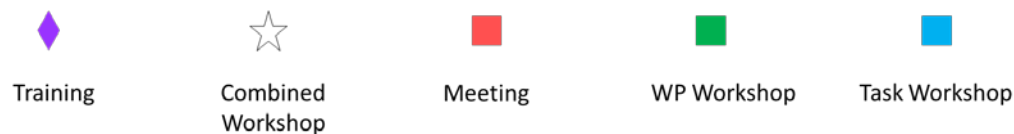


Figure 5 – EURAD Programme Management timing

The breakdown of WPs into tasks and subtasks and the timing of each is included in the diagrams below. Tasks are denoted 'TX' and subtasks are denoted as 'TX.X'. The timing of deliverables is included using notation of 'DX.X'. The final column shows the extent to which the activities will be complete within the first year, expressed as a percentage.

Legend



WP 2 – Assessment of Chemical Evolution of ILW and HLW Disposal Cells (ACED)

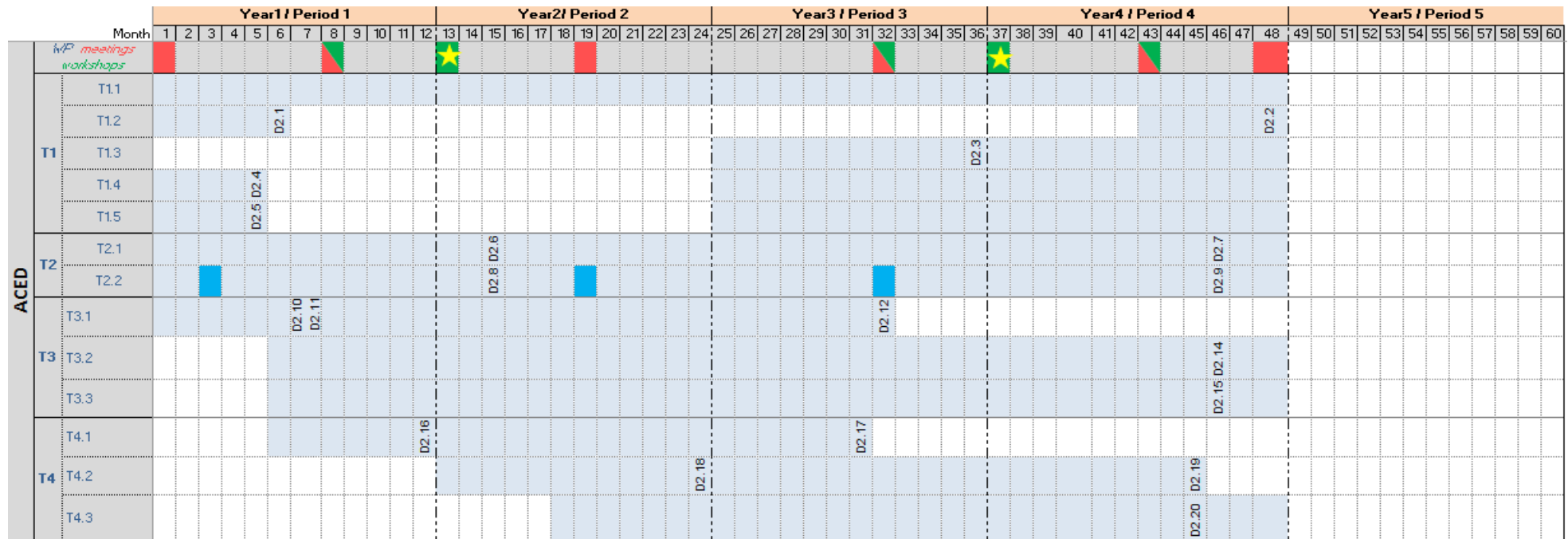


Figure 6 - Timing of WP2-ACED

WP 3 – Cement-Organic-Radionuclide-Interactions (CORI)

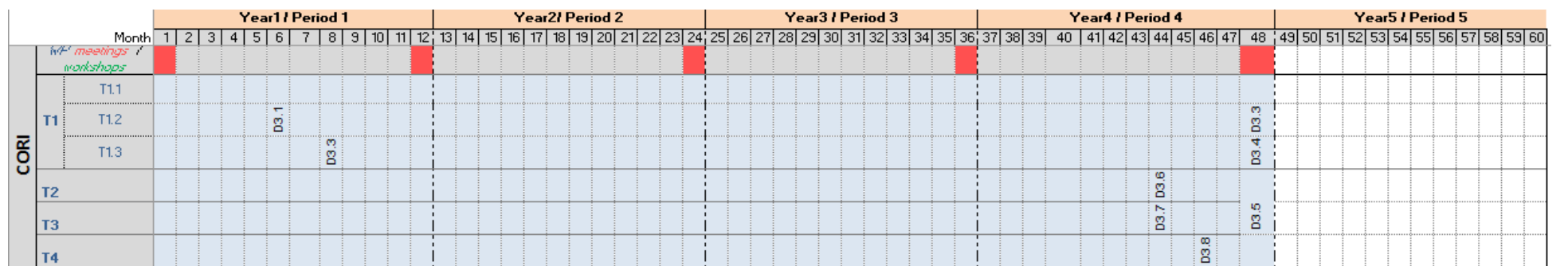


Figure 7 - Timing of WP3-CORI

WP 4 – Development/improvement of numerical methods & tools for modelling coupled processes (DONUT)

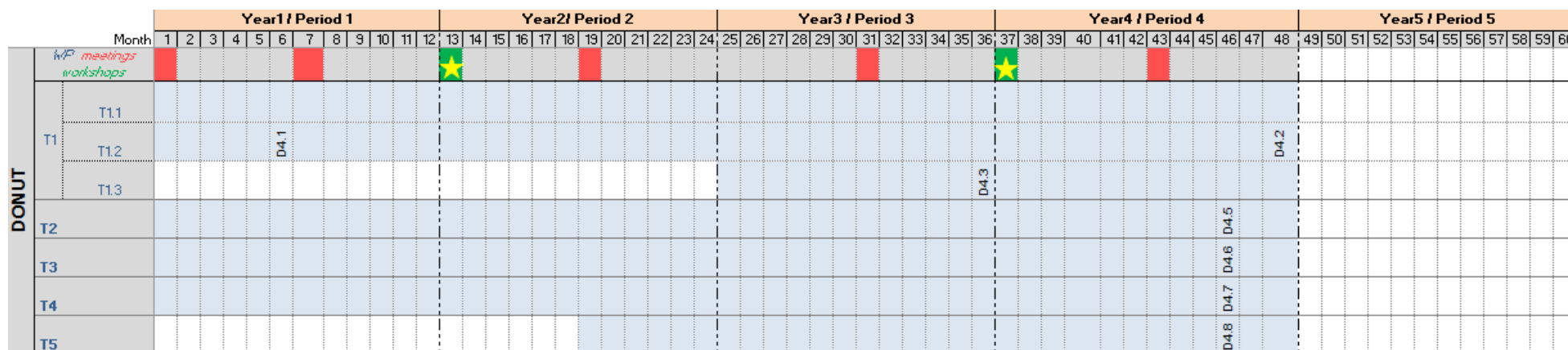


Figure 8 - Timing of WP4-DONUT

WP 5 – Fundamental understanding of radionuclide retention (FUTuRE)

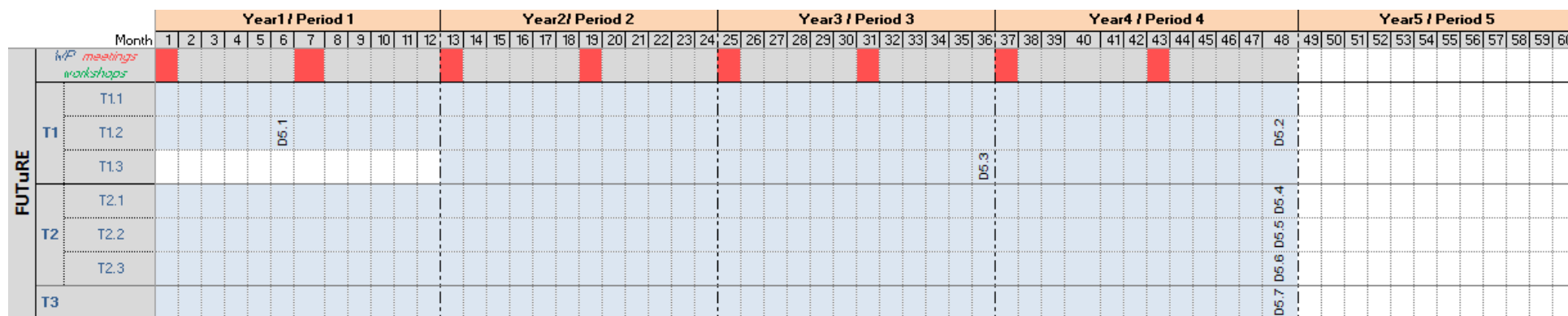


Figure 9 - Timing of WP5-FUTuRE

WP6-Mechanistic understanding of gas transport in clay materials (GAS) and WP7-Influence of temperature on clay-based material behaviour (HITEC)

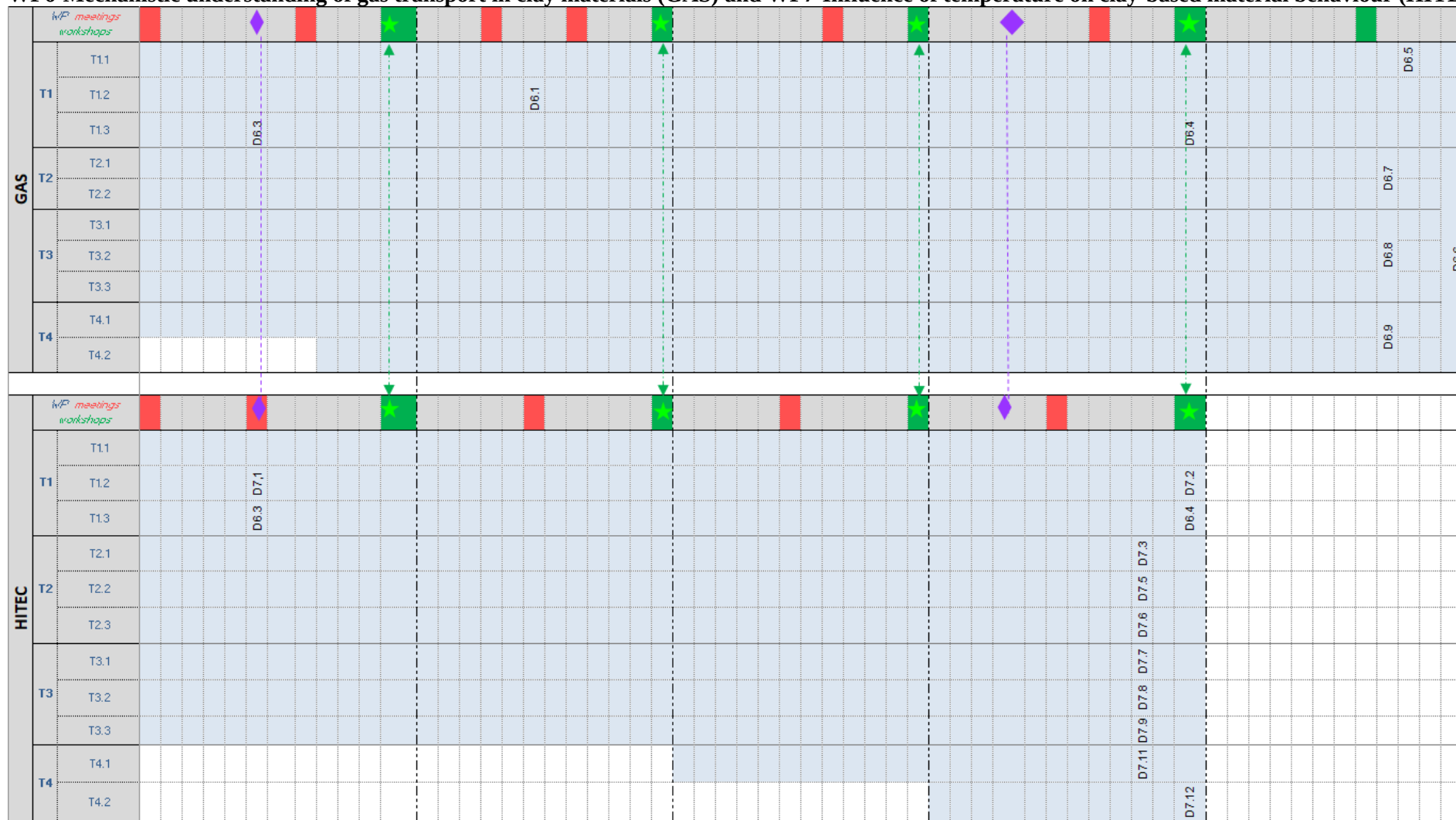


Figure 10 - Timing of WP6-GAS and WP7- HITEC

WP 8 – Spent Fuel Characterization and Evolution Until Disposal (SFC)

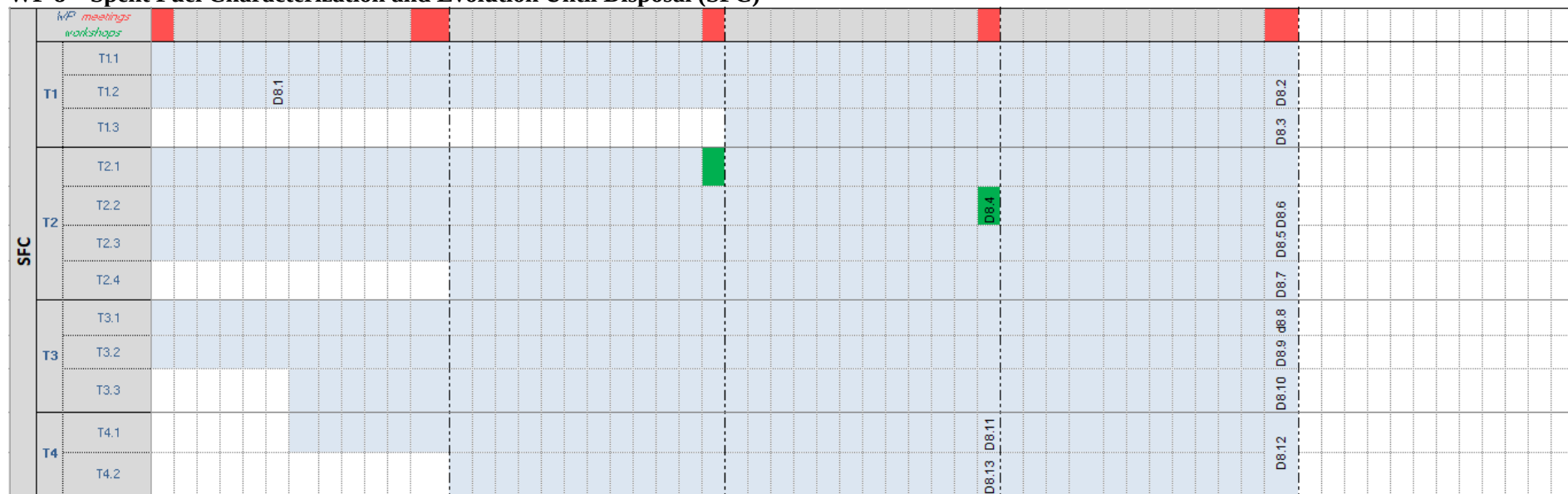


Figure 11 - Timing of WP8-SFC

WP 9 – Waste management routes in Europe from cradle to grave (ROUTES)

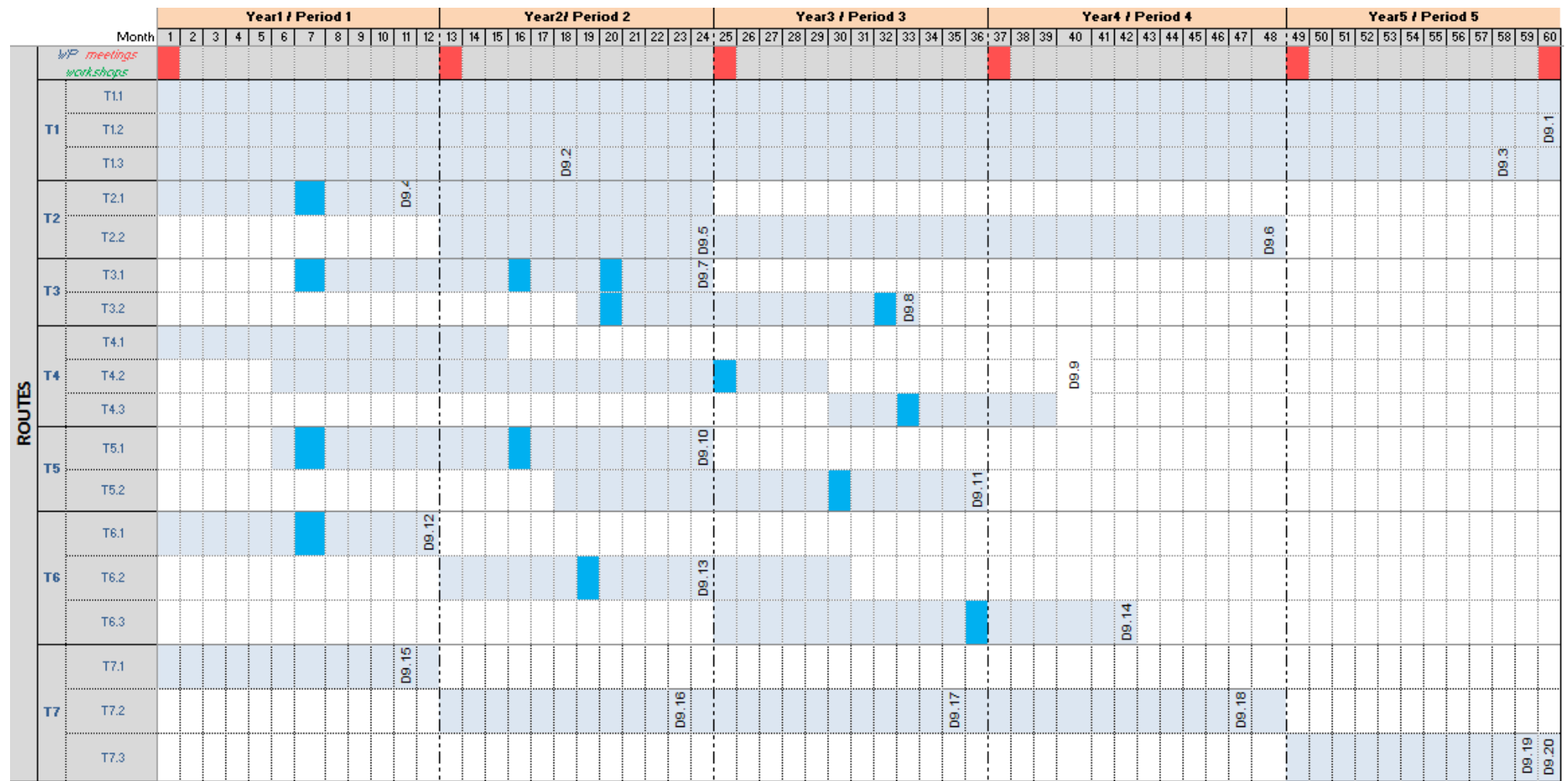


Figure 12 - Timing of WP10-ROUTES

WP10 – Uncertainty Management multi-Actor Network (UMAN)

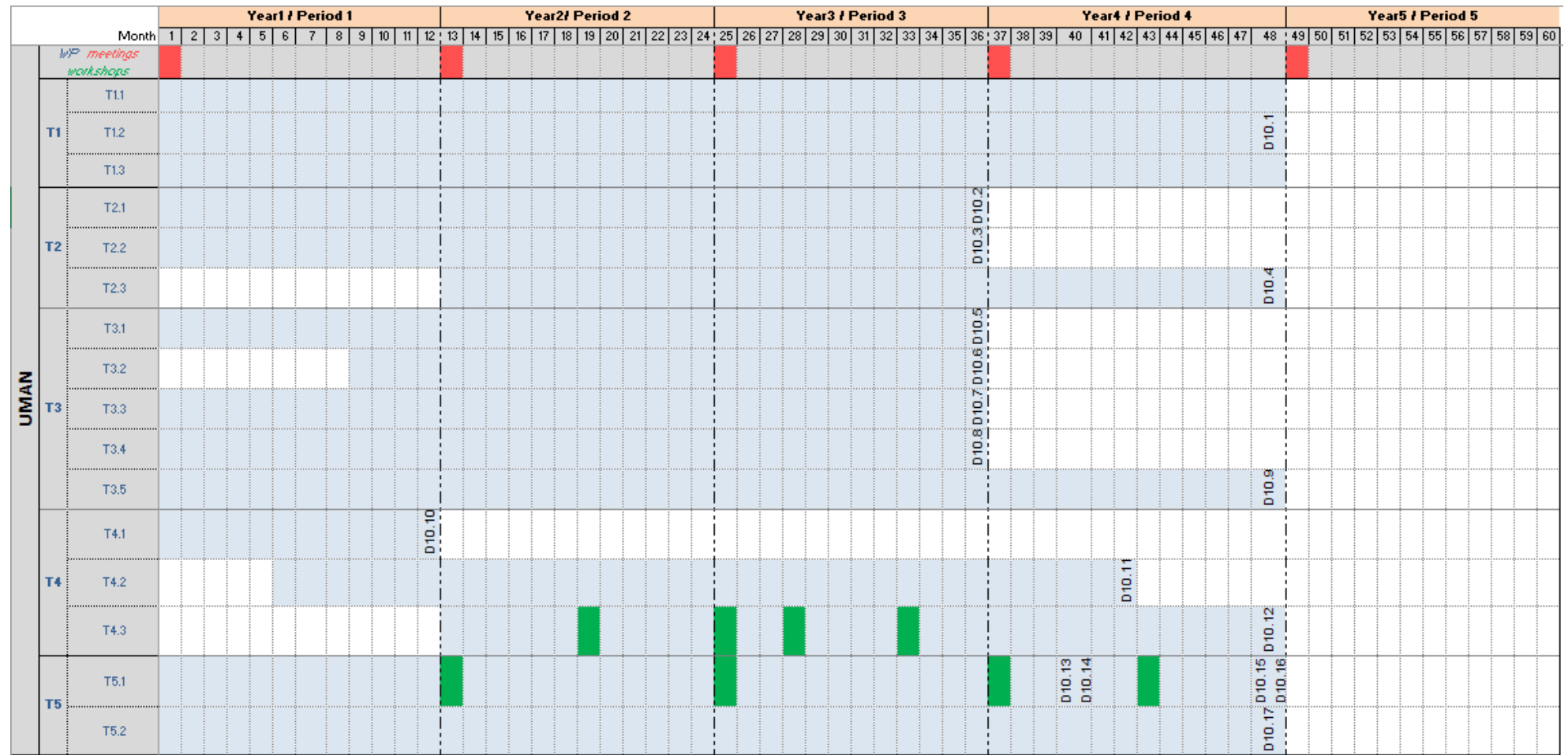


Figure 13 - Timing of WP11-UMAN

WP11 – State-of-Knowledge (SoK)

[illegible]

Figure 14 - Timing of WP12- SoK

WP12 – Guidance

[illegible]

Figure 15 - Timing of WP12-Guidance

WP13 – Training/Mobility

[illegible]

Figure 16 - Timing of WP13-Training/Mobility

3.2. Management structure, milestones and procedures

The overall EURAD-1 organisation can be seen in the Figure below.

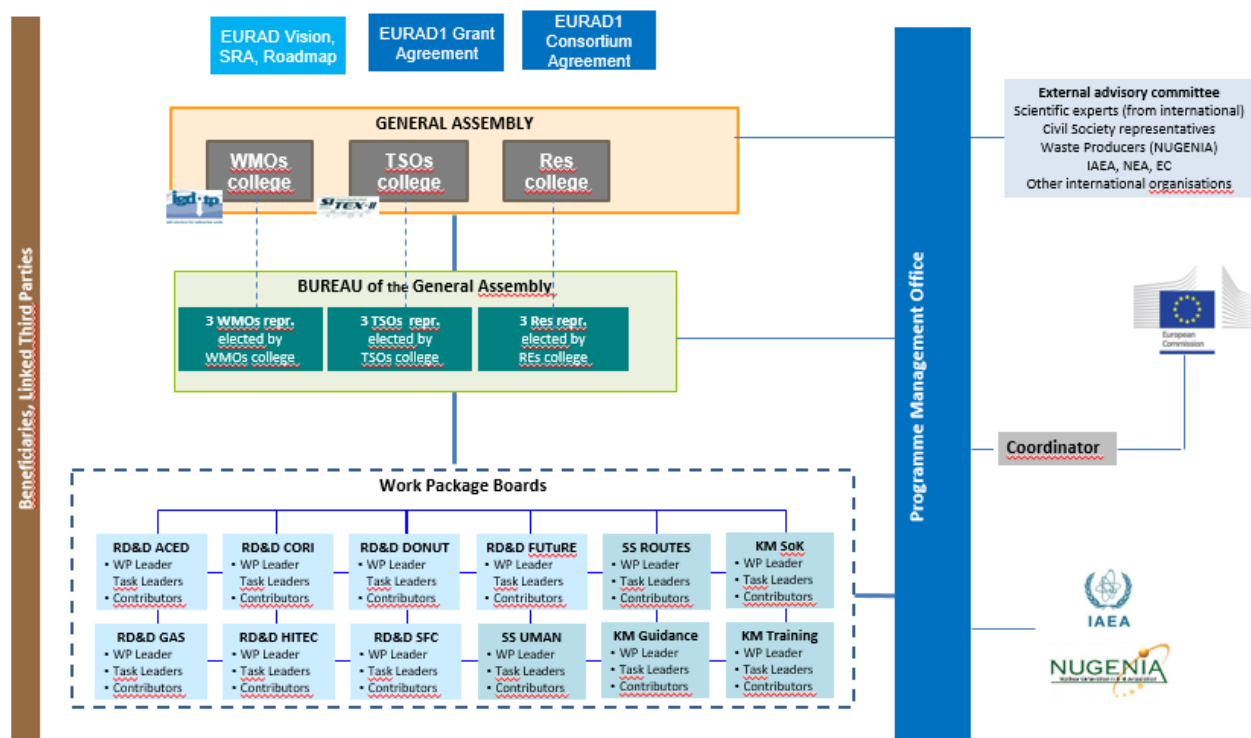


Figure 17 -Governance of the EURAD-1

The **General Assembly** is the ultimate decision-making body of the EURAD consortium. It is responsible for agreeing the strategy of EURAD in line with the content of the Vision, SRA/Roadmap and the Euratom Work Programme. It is composed of one representative of each Beneficiary (Mandated organisations). Beneficiaries fall into one of the three following colleges: Waste Management Organisations (WMOs), Technical Support Organisations (TSOs) and Research Entities (REs). Each category has its own **college** within the General Assembly: WMOs college, TSOs college and REs college⁴.

The General Assembly shall be free to act on its own initiative to formulate proposals and take decisions, following preview with the Bureau and/or Programme Management Office. In addition, proposals made by the Bureau and by the Programme Management Office shall be considered and decided upon by the General Assembly.

The General Assembly shall meet regularly (at least twice a year). The members of the Bureau and the PMO shall also participate in the General Assembly meetings. It is anticipated that the WP Leaders and the CS representative shall be invited as observers, however the General Assembly reserves the right to call closed meetings, if required.

The General Assembly shall establish a **Bureau**. The Bureau is accountable to the General Assembly. It proposes documents and decisions to be taken by the General Assembly. It acts on behalf of the General Assembly in close interactions with the Programme Management Office during the elaboration of proposals, for subsequent decision by the General Assembly. The Bureau shall be composed of a total of nine representatives; 3 elected by each General Assembly.

⁴ The establishment of the colleges is meant to be compatible with the boundary conditions of independence (Maintenance of Independence principle) between the “expertise function” (fulfilled by TSOs and by some Research Entities) and the “implementer function” (fulfilled by WMOs). It shall allow verification that the positions/decisions of the GA are inclusive in terms of actors (Inclusiveness principle).

- The WMOs College appoints its three Bureau representatives (including one representative from a country with early stage/ small RWM programme).
- The TSOs College appoints its three Bureau representatives (including one representative from a country with early stage/small RWM programme).
- The REs College appoints its three Bureau representatives (including one representative from a country with early stage/small RWM programme).

The Bureau members shall represent the interest of their respective community and not the interest of their own organisation or country. The composition of the Bureau shall be regularly reviewed/re-elected for suitability of roles, responsibilities and membership (at least by mid-term of the first 5-year implementation). This shall be done through consultation with each of the Colleges and any changes approved by the General Assembly.

Participation of a CS Expert (facilitator) in Bureau meetings as Observer

A representative from an organisation acting as CS Expert (LTP) may be invited by the bureau in a number of bureau meetings to express CS views on the activities to develop by the EJP. He/she will be designated by the CSO group.

The aim is to enable CSOs through one of their CS Expert to express their views during the update of the Strategic Research Agenda/Roadmap and the definition of future waves of activities. The ambition of the EURAD Consortium is to establish effective dialogue with Civil Society in order to enhance mutual on the RD&D needed to develop safe solutions in the processing and disposal of radioactive waste.

If the Chairperson of the Bureau deems it necessary, or on request of a Bureau member, the Bureau may, regarding either all or part of the agenda, be convened as a closed session where participation may be limited to the Bureau members.

The **Programme Management Office (PMO)** is in charge of scientific and technical coordination of the implementation of the programme, as well as the day-to-day management and communication activities. It is responsible to the General Assembly for the overall top-level planning, coordination and implementation of the EURAD Work Plan in line with the strategy agreed by the General Assembly. It interacts with the EC and key stakeholders: national programmes, international organisations/ programmes, Civil Society Organisations, science/policy interface.

The PMO is housed in the premises of the Coordinator [**Andra**] which is the legal entity acting as the intermediary between the Parties and the European Commission. For the first 2,5 years (except for [**JRC**] who will be involved in the PMO over the 5 years), staff from [**CNRS**], [**RWM**], [**IRSN**] and [**JRC**] will participate in the PMO. The PMO shall organise regular meetings gathering all the WP Leaders to ensure interactions between the projects and ensuring joint programming of activities. A dedicated Work Package is established for the activities of the PMO. In addition, the PMO shall be reinforced with a Chief Scientific Officer that shall act as a EURAD high-level spokesperson with a recognized broad and high-level strategic overview, able to contextualize EURAD progress and results vis-a-vis the Roadmap, i.e. linking EURAD scientific/technical/strategic outcomes to milestones typical of different phases of a RWM programme. Such a role shall be given on a rolling basis, e.g. every two years.

For each technical Work Package a **Work Package (WP) Board** is set-up. It is composed of the Work Package Leader and the task leaders. The WP Board ensures that the WP is progressing according to the agreed specifications, milestones and planning. The WP Board is also responsible for reporting the work progress, any WP deliverables and eventual modifications of the WP work plan to the Programme Management Office.

External advisory board (EAB) advises the General Assembly on strategic and implementation issues related to the EURAD and its coherence with respect to the Strategic Research Agenda and Vision. The EAB is composed of scientific and technical experts at international level, Civil Society Expert (external to EURAD, e.g. a social scientist or CS expert outside Europe), IAEA representative, NUGENIA and other potential international organisations, nuclear safety authorities' representatives (through WENRA and

ENSREG networks). The constitution of the EAB shall be approved during the first General Assembly meeting.

The EAB shall be invited to the annual meeting and shall provide external advice and recommendations for the implementation of EURAD.

Conditions for Participation

The beneficiaries of the Joint Programme have received a mandate by their National Programme owner to participate in the JP implementation phase (the mandate shall confirm that organisations are responsible for managing/implementing a RWM programme and/or managing/ implementing a RD&D programme needed for implementation). The Joint Programme assumes no responsibilities for maintenance or impact of the National Programme. The Joint Programme is complementary to Member-States National Programme, and the interactions between the two are managed via the national mandate. This includes the preservation of the independence and role of Beneficiaries in the national-decision making process.

According to Article 6 of the 2011/70/EURATOM directive, Member-States shall ensure that the competent regulatory authority is functionally separated from any other body or organisation concerned with the management of spent fuel and radioactive waste, in order to ensure effective independence from undue influence on its regulatory function. This requirement has several implications for the expertise function which is aimed at providing the technical and scientific basis for supporting the decision made by the regulatory function. Arrangements must therefore be made by the Member-States National Programme to maintain the independence role of potentially different Joint Programme participants. Regarding the Joint Programme, the use and interpretation of results, (produced by the Joint Programme) in the context of the national geological disposal programme is the respective responsibility of the WMOs and TSOs.

3.3. Consortium as a whole

EURAD participants are those organisations with scientific and technical responsibilities and a national mandate for research in radioactive waste management, including disposal. This includes the implementer, the regulatory expertise function, and those with scientific and technical responsibilities and a national mandate for research and development in radioactive waste management in their respective countries.

As of today, 52 organisations and 23 countries (21 EU Member-States and 2 Associated Countries) have received a mandate by their National Programme owner to participate as “Mandated Actors” (i.e. Participants) in EURAD (See List of EURAD Mandated Actors under Appendix Founding Document). This includes:

- **Waste Management Organisations (WMOs)** – have ultimate responsibility for the implementation of geological disposal (which includes the management of a supporting RD&D programme), and for some the wider remit of RWM (including waste characterisation, treatment and packaging). WMOs from across Europe form a core part of the Joint Programme and provide a driving force for what is needed for successful and practical implementation from an industrial perspective. WMOs have established a network and coordination framework for RD&D needs of the implementers of geological disposal at the European level via the Implementing Geological Disposal Technology Platform (see, [IGD-TP](#));
- **Technical Support Organisations (TSOs)** – carrying out activities aimed at providing the technical and scientific basis for supporting the decisions made by a national regulatory body⁵. As safety cases for waste processing, storage and geological disposal develop, so too does the safety case review and independent scrutiny responsibility by regulatory organisations in the framework of the decision-making process. This requires specific skills from the regulatory expertise function undertaken by safety authorities, regulators, and their technical support organisations (TSOs). Several TSOs, together with

⁵ It is noted that the distinction between TSOs and REs in several Member States is a somewhat grey area as several Research Entities also fulfil (at least partially) an expertise function in their country and therefore also meet the conditions associated with the terms of a “TSO”.

other organisations fulfilling a regulatory expertise function and CSOs have established the [SITEX](#) network to support independent technical expertise in the field of safety of geological disposal of radioactive waste; and

- **Research Entities (REs)** – working to different degrees on the challenges of RWM including disposal (and sometime in direct support to implementers or WMOs or TSOs), under the responsibility of Member-States. This includes national research centres, some research organisations and some universities that could also be funded by other sources. RE's provide scientific excellence and leading-edge research on basic components and generic processes in relation to the management of radioactive waste, and therefore represent a large proportion of the contributions to the Joint Programme.

National RWM programmes involved in EURAD cover a broad spectrum of stages of development and level of advancement, particularly with respect to their plans and national policy towards implementing geological disposal ('Advanced Stage Programme', 'Early Stage Programme'). Programmes differ significantly depending on the national waste inventory, with some Member-States only responsible for relatively small volumes of medical and research reactor-derived wastes ('Small Inventory Programme'), compared to others that have comparatively large and /or complex waste inventories derived from large nuclear power (and fuel reprocessing) and defence programmes. Programmes also differ significantly in the way in which they are managed, particularly with respect to the national policy and socio-political landscape with respect to long-term storage solutions and geological disposal.

Regardless of size and stage of implementation, all Member-States are responsible for the safe management of radioactive waste and are required to report periodically on the status of their National Programme (See, [Waste Directive](#)).

3.4. Resources to be committed

As explained in introduction of Section 3 Implementation, and according to the EURATOM WP2018 call, the Joint Programme shall remain flexible to include new activities in order to be as needs-driven as possible and to allow later inclusion of new organisations that would be mandated during the course of an implementation phase.

Under the EURAD first implementation phase (EURAD-1), we propose to ensure this by allocating about 70% of the available RD&D/Strategic Studies budget to RD&D/Strategic Studies WPs/tasks that shall start at Month 1. The not allocated budget be allocated to existing or new WPs/tasks that will be approved by the General Assembly during the course of EURAD-1 and integrated in the Annual Work Plan 3.

For KM WPs 46% of the budget has been allocated. The remaining 54% of the budget will be allocated on an annual basis.

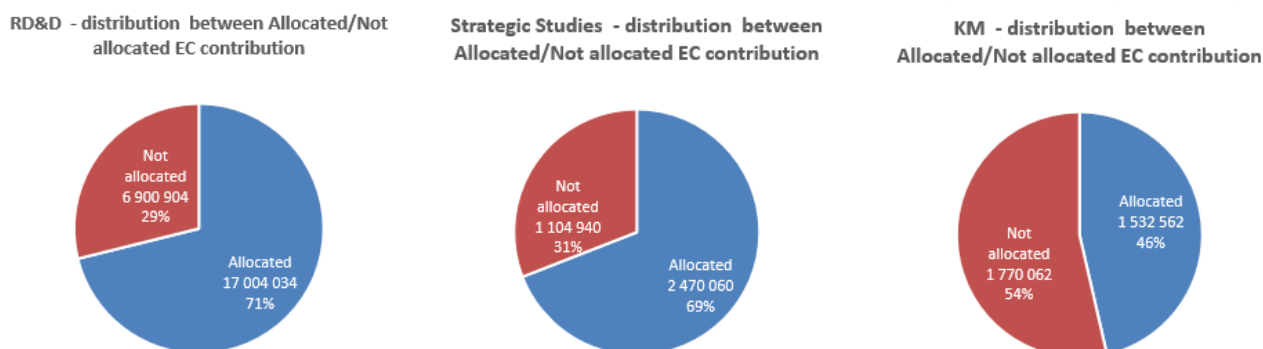


Figure 18 – Distribution of EC contribution between Allocated and Not Allocated budget for RD&D, SS an KM

3.4.1. Overview of total eligible costs/EC requested contribution

Table 2 – overview of total eligible costs/EC requested contribution (allocated and not allocated budget) per categories of WP and per categories of activity

Allocated budget – « first wave »												
	KM activities		RDD activities		SS activities		Administration		ICS activities		Total	
	Total	EC requested contribution	Total	EC requested contribution	Total	EC requested contribution	Total	EC requested contribution	Total	EC requested contribution	Total	EC requested contribution
RDD WPs	497 125	248 563	34 208 357	16 821 630							34 705 482	17 070 193
SS WPs					3 259 570	2 281 474			227 369	193 429	3 486 939	2 474 903
KM WPs	1 820 515	1 177 708	0						0		1 820 515	1 177 708
PMO WP	182 405	182 405	182 405	182 405	182 405	182 405	1 780 515	1 532 562	264 749	264 749	2 592 478	2 344 524
total	2 500 045	1 608 676	34 390 761	17 004 034	3 441 974	2 463 878	1 780 515	1 532 562	492 117	458 178	42 605 414	23 067 328
Not Allocated budget - (secured under Coordinator budget)												
	KM activities		RDD activities		SS activities		Administration		ICS activities		Total	
	Total	EC requested contribution	Total	EC requested contribution	Total	EC requested contribution	Total	EC requested contribution	Total	EC requested contribution	Total	EC requested contribution
RDD WPs			13 801 808	6 900 904							13 801 808	6 900 904
SS WPs					1 587 317	1 111 122			274 031	191 822	1 861 348	1 302 944
KM WPs	1 416 178	991 324									1 416 178	991 324
PMO WP							237 500	237 500			237 500	237 500
total	1 416 178	991 324	13 801 808	6 900 904	1 587 317	1 111 122	237 500	237 500	274 031	191 822,00	17 316 834	9 432 672
Total budget												
	KM activities		RDD activities		SS activities		Administration		ICS activities		Total	
	Total	EC requested contribution	Total	EC requested contribution	Total	EC requested contribution	Total	EC requested contribution	Total	EC requested contribution	Total	EC requested contribution
RDD WPs	497 125	248 563	48 010 165	23 722 534	0	0	0	0	0	0	48 507 290	23 971 097
SS WPs	0	0	0	0	4 846 886	3 392 596	0	0	501 400	385 251	5 348 287	3 777 847
KM WPs	3 236 693	2 169 033	0	0	0	0	0	0	0	0	3 236 693	2 169 033
PMO WP	182 405	182 405	182 405	182 405	182 405	182 405	2 018 015	1 770 062	264 749	264 749	2 829 978	2 582 024
total	3 916 223	2 600 000	48 192 570	23 904 939	5 029 291	3 575 000	2 018 015	1 770 062	766 149	650 000	59 922 248	32 500 000

3.4.2. Indicative Distribution of EC between the different types of activities

The Figure below shows the initial distribution of EC contribution between the different types of activities, as detailed in Table 8. The distribution of EC contribution between the different types of activities shall not be capped. It can be subject to modification after approval by the General Assembly

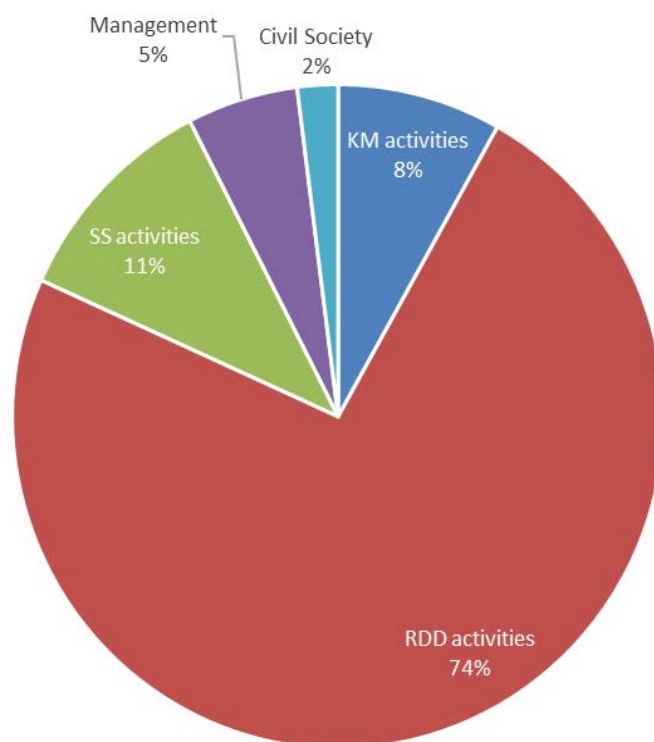


Figure 19 - Distribution of EC contribution between the different types of EURAD Deployment Activities (allocated and not allocated)

3.4.3. Distribution allocated budget between the different types of eligible costs

Figure 28 below shows the distribution of the total allocated budget between the different categories of eligible costs.

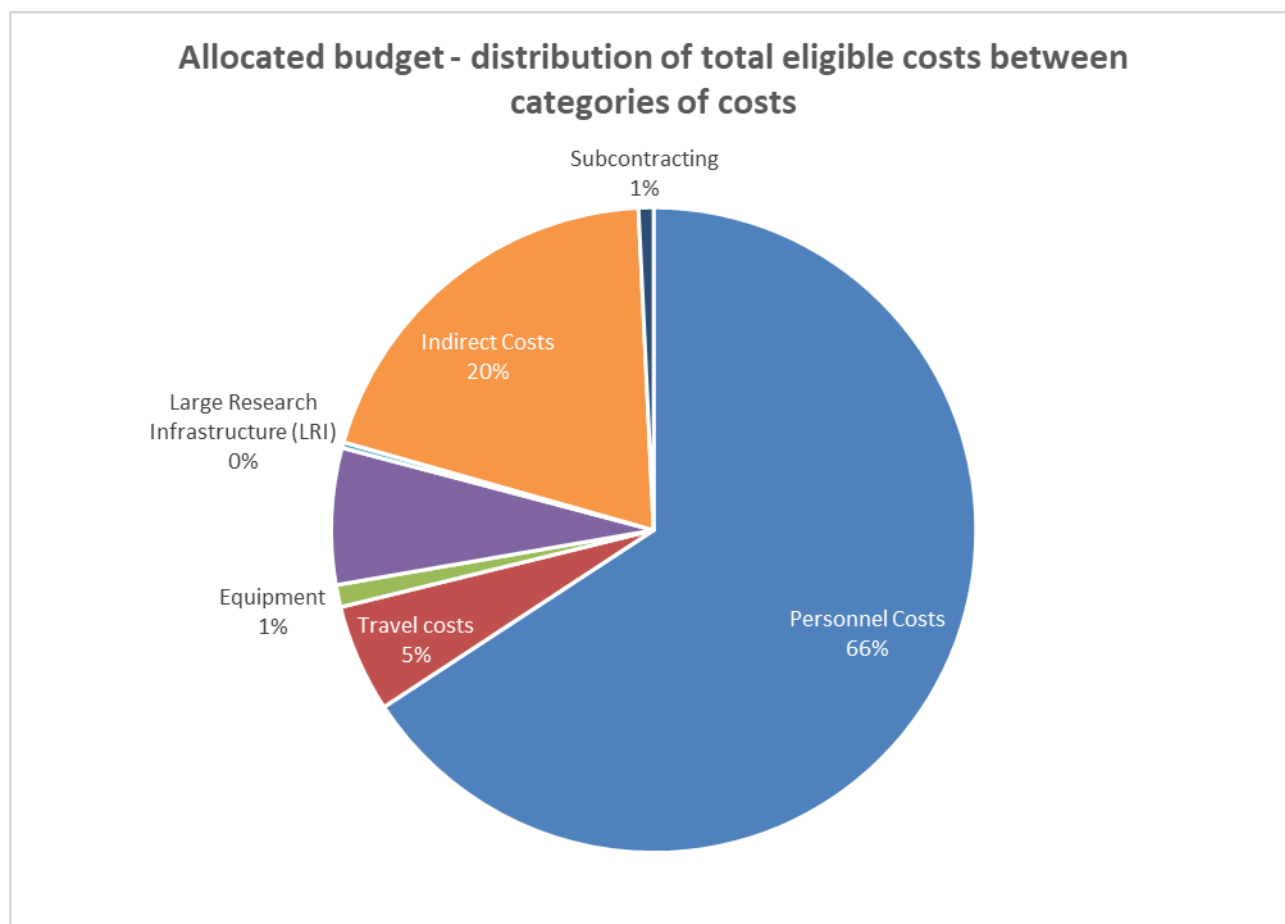


Figure 20 - Allocated budget - distribution of total eligible costs between categories of costs

3.4.4. 'Other direct cost' items (travel, equipment, other goods and services, large research infrastructure)

1/Andra

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for Andra.

2/ARAO	Cost (€)	Justification
Travel	5 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	5 000	

3/BEL V	Cost (€)	Justification
Travel	28 500	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	57 172	Costs for Other goods and services are planned under the following RD&D WPs: - ACED: 17 000€. Consumables and raw materials for the implementation of the new in-situ experiment NE2-2/1 of Task 2. Costs for Other goods and services are planned under the following Strategic Studies WPs: - UMAN: 40 172€. Organization of seminars and workshops of the WP (budget will be transferred to the organizations hosting these workshops/seminars when identified).
Total	85 672	

4/BGE

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for BGE.

5/CEA	Cost (€)	Justification
Travel	68 500	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	231 818	Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - ACED: 116 000€ : it corresponds to consumables for solution and solid analyses (ICPM-MS analysis ; SEM, TEM, Raman, ToF-SIMS) of the various experiments (glass/steel/clay and glass/steel/cement buffer/clay) - DONUT: 2 200€ : Consumables for computer - HITEC: 5 894€ : this cost corresponds to consumables for the several mechanical tests performed on clay host rock - FUTuRE: 37 000€ : it corresponds to consumables necessary for the diffusion experiments (for example radioactive and non-radioactive tracers), and for post-mortem analysis of solid samples (m-XAS, m-XRF, m-LIBs) - CORI: 69 724€ : it corresponds to consumables that are necessary for the migration experiments planned with C-14 radiolabeled organics Costs for <i>Other goods and services</i> are planned under the following Strategic Studies WPs: - ROUTES: 1 000€. organisation of a meeting
Total	300 318	

6/CIEMAT

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for CIEMAT.

7/ChRDI	Cost (€)	Justification
Travel	15 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	1 000	Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - HITEC: 1 000€. Costs for organizing of seminars/meetings, rental of equipment for presentations
Total	16 000	

8/CNRS	Cost (€)	Justification
Travel	167 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	109 922	Equipment costs are planned under the following RD&D WPs: - GAS: 20 000€ - Characterization of the nano-porous structure properties and its effect on H2 sorption, Raman Spectroscopy, X-ray diffraction, QUENS, CT, TEM... - CORI: 10 000€ - HITEC: 30 000€ - Triaxial cell transparent to X-ray under high Temperature and confining pressure - SFC: 49 922,1€ - Experiment approach for study of degradation process of spent nuclear fuel: Cutting-edge synchrotron methods at the Rossendorf beamline (i.e. high resolution diffraction, x-ray absorption spectroscopy and x-ray emission spectroscopies)
Other goods and services	396 738	Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - ACED: 33 500€ - Consumables and samples for in situ experiment for mineralogical, chemical and transport properties evolution, chemical and mineralogical analyses of solid phases (X-ray tomography, XRD, SEM EDS, Raman spectrometry and TEM) - DONUT: 24 560€. CPU for Diffusion Poisson Coupled Model and new numerical methods. Workshops/meetings. - GAS: 132 700€. Characterization the nano porous structure properties, gas sorption desorption and propagation process in a large range of pressure, Raman Spectroscopy, X-ray diffraction, QUENS, CT, TEM + meetings and workshop organizations - HITEC: 54 550€. Consumables and samples of Boom Clay, Opalinus Clay, Callovo Oxfordian clay for X-ray measurement under high Temperature and confining pressure - FUTuRE: 100 428€. Preparation of clay samples, consumable sorption and redox experiment in a specifically designed chemical reactor - CORI: 51 000€. Consumable and supplies for alpha and gamma radiolytic degradation pf PCE
Total	673 660	

9/COVRA	Cost (€)	Justification
Travel	48 500	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	15 100	Costs for Other goods and services are planned under the following RD&D WPs: - ACED: 12 800€. Certified concrete samples have been exposed to geological representative clay media for several years at start of ACED. To support chemical evolution models, these samples are experimentally investigated by Jülich, ZAG and COVRA. Each organisation performs different chemical analysis to obtain a coherent image. COVRA's in-house laboratory equipment will also be used. The costs are for the sample preparation and measurement of chemical elements using ICP. - DONUT: 300€. DONUT is WP on the development and improvement of numerical methods and tools for modelling of coupled processes. COVRA will prepare benchmarks for the evaluation of the methods and numerical tools described considering their relevance in the scope of multi-physical assessment from the point of view of the implementer. Specifically COVRA plans to develop a benchmark for numerical models with steep chemical gradients across solid interfaces. This contribution can be of help with the evaluation of the efficiency and computational cost of different numerical models/solvers for models with a steep chemical gradient across interfaces between solid materials. Costs for Other goods and services are planned under the following Strategic Studies WPs: - ROUTES: 2 000€. The WP will describe and compare the different approaches to characterization, treatment and conditioning and to long-term waste management routes, and identify opportunities for collaboration between MS (Member-States). It will identify safety-relevant issues and their R&D needs associated with the waste management routes (cradle to grave), including the management routes of legacy and historical waste, taking into account that programmes are at different stages of development, have with different amounts and types of radioactive waste to manage and considering interdependencies between the routes. COVRA will coordinates the task to evaluate the potential for developing and using shared technologies and facilities.
Total	63 600	

10/FTMC	Cost (€)	Justification
Travel	24 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	9 000	Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - CORI: 9 000€ In Task 2, FTMC will perform hydrolytic degradation of PVC/Cellulose and identification of degradation products. For this task the material (PVC, cellulose) as an object of research, chemicals and goods for hydrolytic degradation are needed. Ion exchange/gas chromatography sorbents, pipette tips, centrifuge tubes, pH electrode will also be needed for detection of degradation products. In Task 4, for study of the competitive effect of Fe(II)/Fe(III) onto radionuclides (Am-243 and Pu-242) sorption in the presence of organics (low molecular weight organic acids / phthalate / adipate) in contact with CEM I/ CEM V cement-based materials (pH 12.5) FTMC must purchase organics and radionuclide solutions (Am-243 and Pu-242). Laboratory glass, goods for filtration (filters) and centrifugation (centrifuge tubes) will be needed. For the examination of chemical and phase composition of the cement the service at X-ray spectroscopy and XRD will be need during experiments.
Total	33 000	

11/CV REZ	Cost (€)	Justification
Travel	8 500	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	20 000	Equipment costs are planned under the following RD&D WPs: - CORI: 20 000€ Task 2 and 3: gamma radiation source Cobalt-60 with the half-life 5 years. Total price of the source is approximately 80 000 €. Whole CORI contribution (20 000€) will be used for the project issues.
Other goods and services	13 000	Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - CORI: 13 000€ This money will be used for the material, necessary for irradiation and testing of the superplasticizers (Task 1) and cement samples (task 2), e.g. ducts for gasses, gauges, glass, cables or so on.
Total	41 500	

12/DEKOM	Cost (€)	Justification
Travel	8 500	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	8 500	

13/EEAE	Cost (€)	Justification
Travel	8 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	8 000	

14/ENRESA

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for ENRESA.

15/JUELICH

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for JUELICH.

16/GRS

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for GRS.

17/IAE	Cost (€)	Justification
Travel	5 500	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars); to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	5 500	

18/INCT	Cost (€)	Justification
Travel	7 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	1 000	Costs for <i>Other goods and services</i> are planned under the following Strategic Studies WPs: - ROUTES: 1 000€. Cost of organization of internal meetings, small consumables, dissemination of information between Polish stakeholders (webpage, posters, leaflet).
Total	8 000	

19/IRSN	Cost (€)	Justification
Travel	128 500	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	10 000	Equipment costs are planned under the following RD&D WPs: - GAS: 10 000€. Development of a special set-up consisting on a transparent PMMA (Polymethyl methacrylate) cell will be used to perform a microstructural analysis of the mixture at initial state and during gas /water injections by X-ray micro-tomography and laboratory consumables for the mock-up test of gas injection into highly heterogeneous bentonite pellet-powder sample.
Other goods and services	161 000	Costs for <i>Other goods and services</i> are planned under the following WP: - PMO: 80 000€. Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - ACED: 64 500€. Laboratories materials and consumables. - DONUT: 1 500€. Laboratories materials and consumables. Costs for <i>Other goods and services</i> are planned under the following Strategic Studies WPs: - ROUTES: 15 000€. Organisation of workshops and meetings.
Total	299 500	

20/IST-LPSR	Cost (€)	Justification
Travel	7 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	7 000	

21/IST-ID	Cost (€)	Justification
Travel	7 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	4 000	Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - ROUTES: 4000€. Organisation of meetings.
Total	11 000	

22/JSI	Cost (€)	Justification
Travel	67 500	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	98 400	Costs for <i>Other goods and services</i> are planned under the following WP: - PMO: 28 400€. Organisation of meetings. Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - ACED: 8 000€. Chemicals, gases for instruments, standards, laboratory consumables. - CORI: 62 000€. Chemicals, gases for instruments, standards, laboratory consumables. - SFC: 4 000€. Chemicals, gases for instruments, standards, laboratory consumables.
Total	165 900	

23/JRC	Cost (€)	Justification
Travel	70 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	208 631	Costs for Other goods and services are planned under the following WP: - PMO: 2 000€. Organisation of meetings. Costs for Other goods and services are planned under the following RD&D WPs: - SFC: 206 631€. Waste and consumables for implementation in SFC WP
Total	278 631	

24/KIT

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for KIT.

25/LEI	Cost (€)	Justification
Travel	37 500	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	2 000	Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - DONUT: 2 000€. Consumables and supplies, dissemination and conference fee, open acces publication fee
Total	39 500	

26/MTA EK	Cost (€)	Justification
Travel	24 900	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	18 500	Equipment costs are planned under the following RD&D WPs: - ACED: 6 500€. Encapsulation machine, boxes for the in-situ experiments (with temperature, humidity pH control), access to study the surface of the containers (exp. wet catalytic oxidation, corrosion and other redox processes on steel container surfaces). - DONUT: 8 000€. Rental of CPU run-time for numerical simulations; (exp. GPU-CPU 1U Server with 2 × Tesla C2050 + 2x Intel Xeon X5550, 96 GB RAM). - SFC: 4 000€. Rental of Ar, N2, H2 gas cylinders, in-situ cells, for irradiation test, special capsules.
Other goods and services	26 600	Costs for Other goods and services are planned under the following RD&D WPs: - ACED: 4 000€. Consumables: radioisotopes, chemicals, laboratory material for supporting experimental work, steel containers for several experiments. Dissemination cost (workshops, meetings); to present the results. - DONUT: 6 000€. Dissemination cost (workshops, meetings, publications); to present the results of the comparison for different programming modules (CUDA, OpenCL, OpenMP, OpenACC) and optimize a module for a cost effective and reliable numerical method. - SFC: 9 000 EUR. Consumables like: thermocouples, sealing rings etc... - FUTuRE: 7 600€. Consumables: radioisotopes in solution form, chemicals, laboratory material for supporting experimental work
Total	70 000	

27/NAGRA

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for NAGRA.

28/NCSR	Cost (€)	Justification
Travel	19 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	1 000	Costs for <i>Other goods and services</i> are planned under the following Strategic Studies WPs: - ROUTES: 1 000€. Costs for organising a meeting
Total	20 000	

29/NES	Cost (€)	Justification
Travel	7 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	1 000	Costs for <i>Other goods and services</i> are planned under the following Strategic Studies WPs: - ROUTES: 1 000€. Costs for organising a meeting
Total	8 000	

30/NJF	Cost (€)	Justification
Travel	5 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	5 000	

31/NRG

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for NRG.

32/ONDRAF/NIRAS

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for ONDRAF/NIRAS.

33/Posiva	Cost (€)	Justification
Travel	14 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	14 000	

34/PSI

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for PSI.

35/PURAM	Cost (€)	Justification
Travel	12 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	12 000	

36/RATEN	Cost (€)	Justification
Travel	27 500	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	29 500	Costs for Other goods and services are planned under the following RD&D WPs: - FUTURE: 13 900€ - purchasing 99Tc standard solution, pure clay minerals, and other lab ware. - CORI: 14 600€ - purchasing 59Ni and organic 14C radioactive solutions, and other lab ware Costs for Other goods and services are planned under the following Strategic Studies WPs: - ROUTES: 1 000€ (cost for hosting one meeting)
Total	57 000	

37/RWM	Cost (€)	Justification
Travel	44 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	44 000	

38/SCK•CEN	Cost (€)	Justification
Travel	94 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	8 000	Equipment costs are planned under the following RD&D WPs: - GAS: 8 000€. Equipment costs: pressure sensors, diffusion cells, Swagelok material, magnetic coupled gear pumps, pump heads
Other goods and services	194 145	Costs for Other goods and services are planned under the following RD&D WPs: - ACED: 30 000€ - o Organisation of ACED WP meetings - o Computer and software licences, open access publications - DONUT: 3 445€ - o Computer and software licences, open access publications - FUTuRE: 17 000€ - o Lab consumables, analysis costs, radioactive spike solutions, diffusion cells - CORI: 143 700€ - o ISA and carbohydrate measurements - o 24 stainless steel irradiation containers with Swagelok material - o 24 teflon containers (2L) for chemical degradation studies - o Purchase of pure alpha and beta ISA
Total	296 145	

39/SKB	Cost (€)	Justification
Travel	36 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	20 000	Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - SFC: 20 000€. Costs for other goods and services are needed to arrange workshops and meetings planned for in the SFC work package
Total	56 000	

40/SSTC NRS	Cost (€)	Justification
Travel	47 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	47 000	

41/STUBA	Cost (€)	Justification
Travel	5 500	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	5 500	

42/SÚRAO	Cost (€)	Justification
Travel	187 500	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	58 000	Equipment costs are planned under the following RD&D WPs: - ACED: 8 000€ (UJV). Modification of existing experimental apparatus for evaluation of specific issues, computing technology - GAS: 8 500€ (UJV). Migration cells, GDS pumps, possible modification of existing experimental apparatus. - HITEC: 16 500€ (CU, UJV). Modification of existing experimental apparatus, sensors (5000€ for UJV) - FUTuRE: 15 000€ (UJV). Migration cells; GDS Pumps; Shielding; equipment for tracer tests - CORI: 10 000€ (UJV). Experimental apparatus and cells, pressure pumps, depreciation costs of analytical device
Other goods and services	154 555	Costs for Other goods and services are planned under the following RD&D WPs: - ACED: 10 000€. (UJV). External analyses, software licences, publication costs - DONUT: 12 780€ (SÚRAO, CTU, CU, TUL, UJV). Translation costs, software licences (?) - GAS: 27 500€ (CTU, UJV) Laboratory materials and consumables, maintenance of migration apparatus. - HITEC: 38 875€ (CTU, CU, UJV). Laboratory chemicals and consumables, external analyses (8500€ for UJV) - FUTuRE: 15 100€ (UJV). Radionuclide source purchase; Laboratory chemicals; Maintenance of migration apparatus; External analyses (XRD) - CORI: 50 300€ (CTU, UJV). Radiochemicals, external analyses, laboratory tools and consumables
Total	400 055	

43/SURO	Cost (€)	Justification
Travel	29 500	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	1 000	Costs for <i>Other goods and services</i> are planned under the following Strategic Studies WPs: - ROUTES: 1 000€. Workshop/meetings organisation within T5
Total	30 500	

44/TNO	Cost (€)	Justification
Travel	5 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	5 000	Equipment costs are planned under the following RD&D WPs: - FUTuRE: 5000€. TNO shares its geochemical lab with Utrecht University and Deltares. We need to rent equipment from UU for the experiments foreseen. This will be arranged under the partnership agreement that exists among these three organisations. Additionally, depreciations costs for expensive apparatus and analyses must be booked.
Other goods and services	12 800	Costs for Other goods and services are planned under the following RD&D WPs: - FUTuRE: 12 800€. Chemicals as well as commercially available minerals must be bought for the experimental activities. Besides, small laboratory equipment may be bought.
Total	22 800	

45/TS ENERCON	Cost (€)	Justification
Travel	12 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	750	Costs for Other goods and services are planned under the following RD&D WPs: - DONUT: 750 €. Cost for organisation of a meeting
Total	12 750	

46/TUS	Cost (€)	Justification
Travel	30 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	8 483	Costs for Other goods and services are planned under the following RD&D WPs: - SFC: 683€ - Consumables, supplies, post costs, communication costs, organisation of meetings with experts from other Bulgarian organisations. - DONUT: 7 800€ - Consumables, supplies, organisation of annual workshops and periodical meetings with experts, post and communication costs.
Total	38 483	

47/UCY	Cost (€)	Justification
Travel	10 500	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	10 500	

48/UHelsinki	Cost (€)	Justification
Travel	30 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	64 600	Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - DONUT: 3 000€. Supplies / Computational services - HITEC: 57 600€. (JYFL) Temperature and water flow controlling units. Sample holders and instrumentation for X-ray tomographic experiments / Laboratory instruments and supplies for X-ray tomographic experiments / (GTK) XCT using time (UHelsinki) Laboratory supplies - FUTURE: 4 000. Laboratory supplies and irradiation services
Total	94 600	

49/UKRI-BGS	Cost (€)	Justification
Travel	22 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	238 884	Costs for Other goods and services are planned under the following RD&D WPs: - GAS: 102 430€ - HITEC: 136 454€ This budget covers: ▪ Dedicated cells (isostatic, triaxial, uniaxial) ▪ Flow meters ▪ Consumables for gas injection ▪ Tubing and pressure fittings ▪ Displacement and pressure transducers ▪ Data acquisition ▪ Construction and commissioning of apparatus, ▪ Numerical modelling ▪ Regular lab analyses ▪ Imaging and data processing ▪ Sample Preparation ▪ Petrophysical characterisation
Total	260 884	

50/VTT	Cost (€)	Justification
Travel	59 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	17 000	Costs for Other goods and services are planned under the following RD&D WPs: - ACED: 8 000€. Consumables, publications - HITEC: 9000€. 2 000 € for publication, 2 000 € for meeting organisation costs and 5 000 € for material & consumables
Large research infrastructure	121 942	- SFC: 7 900€ - ACED: 55 458€ - HITEC: 58 584€ LRI cost of VTT Research Facility. The LRI costs are calculated based on working hours of the project and according to VTT's ex-ante assessment of the methodology on Direct Costing for Large Research Infrastructures (LRI), approved by the Commission on 24th February 2015. The Materials, Production & Performance Research Facilities covers wide variety of material R&D laboratories in VTT locations. The laboratories are divided in to subgroups; autoclaves simulating process facilities, electron microscopy laboratory e.g. with high resolution requirement, trailer laboratory for dangerous liquid environments, tribology laboratory including the

		nanoindentation device, accredited non-destructive testing (NDT) laboratory, hotlab for elevated temperatures, creep laboratory for long-term loading, metallographic laboratory, destructive materials testing laboratory, fatigue laboratory and additive manufacturing laboratory with 3D printing devices for metallic materials. The laboratories concentrating on powder technologies and are divided in to two groups; powder manufacturing laboratory and consolidation laboratory e.g. hot isostatic pressing (HIP). The Research Facility provides also equipment for testing and experimental research in the area of vibration and durability in the area of Robotics multi-technology research, development and testing facilities. Centre for Nuclear Safety (CNS) will include class A, B and C facilities for experimental research and handling of radioactive materials. Research facility consists of hot cells and equipment used in CNS. Hot cells that protect employees from radiation are situated in class A laboratory in two separate floors. Equipment that are used to examine the properties of radioactive material samples are located inside the hot cells. Samples are handled behind lead glass utilizing manipulators and cameras. Opening of transport capsules of radioactive materials, storing of radioactive samples and specimens as well as handling of radioactive waste will also occur in class A laboratory. A Comprehensive set of microscopes will be linked to the class A laboratory. VTT's methodology on LRI complies with the clauses of the H2020 Grant Agreement (Capitalised and operating costs of large research infrastructure Article 6.2.D.4, the extent verified during the audit) and therefore, the LRI costs should be considered as direct costs of the project.
Total	197 942	

51/VUJE	Cost (€)	Justification
Travel	5 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	5 000	

3.4.5. Detailed allocated budget per WP and per Participant

WP	Category of cost	TOTAL		Andra		not allocated		ARAO		BEL V		BGE		CEA		CHRD		CIEMAT		CNRS		COVRA	
		Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm
PMO	Personnel costs - task 1 - admin, legal &	426,0	60,0	426,0	60,0																		
	Personnel costs - task 2 - overall S/T	290,9	28,8	21,3	3,0															84,0	6,0		
	Personnel costs - task 3 - Extension/update of	125,5	15,3	71,0	10,0															14,0	1,0		
	Personnel costs - task 4 - Identificaton of	21,3	3,0	21,3	3,0																		
	Personnel costs - task 5 - Internal	85,2	12,0	85,2	12,0																		
	Personnel costs - task 6 - Dissemination	92,0	12,0	71,0	10,0															7,0	0,5		
	Personnel costs - task 7 - International	14,2	2,0	14,2	2,0																		
	Personnel costs - task 8 - Coordination of ICS	158,9	17,0																				
	Total Personnel Costs	1 364,1	150,0	710,0	100,0	150,0														105,0	7,5		
	Travel Costs	229,5		55,0		40,0														40,0			
	meetings	150,4		120,0																			
	Website + Extranet	90,0		90,0																			
	invitation for external experts	170,0		170,0																			
	Envelop for CS group	80,0																					
	Total Other goods & services	490,4		380,0																			
	Total other Direct costs	699,9		435,0		40,0														20,0			
	Total Direct costs	2 064,0		1 145,0		190,0														125,0			
	Total Indirect Costs	516,0		286,3		47,5														31,3			
	Subcontracting -	250,0		250,0																			
	TOTAL Costs	2 592,5		1 681,3		237,5														156,3			
	EC requested contribution	2 344,5		1 681,3		237,5														156,3			

ACED	Personnel costs - Task 1	301,5	32,5	24,8	2,8													6,7	1,5			70,4	5,5
	Personnel costs - Task 2	1 276,3	240,0							42,8	4,0							167,9	49,0	85,9	13,0		
	Personnel costs - Task 3	1 227,9	174,6	215,0	25,6									346,1	62,5				103,6	19,0	38,4	3,0	
	Personnel costs - Task 4	498,4	69,0	26,5	3,0																25,6	2,0	
	Total Personnel Costs	3 303,9	516,1	266,3	31,4					42,8	4,0			346,1	62,5			174,6	50,5	189,5	32,0	134,4	10,5
	Total travel costs	212,5		13,5						5,0				10,0				10,0		22,0		13,5	
		33,0																					
	goods & services	369,0		3,0						17,0				116,0				44,0		33,5		12,8	
	Large Research Infrastructure (LRI)	55,5																					
	Total direct costs	3 973,9		282,8						64,8				472,1				228,6		245,0		160,7	
	Total Indirect Costs	993,5		70,7						16,2				118,0				57,1		61,3		40,2	
	Total subcontracting	140,5																					
	TOTAL BUDGET	5 107,8		353,4						81,0				590,1				285,7		306,3		200,9	
	EC requested contribution	2 553,9		176,7						40,5				295,1				142,9		153,1		100,4	

DONUT	Personnel costs - Task 1	49,0	8,5	19,6	2,5														9,0	1,5		
	Personnel costs - Task 2	1 163,7	262,0	87,8	11,0									144,8	9,5				432,4	74,5		
	Personnel costs - Task 3	515,0	73,0	87,8	11,0																	
	Personnel costs - Task 4	719,9	141,7	79,8	10,0																	
	Personnel costs - Task 5	176,8	33,9	25,0	2,5																7,5	0,6
	Total Personnel Costs	2 624,5	519,1	300,1	37,0									144,8	9,5				441,4	76,0	7,5	0,6
	Total Travel costs	178,5		17,0										5,0					25,0		5,0	
	Total Equipment	8,0																				
	Total Other goods & services	90,7		4,0										2,2					24,6		300	
	Total direct costs	2 901,7		321,1										152,0					491,0		12,8	
	Total Indirect Costs	725,4		80,3										38,0					122,8		3,2	
	Total subcontracting	89,4																				
	TOTAL BUDGET	3 716,5		401,4										190,0					613,8		16,0	
	EC requested contribution	1 858,2		200,7										95,0					306,9		8,0	

		CVREZ		Dekom		EEAE		ENRESA		CPST		FZJ		GRS		IAE		INCI		IRSN		IST-ID		IST-LPSR		JRC	
WP		Category of cost		Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm
PMO	Personnel costs - task 1 - admin, legal &																			17,5	1,8					125,1	12,0
	Personnel costs - task 2 - overall S/T																			12,5	1,3					20,8	2,0
	Personnel costs - task 3 - Extension/update of																										
	Personnel costs - task 4 - Identificaton of																										
	Personnel costs - task 5 - Internal																										
	Personnel costs - task 6 - Dissemination																									10,4	1,0
	Personnel costs - task 7 - International																										
	Personnel costs - task 8 - Coordination of ICS																			147,2	14,8						
	Total Personnel Costs																			177,2	17,8					156,4	15,0
	Travel Costs																			29,5						40,0	
	meetings																									2,0	
	Website + Extranet																										
	invitation for external experts																										
	Envelop for CS group																			80,0							
	Total Other goods & services																			80,0						2,0	
	Total other Direct costs																			109,5						42,0	
	Total Direct costs																			286,7						198,4	
	Total Indirect Costs																			71,7						49,6	
	Subcontracting -																										
	TOTAL Costs																			358,4						248,0	
	EC requested contribution																			358,4							
ACED	Personnel costs - Task 1							8,2	1,0			51,3	6,8							270,2	41,0						
	Personnel costs - Task 2																										
	Personnel costs - Task 3											29,3	4,0														
	Personnel costs - Task 4											62,0	10,0							52,0	7,0						
	Total Personnel Costs							8,2	1,0			142,6	20,8							322,2	48,0						
	Total travel costs							8,5				10,0								18,5							
	Total Equipment											1,0															
	Total Other goods & services											4,0								64,5							
	Large Research Infrastructure (LRI)																										
	Total direct costs							16,7				157,6								405,2							
	Total Indirect Costs							4,2				39,4								101,3							
DONUT	Total subcontracting							140,5																			
	TOTAL BUDGET							161,4				197,0								506,5							
	EC requested contribution							80,7				98,5								253,3							
	Personnel costs - Task 1											9,9	1,5														
	Personnel costs - Task 2																			73,5	24,0						
	Personnel costs - Task 3											283,0	43,0														
	Personnel costs - Task 4											111,7	14,5	152,0	16,7												
	Personnel costs - Task 5							39,9	4,8					19,5	2,0												
	Total Personnel Costs							39,9	4,8			404,6	59,0	171,5	18,7					73,5	24,0						
	Total Travel costs							13,5				15,0		10,0						5,0							
	Total Equipment																										
	Total Other goods & services											18,4		3,0						1,5							
	Total direct costs							53,4				437,9		184,5						80,0							
	Total Indirect Costs							13,3				109,5		46,1						20,0							
	Total subcontracting							89,4																			
	TOTAL BUDGET							156,1				547,4		230,6						100,0							
	EC requested contribution							78,0				273,7		115,3						50,0							

WP	Category of cost	JSI		KIT		LEI		MTA EK		NAGRA		NCSRD		NES		NRG		NJF		ONDRAF/NIRAS		Posiva		PSI	
		Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm
PMO	Personnel costs - task 1 - admin, legal &																								
	Personnel costs - task 2 - overall S/T																								
	Personnel costs - task 3 - Extension/update of																								
	Personnel costs - task 4 - Identification of																								
	Personnel costs - task 5 - Internal																								
	Personnel costs - task 6 - Dissemination																								
	Personnel costs - task 7 - International																								
	Personnel costs - task 8 - Coordination of ICS	11,7	2,2																						
	Total Personnel Costs	11,7	2,2																						
	Travel Costs	5,0																							
	meetings	28,4																							
	Website + Extranet																								
	invitation for external experts																								
	Envelop for CS group																								
	Total Other goods & services	28,4																							
	Total other Direct costs	33,4																							
	Total Direct costs	45,1																							
	Total Indirect Costs	11,3																							
	Subcontracting -																								
	TOTAL Costs	56,3																							
	EC requested contribution	56,3																							
ACED	Personnel costs - Task 1					5,0	1,0																		
	Personnel costs - Task 2	80,0	19,0					20,0	5,0	299,6	54,0					66,0	6,0							134,7	12,0
	Personnel costs - Task 3	80,0	19,0					24,0	6,0							110,0	10,0							87,0	6,0
	Personnel costs - Task 4					50,0	10,0									44,0	4,0								
	Total Personnel Costs	160,0	38,0			55,0	11,0	44,0	11,0	299,6	54,0					220,0	20,0							221,7	18,0
	Total travel costs	8,5				5,0		8,5		5,0						11,0									13,5
	Total Equipment							6,5		17,5															
	Total Other goods & services	8,0						4,0		2,2						8,0									4,0
	Large Research Infrastructure (LRI)																								
	Total direct costs	176,5				60,0		63,0		324,3						239,0									239,2
	Total Indirect Costs	44,1				15,0		15,8		81,1						59,8									59,8
	Total subcontracting																								
	TOTAL BUDGET	220,6				75,0		78,8		405,4						298,8									299,0
	EC requested contribution	110,3				37,5		39,4		202,7						149,4									149,5
DONUT	Personnel costs - Task 1																								
	Personnel costs - Task 2							24,0	12,0							54,5	5,0							123,0	9,0
	Personnel costs - Task 3																							119,5	9,0
	Personnel costs - Task 4																								
	Personnel costs - Task 5					25,0	5,0																		
	Total Personnel Costs					25,0	5,0	24,0	12,0							54,5	5,0							242,5	18,0
	Total Travel costs					5,0		5,0								5,0									8,5
	Total Equipment							8,0																	
	Total Other goods & services					2,0		6,0								1,0									
	Total direct costs					32,0		43,0								60,5									251,0
	Total Indirect Costs					8,0		10,8								15,1									62,8
	Total subcontracting																								
	TOTAL BUDGET					40,0		53,8								75,6									313,8
	EC requested contribution					20,0		26,9								37,8									156,9


Associated with document Ref. Are

WP	Category of cost	PURAM		RATEN		SURAO		RWM		SCK-CEN		SKB		SSTC NRS		STUBA		SURO		TNO		TS ENERCON		
		Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	
PMO	Personnel costs - task 1 - admin, legal &																							
	Personnel costs - task 2 - overall S/T							43,1	6,0															
	Personnel costs - task 3 - Extension/update of							7,2	1,0															
	Personnel costs - task 4 - Identification of																							
	Personnel costs - task 5 - Internal																							
	Personnel costs - task 6 - Dissemination							3,6	0,5															
	Personnel costs - task 7 - International																							
	Personnel costs - task 8 - Coordination of ICS																							
	Total Personnel Costs							53,8	7,5															
	Travel Costs							20,0																
	meetings																							
	Website + Extranet																							
	invitation for external experts																							
	Envelop for CS group																							
	Total Other goods & services																							
	Total other Direct costs							20,0																
	Total Direct costs							73,8																
Total Indirect Costs							18,5																	
Subcontracting -																								
TOTAL Costs							92,3																	
EC requested contribution							92,3																	
ACED	Personnel costs - Task 1					6,0	1,5			99,2	8,5													
	Personnel costs - Task 2					49,2	29,0																	
	Personnel costs - Task 3									134,5	11,5													
	Personnel costs - Task 4					28,0	12,5			157,8	13,5													
	Total Personnel Costs					83,2	43,0			391,4	33,5													
	Total travel costs					13,5				20,5														
	Total Equipment					8,0																		
	Total Other goods & services					10,0				30,0														
	Large Research Infrastructure (LRI)																							
	Total direct costs					114,7				441,9														
	Total Indirect Costs					28,7				110,5														
	Total subcontracting																							
	TOTAL BUDGET					143,3				552,3														
EC requested contribution					71,7				276,2															
DONUT	Personnel costs - Task 1					4,8	1,5															5,7	1,5	
	Personnel costs - Task 2					223,6	117,0																	
	Personnel costs - Task 3					24,7	10,0																	
	Personnel costs - Task 4					74,6	36,0			115,6	26,0											70,3	18,5	
	Personnel costs - Task 5					40,7	15,0																	
	Total Personnel Costs					368,5	179,5			115,6	26,0											75,9	20,0	
	Total Travel costs					39,5				5,0												5,0		
	Total Equipment																							
	Total Other goods & services					12,8				3,4												750		
	Total direct costs					420,7				124,0												81,7		
	Total Indirect Costs					105,2				31,0												20,4		
	Total subcontracting																							
	TOTAL BUDGET					525,9				155,0												102,1		
EC requested contribution					263,0				77,5												51,1			

WP	Category of cost	TUS		UCY		UHelsinki		UKRI-BGS		VTT		VUJE	
		Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm
PMO	Personnel costs - task 1 - admin, legal &												
	Personnel costs - task 2 - overall S/T												
	Personnel costs - task 3 - Extension/update of												
	Personnel costs - task 4 - Identification of												
	Personnel costs - task 5 - Internal												
	Personnel costs - task 6 - Dissemination												
	Personnel costs - task 7 - International												
	Personnel costs - task 8 - Coordination of ICS												
	Total Personnel Costs												
	Travel Costs												
	meetings												
	Website + Extranet												
	invitation for external experts												
	Envelop for CS group												
	Total Other goods & services												
	Total other Direct costs												
	Total Direct costs												
	Total Indirect Costs												
	Subcontracting -												
	TOTAL Costs												
	EC requested contribution												
ACED	Personnel costs - Task 1									30,0	4,0		
	Personnel costs - Task 2									60,0	8,0		
	Personnel costs - Task 3									60,0	8,0		
	Personnel costs - Task 4									52,5	7,0		
	Total Personnel Costs									202,5	27,0		
	Total travel costs									16,0			
	goods & services									8,0			
	Large Research Infrastructure (LRI)									55,5			
	Total direct costs									282,0			
	Total Indirect Costs									70,5			
	Total subcontracting												
	TOTAL BUDGET									352,4			
	EC requested contribution									176,2			
DONUT	Personnel costs - Task 1												
	Personnel costs - Task 2												
	Personnel costs - Task 3												
	Personnel costs - Task 4					116,0	20,0						
	Personnel costs - Task 5	19,2	4,0										
	Total Personnel Costs	19,2	4,0			116,0	20,0						
	Total Travel costs	5,0				5,0							
	Total Equipment												
	Total Other goods & services	7,8				3,0							
	Total direct costs	32,0				124,0							
	Total Indirect Costs	8,0				31,0							
	Total subcontracting												
	TOTAL BUDGET	40,0				155,0							
	EC requested contribution	20,0				77,5							

WP	Category of cost	TOTAL		Andra		not allocated		ARAO		BEL V		BGE		CEA		CHRD		CIEMAT		CNRS		COVRA	
		Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm
GAS	Personnel costs - task 1	114,2	10,0																				
	Personnel costs - task 2	1 733,2	364,5									10,8	0,8					149,9	32,0	385,2	104,1	36,7	4,5
	Personnel costs - task 3	1 424,8	236,8	60,0	6,0							34,8	2,7	61,2	5,0			69,3	13,0	175,8	36,8	47,9	6,0
	Personnel costs - task 4	602,3	70,5	81,0	9,0									56,2	4,5							94,7	9,8
	Total Personnel Costs	3 874,4	681,7	141,0	15,0							45,5	3,6	117,4	9,5			219,2	45,0	561,0	140,9	179,4	20,3
	Total travel costs	251,0			13,5							8,5		8,5				13,5		24,5		16,0	
	Total Equipment	91,5																		20,0			
	Total Other goods & services	291,7																16,1		132,7			
	Total direct costs	4 508,6			154,5							54,0		125,9				248,8		738,2		195,4	
	Total Indirect Costs	1 127,2			38,6							13,5		31,5				62,2		184,6		48,9	
	Total subcontracting																						
	TOTAL BUDGET	5 635,8			193,1							67,5		157,4				311,0		922,8		244,3	
	EC requested contribution	2 638,3			96,5							33,8		78,0				155,5		436,7		111,2	
HITEC	Personnel costs - task 1	178,7	25,4	10,0	1,0							9,5	0,7					22,3	5,5				
	Personnel costs - task 2	1 630,6	263,1	117,0	11,7							155,0	12,2	240,2	25,5			117,3	22,0	398,2	83,0		
	Personnel costs - task 3	1 453,7	392,2	135,3	16,7											61,0	69,0	285,7	64,0				
	Personnel costs - task 4	188,3	20,1	10,0	1,0							9,5	0,7										
	Total Personnel Costs	3 451,3	700,7	272,3	30,4							173,9	13,7	240,2	25,5	61,0	69,0	425,3	91,5	398,2	83,0		
	Total travel costs	218,0			18,5							8,5		10,0				18,5		15,0			
	Total Equipment	81,5			18,0													17,0		30,0			
	Total Other goods & services	367,4			15,0									5,9		1,0		23,9		54,6			
	Large Research Infrastructure (LRI)	58,6																					
	Total direct costs	4 176,8			323,8							182,4		256,1		72,0		484,7		497,8			
	Total Indirect Costs	1 044,2			80,9							45,6		64,0		18,0		121,2		124,4			
	Total subcontracting																						
	TOTAL BUDGET	5 220,9			404,7							228,0		320,1		90,0		605,8		622,2			
	EC requested contribution	2 507,5			202,4							114,0		160,1		45,0		302,9		311,1			
FUTURE	Personnel costs - task 1	81,8	8,3	10,0	1,0									8,5	1,0								
	Personnel costs - task 2	1 813,1	349,7	131,8	16,3									12,7	1,5			146,5	33,0	355,7	93,0		
	Personnel costs - task 3	1 158,6	237,2	121,2	15,2									149,9	20,5			88,8	20,0	151,9	31,0		
	Total Personnel Costs	3 053,5	595,1	263,0	32,5									171,0	23,0			235,3	53,0	507,6	124,0		
	Total travel costs	149,4			18,5									8,5				8,5		20,0			
	Total Equipment	73,0																15,0					
	Total Other goods & services	379,7			44,0									37,0				30,0		100,4			
	Total direct costs	3 655,7			325,5									216,5				288,8		628,0			
	Total Indirect Costs	913,9			81,4									54,1				72,2		157,0			
	Total subcontracting																						
	TOTAL BUDGET	4 569,6			406,9									270,7				361,0		785,0			
	EC requested contribution	2 284,8			203,4									135,3				180,5		392,5			
CORI	Personnel costs - task 1	77,1	9,9	24,0	2,4									11,3	1,4			6,2	1,4	12,0	1,4		
	Personnel costs - Task 2	916,0	155,1	125,6	16,4															224,9	38,6		
	Personnel costs - Task 3	794,1	163,5	30,0	3,0									112,6	17,0			202,2	51,0				
	Personnel costs - Task 4	1 063,5	205,7	20,0	2,0									97,2	17,0			97,7	22,0	134,3	20,0		
	Total Personnel Costs	2 850,7	534,2	199,6	23,8									221,0	35,4			306,0	74,4	371,2	60,0		
	Total travel costs	214,5			16,0									13,5				13,5		18,5			
	Total Equipment	72,0			10,0													22,0		10,0			
	Total Other goods & services	616,9			88,5									69,7				35,0		51,0			
	Total direct costs	3 754,2			314,1									304,3				376,5		450,7			
	Total Indirect Costs	938,5			78,5									76,1				94,1		112,7			
	Total subcontracting																						
	TOTAL BUDGET	4 692,7			392,6									380,3				470,7		563,4			
	EC requested contribution	2 346,3			196,3									190,2				235,3		281,7			

WP		CVREZ		Dekom		EEAE		ENRESA		CPST		FZJ		GRS		IAE		INCT		IRSN		IST-ID		IST-LPSR		JRC		
		Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	
GAS	Personnel costs - task 1																			6,0	1,0							
	Personnel costs - task 2																			156,0	26,0							
	Personnel costs - task 3											74,0	12,0	102,5	11,0					6,0	1,0							
	Personnel costs - task 4																			78,0	12,0							
	Total Personnel Costs											74,0	12,0	102,5	11,0					246,0	40,0							
	Total travel costs											10,0		5,0						16,0								
	Total Equipment													5,0						10,0								
	Total Other goods & services											6,0																
	Total direct costs											90,0		112,5						272,0								
	Total Indirect Costs											22,5		28,1						68,0								
	Total subcontracting																											
TOTAL BUDGET											112,5		140,7						340,0									
EC requested contribution											56,3		70,3						168,0									

HITEC	Personnel costs - task 1							9,2	1,1																		
	Personnel costs - task 2																										
	Personnel costs - task 3																										
	Personnel costs - task 4							8,2	1,0																		
	Total Personnel Costs							17,4	2,1																		
	Total travel costs							5,0																			
	goods & services																										
	Large Research Infrastructure (LRI)																										
	Total direct costs							22,4																			
	Total Indirect Costs							5,6																			
Total subcontracting																											
TOTAL BUDGET							28,0																				
EC requested contribution							14,0																				

FUTURE	Personnel costs - task 1											29,6	3,0													
	Personnel costs - task 2											296,8	40,0	83,2	10,4											
	Personnel costs - task 3											160,0	36,0													
	Total Personnel Costs											486,4	79,0	83,2	10,4											
	Total travel costs											25,5		5,0												
	goods & services											52,3														
	Total direct costs											564,2		88,2												
	Total Indirect Costs											141,1		22,1												
	Total subcontracting																									
TOTAL BUDGET											705,3		110,3													
EC requested contribution											352,7		55,1													

CORI	Total Equipment																									
	Personnel costs - task 1																									
	Personnel costs - Task 2	15,0	5,0							29,0	10,0	73,3	10,0													
	Personnel costs - Task 3	21,0	7,0																							
	Personnel costs - Task 4									23,0	10,0	129,0	17,0													
	Total Personnel Costs	36,0	12,0							52,0	20,0	202,3	27,0													
	Total travel costs	8,5								8,5		13,5														
	Total Equipment	20,0																								
	Total Other goods & services	13,0								9,0		7,8														
	Total direct costs	77,5								69,5		223,6														
	Total Indirect Costs	19,4								17,4		55,9														
	Total subcontracting																									
	TOTAL BUDGET	96,9								86,9		279,5														
	EC requested contribution		48,4							43,4		139,7														

WP	Category of cost	JSI		KIT		LEI		MTA EK		NAGRA		NCSRD		NES		NRG		NJF		ONDRAF/NIRAS		Posiva		PSI	
		Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm
GAS	Personnel costs - task 1									16,0	1,0									59,2	4,5				
	Personnel costs - task 2			32,2	5,0															162,0	30,4			120,0	24,0
	Personnel costs - task 3			32,2	5,0					512,0	83,0									50,0	9,6				
	Personnel costs - task 4			19,3	3,0	32,5	6,5			48,0	3,0									70,2	7,8				
	Total Personnel Costs			83,6	13,0	32,5	6,5			576,0	87,0									341,5	52,3			120,0	24,0
	Total travel costs			11,0		5,0				28,5										28,0				5,0	
	Total Equipment									40,0															
	Total Other goods & services			2,0						5,0															
	Total direct costs			96,6		37,5				649,5										369,5				125,0	
	Total Indirect Costs			24,1		9,4				162,4										92,4				31,3	
	Total subcontracting																								
	TOTAL BUDGET			120,7		46,9				811,9										461,8				156,3	
	EC requested contribution			59,9		23,4				387,2										230,9				78,1	
HITEC	Personnel costs - task 1									16,0	1,0									31,3	4,9	3,0	0,5		
	Personnel costs - task 2					50,0	10,0			22,4	1,4									232,3	39,7				
	Personnel costs - task 3			45,0	9,0																	6,0	1,0		
	Personnel costs - task 4									16,0	1,0									9,3	0,8	6,0	1,0		
	Total Personnel Costs			45,0	9,0	50,0	10,0			54,4	3,4									272,9	45,4	15,0	2,5		
	Total travel costs			5,0		5,0				8,5										13,5		8,5			
	goods & services																								
	Large Research Infrastructure (LRI)			500						3,3										21,3					
	Total direct costs			50,5		55,0				66,2										307,7		23,5			
	Total Indirect Costs			12,6		13,8				16,6										76,9		5,9			
	Total subcontracting																								
	TOTAL BUDGET			63,1		68,8				82,8										384,6		29,4			
	EC requested contribution			31,6		34,4				41,4										192,3		14,7			
FUTURE	Personnel costs - task 1																							12,2	1,0
	Personnel costs - task 2			153,6	28,0			62,0	21,0															287,5	45,5
	Personnel costs - task 3			189,2	44,0																			166,0	35,5
	Total Personnel Costs			342,8	72,0			62,0	21,0															465,7	82,0
	Total travel costs			13,5				6,4																13,5	
	Total Equipment			8,0																				30,0	
	Total Other goods & services			30,0				7,6																15,6	
	Total direct costs			394,3				76,0																524,8	
	Total Indirect Costs			98,6				19,0																131,2	
	Total subcontracting																								
	TOTAL BUDGET			492,9				95,0																655,9	
	EC requested contribution			246,4				47,5																328,0	
CORI	Personnel costs - task 1			23,6	3,3																			128,7	13,0
	Personnel costs - Task 2	101,5	14,0	22,5	5,0																			99,0	11,0
	Personnel costs - Task 3	87,0	12,4	94,5	17,0																				
	Personnel costs - Task 4			419,6	80,0																				
	Total Personnel Costs	188,5	26,4	560,2	105,3																			227,7	24,0
	Total travel costs	8,5		46,5																				10,0	
	Total Equipment																								
	Total Other goods & services	62,0		44,0																				28,3	
	Total direct costs	259,0		650,7																				266,0	
	Total Indirect Costs	64,8		162,7																				66,5	
	Total subcontracting																								
	TOTAL BUDGET	323,8		813,4																				332,4	
	EC requested contribution	161,9		406,7																				166,2	

WP	Category of cost	PURAM		RATEN		SURAO		RWM		SCK-CEN		SKB		SSTC NRS		STUBA		SURO		TNO		TS ENERCON	
		Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm
GAS	Personnel costs - task 1									23,3	2,0												
	Personnel costs - task 2					79,7	30,0			106,2	24,0												
	Personnel costs - task 3					83,4	23,0																
	Personnel costs - task 4							26,5	3,5	63,0	5,4												
	Total Personnel Costs					163,1	53,0	26,5	3,5	192,6	31,4												
	Total travel costs					18,5		5,0		16,0													
	Total Equipment					8,5				8,0													
	Total Other goods & services					27,5																	
	Total direct costs					217,6		31,5		216,6													
	Total Indirect Costs					54,4		7,9		54,1													
	Total subcontracting																						
	TOTAL BUDGET					272,0		39,4		270,7													
	EC requested contribution					136,0		22,8		135,4													
HITEC	Personnel costs - task 1					13,8	4,0	11,2	1,6			15,0	2,0										
	Personnel costs - task 2							31,5	4,5														
	Personnel costs - task 3					316,4	113,0	22,4	3,2			30,0	4,0										
	Personnel costs - task 4					8,1	3,0	11,2	1,6			22,5	3,0										
	Total Personnel Costs					338,3	120,0	76,3	10,9			67,5	9,0										
	Total travel costs					28,5		11,0				8,5											
	Total Equipment					16,5																	
	Total Other goods & services					38,9																	
	Large Research Infrastructure (LRI)																						
	Total direct costs					422,2		87,3		76,0													
	Total Indirect Costs					105,5		21,8		19,0													
	TOTAL BUDGET					527,7		109,1		95,0													
	EC requested contribution					263,9		54,6		47,5													
FUTURE	Personnel costs - task 1									15,2	1,3									6,4	1,0		
	Personnel costs - task 2									108,8	11,0												
	Personnel costs - task 3			48,4	22,0															83,2	13,0		
	Total Personnel Costs			48,4	22,0	66,6	32,0			124,0	12,3									89,6	14,0		
	Total travel costs			5,0		10,0				5,0										5,0			
	Total Equipment					15,0														5,0			
	Total Other goods & services			13,9		15,1				17,0										12,8			
	Total direct costs			67,3		106,7				146,0										112,4			
	Total Indirect Costs			16,8		26,7				36,5										28,1			
	Total subcontracting																						
	TOTAL BUDGET			84,1		133,3				182,5										140,5			
	EC requested contribution			42,1		66,7				91,3										70,3			
CORI	Personnel costs - task 1																						
	Personnel costs - Task 2					102,8	33,4			92,8	9,7												
	Personnel costs - Task 3			26,4	12,0	82,5	29,6			39,0	3,5												
	Personnel costs - Task 4			11,0	5,0	62,3	23,6			55,9	5,1												
	Total Personnel Costs			37,4	17,0	247,6	86,6			187,7	18,3												
	Total travel costs			8,5		33,0				11,0													
	Total Equipment					10,0																	
	Total Other goods & services			14,6		50,3				143,7													
	Total direct costs			60,5		340,9				342,4													
	Total Indirect Costs			15,1		85,2				85,6													
	Total subcontracting																						
	TOTAL BUDGET			75,6		426,1				428,0													
	EC requested contribution			37,8		213,1				214,0													

WP	Category of cost	TUS		UCY		UHelsinki		UKRI-BGS		VTT		VUJE	
		Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm
GAS	Personnel costs - task 1							9,6	1,5				
	Personnel costs - task 2							494,4	83,6				
	Personnel costs - task 3							115,7	22,7				
	Personnel costs - task 4					32,9	6,0						
	Total Personnel Costs					32,9	6,0	619,8	107,8				
	Total travel costs					5,0		13,5					
	Total Equipment												
	Total Other goods & services							102,4					
	Total direct costs					37,9		735,7					
	Total Indirect Costs					9,5		183,9					
	Total subcontracting												
	TOTAL BUDGET					47,3		919,6					
	EC requested contribution					23,6		334,7					
HITEC	Personnel costs - task 1									37,5	3,0		
	Personnel costs - task 2							266,7	53,1				
	Personnel costs - task 3					261,7	62,0	173,9	31,8	116,4	18,5		
	Personnel costs - task 4									87,5	7,0		
	Total Personnel Costs					261,7	62,0	440,5	84,8	241,4	28,5		
	Total travel costs					15,0		8,5		20,5			
	goods & services					57,6		136,5		9,0			
	Large Research Infrastructure (LRI)									58,6			
	Total direct costs					334,3		585,5		329,5			
	Total Indirect Costs					83,6		146,4		82,4			
	Total subcontracting												
	TOTAL BUDGET					417,9		731,9		411,9			
	EC requested contribution					208,9		263,0		205,9			
FUTURE	Personnel costs - task 1												
	Personnel costs - task 2					108,0	18,0						
	Personnel costs - task 3												
	Total Personnel Costs					108,0	18,0						
	Total travel costs					5,0							
	goods & services					4,0							
	Total direct costs					117,0							
	Total Indirect Costs					29,3							
	Total subcontracting												
	TOTAL BUDGET					146,3							
	EC requested contribution					73,1							
CORI	Total Equipment												
	Personnel costs - task 1												
	Personnel costs - Task 2												
	Personnel costs - Task 3												
	Personnel costs - Task 4					13,6	4,0						
	Total Personnel Costs					13,6	4,0						
	Total travel costs					5,0							
	Total Equipment												
	Total Other goods & services												
	Total direct costs					18,6							
	Total Indirect Costs					4,7							
	Total subcontracting												
	TOTAL BUDGET					23,3							
	EC requested contribution					11,6							

		TOTAL		Andra		not allocated		ARAO		BEL V		BGE		CEA		CHRD		CIEMAT		CNRS		COVRA	
WP	Category of cost	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm
SFC	Personnel costs - Task 1	89,6	12,3															8,9	2,0				
	Personnel costs - Task 2	1 048,7	159,8															131,7	29,7				
	Personnel costs - Task 3	2 320,3	406,5															632,1	146,6	409,3	79,1		
	Personnel costs - Task 4	430,9	74,1											75,6	10,9	9,0	4,5	223,2	44,2				
	Total Personnel Costs	3 889,6	652,7											75,6	10,9	9,0	4,5	995,9	222,5	409,3	79,1		
	Total Travel costs	195,5												5,0		5,0		26,0		15,0			
	Total Equipment	113,4																39,6		49,9			
	Total Other goods & services	236,3																					
	Large Research Infrastructure (LRI)	7,9																					
	Total direct costs	4 442,7												80,6		14,0		1 061,5		474,2			
	Total Indirect Costs	1 110,7												20,2		3,5		265,4		118,6			
	Total subcontracting	208,8																					
	TOTAL BUDGET	5 762,1												100,8		17,5		1 326,8		592,8			
	EC requested contribution	2 881,1												50,4		8,8		663,4		296,4			
UMAN	Personnel costs - task 1	107,8	11,5							58,9	5,5	15,9	1,3										
	Personnel costs - task 2	218,6	25,7	3,2	0,4					10,7	1,0							4,4	1,0	4,6	0,5	6,4	0,5
	Personnel costs - task 3	262,3	37,4	22,5	2,5					16,1	1,5							11,1	2,5	23,0	2,5	12,8	1,0
	Personnel costs - task 4	228,7	24,2	13,5	1,5					26,8	2,5	57,2	4,5							4,6	0,5		
	Personnel costs - task 5	296,5	34,7	31,5	3,5					5,4	0,5												
	Total Personnel Costs	1 113,9	133,5	70,7	7,9					117,7	11,0	73,0	5,8					15,5	3,5	32,2	3,5	19,2	1,5
	Total Travel Costs	249,0		8,0						20,0		12,0						5,5		14,0		5,5	
	Total Equipment	40,2								40,2													
	Total Other goods & services																						
	Total direct costs	218,6	25,7	3,2						10,7								4,4		4,6		6,4	
	Total Indirect Costs	349,0		19,7						44,5		21,3						5,3		9,8		6,2	
	Total subcontracting																						
	TOTAL BUDGET	1 745,1		98,3						222,3		106,3						26,3		49,0		30,9	
	EC requested contribution	1 234,0		68,8						155,6		74,4						18,4		34,3		21,6	
ROUTES	Personnel costs - task 1	64,0	6,3	2,5	0,3																	3,2	0,3
	Personnel costs - task 2	114,8	17,1	35,0	3,5					3,1	0,3			4,1	0,3			1,3	0,3				
	Personnel costs - task 3	150,9	25,9											21,0	1,5			15,5	3,5				
	Personnel costs - task 4	278,5	37,0	16,5	1,7									23,1	1,7			7,3	1,7				
	Personnel costs - task 5	175,3	25,3																				
	Personnel costs - task 6	243,7	29,6					5,1	1,2					40,6	2,9			5,3	1,2			47,4	3,7
	Personnel costs - task 7	51,6	6,6																				
	Total Personnel Costs	1 079,0	147,6	54,0	5,4			5,1	1,2	3,1	0,3			88,8	6,3			29,5	6,6			50,6	4,0
	Total Travel Costs	282,5		10,5				5,0		3,5				8,0				7,0				8,5	
	Total Equipment																						
	Total Other goods & services	32,0		1,0										1,0								2,0	
	Total direct costs	1 393,5		65,5				10,1		6,6				97,8				36,5				61,1	
	Total Indirect Costs	348,4		16,4				2,5		1,7				24,4				9,1				15,3	
	Total subcontracting																						
TOTAL BUDGET	1 741,9		81,9				12,6		8,3				122,2				45,6				76,3		
EC requested contribution	1 240,9		57,3				8,8		5,8				85,5				31,9				53,4		
3 8 KM SoK	Personnel costs - task 1	82,9	11,0	5,0	0,5							40,6	4,0					2,2	0,5				
	Personnel costs - task 2	157,4	20,8	5,0	0,5							81,3	8,0					1,1	0,3				
	Personnel costs - task 3	151,3	20,0									81,3	8,0										
	Personnel costs - task 4	96,3	20,0	20,0	2,0							20,3	2,0										
	Personnel costs - task 5	30,5	3,0									30,5	3,0										
	Total Personnel Costs	518,3	74,8	30	3							254,0	25,0					3,3	0,8				
	Travel Costs	61,0										20,0						7,0					
	Other goods & services																						
	Total Direct costs	579,3		38,0								274,0						10,3					
	Total Indirect Costs	144,8		9,5								68,5						2,6					
	Total Costs	724,2		47,5								342,5						12,9					
	EC requested contribution	506,9		33,3								239,8						9,0					

WP		Category of cost	CVREZ		Dekom		EEAE		ENRESA		CPST		FZJ		GRS		IAE		INCT		IRSN		IST-ID		IST-LPSR		JRC		
			Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	
SFC	Personnel costs - Task 1																										16,0	2,0	
	Personnel costs - Task 2								11,4	1,4	11,5	3,8															75,0	9,4	
	Personnel costs - Task 3												150,0	36,0													441,2	52,1	
	Personnel costs - Task 4																												
	Total Personnel Costs								11,4	1,4	11,5	3,8	150,0	36,0													532,2	63,5	
	Total Travel costs								10,0		5,0		5,0														15,0		
	Total Equipment												5,0																
	Total Other goods & services																										206,6		
	Large Research Infrastructure (LRI)																												
	Total direct costs								21,4		16,5		160,0															753,8	
Total Indirect Costs								5,4		4,1		40,0															188,5		
Total subcontracting								208,8																					
TOTAL BUDGET								235,5		20,6		200,0															942,3		
EC requested contribution								117,8		10,3		100,0															471,2		

UMAN	Personnel costs - task 1												11,5	1,3							16,6	1,3						
	Personnel costs - task 2												13,8	1,5							5,3	0,6						
	Personnel costs - task 3							12,4	1,5	7,6	2,0										14,6	1,7						
	Personnel costs - task 4							8,3	1,0												2,7	0,2						
	Personnel costs - task 5													13,8	1,5						171,3	15,4						
	Total Personnel Costs							20,7	2,5	7,6	2,0	25,0	3,3	39,0	4,3						210,5	19,2						
	Total Travel Costs							5,5		3,5		5,5		12,0							28,5							
	Total Equipment																											
	Total Other goods & services																											
	Total direct costs											25,0		13,8							5,3							
Total Indirect Costs								6,6		2,8		7,6		12,7						59,7								
Total subcontracting																												
TOTAL BUDGET								32,8		13,9		38,2		63,7						298,7								
EC requested contribution								22,9		9,7		26,7		44,6						221,5								

ROUTES	Personnel costs - task 1											1,8	0,3							50,0	5,0						
	Personnel costs - task 2											2,1	0,3	2,9	0,3	660	0,2	2,1	0,7	2,9	0,3	767	0,1	2,0	0,3		
	Personnel costs - task 3											29,3	4,0							10,0	1,0	6,8	1,3				
	Personnel costs - task 4											1,8	0,3	4,4	0,5	4,2	1,0	11,9	4,0	16,5	1,7			4,8	0,7		
	Personnel costs - task 5																	3,0	1,0			11,0	2,0	15,5	2,3		
	Personnel costs - task 6			17,4	2,0	4,8	1,2			4,6	1,2	8,8	1,2							12,0	1,2	5,5	1,0	8,3	1,2		
	Personnel costs - task 7																		42,6	4,9							
	Total Personnel Costs			17,4	2,0	12,4	3,1			11,9	3,1	43,9	6,0	19,7	2,0	4,8	1,1	16,9	5,6	134,0	14,0	24,0	4,4	30,6	4,4		
	Total Travel Costs			8,5		8,0				7,0		13,0		7,0		5,5		7,0		31,0		7,0		7,0			
	Total Equipment																										
	Total Other goods & services											4,0						1,0		15,0		4,0					
	Total direct costs			25,9		20,4				18,9		60,9		26,7		10,3		24,9		180,0		35,0		37,6			
	Total Indirect Costs			6,5		5,1				4,7		15,2		6,7		2,6		6,2		45,0		8,8		9,4			
	Total subcontracting																										
TOTAL BUDGET			32,4		25,5				23,7		76,1		33,3		12,9		31,2		225,0		43,8		47,0				
EC requested contribution			22,7		17,8				16,6		53,3		23,3		9,0		21,8		179,1		30,7		32,9				

KM SoK	Personnel costs - task 1											30,8	4,0															
	Personnel costs - task 2											61,6	8,0															
	Personnel costs - task 3											61,6	8,0															
	Personnel costs - task 4											30,8	4,0															
	Personnel costs - task 5																											
	Total Personnel Costs											184,8	24,0															
	Travel Costs											13,0																
	Other goods & services																											
	Total Direct costs											197,8																
	Total Indirect Costs											49,5																
Total Costs											247,3																	
EC requested contribution											173,1																	

WP	Category of cost	JSI		KIT		LEI		MTA EK		NAGRA		NCSRD		NES		NRG		NJF		ONDRAF/NIRAS		Posiva		PSI	
		Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm
SFC	Personnel costs - Task 1			11,5	2,0					32,0	2,0														
	Personnel costs - Task 2	78,4	10,8	74,0	9,4	35,0	7,0			4,3	0,3													152,0	10,7
	Personnel costs - Task 3			238,4	40,0			88,0	22,0	28,8	1,8													275,6	19,4
	Personnel costs - Task 4									76,3	4,8														
	Total Personnel Costs	78,4	10,8	323,9	51,4	35,0	7,0	88,0	22,0	141,5	8,8													427,6	30,1
	Total Travel costs	5,0		18,5		5,0		5,0		11,0															8,5
	Total Equipment			4,5				4,0																	10,5
	Total Other goods & services							9,0																	
	Large Research Infrastructure (LRI)																								
	Total direct costs	83,4		346,9		40,0		106,0		152,5															446,6
	Total Indirect Costs	20,8		86,7		10,0		26,5		38,1															111,7
	Total subcontracting																								
	TOTAL BUDGET	104,2		433,6		50,0		132,5		190,6															558,3
	EC requested contribution	52,1		216,8		25,0		66,3		95,3															279,1
UMAN	Personnel costs - task 1																								
	Personnel costs - task 2	5,3	1,0	12,0	2,0	5,0	1,0			16,0	1,0					10,9	1,0			15,4	1,0				
	Personnel costs - task 3	21,5	3,5	12,0	1,5															15,4	1,0	7,9	1,5	18,9	1,5
	Personnel costs - task 4			8,0	1,0	12,5	2,5			40,0	2,5					30,0	2,8			3,9	0,3				
	Personnel costs - task 5	11,9	2,3	21,0	3,5																	7,9	1,5		
	Total Personnel Costs	38,7	6,8	53,0	8,0	17,5	3,5			56,0	3,5					40,9	3,8			34,7	2,3	15,9	3,0	18,9	1,5
	Total Travel Costs	10,5		11,0		7,0				8,0						7,0				7,0		5,5			3,5
	Total Equipment																								
	Total Other goods & services																								
	Total direct costs	5,3		12,0		5,0				16,0						10,9				15,4					
	Total Indirect Costs	12,3		16,0		6,1				16,0						12,0				10,4		5,3			5,6
	Total subcontracting																								
	TOTAL BUDGET	61,5		80,0		30,6				80,0						59,9				52,1		26,7			28,0
	EC requested contribution	43,1		56,0		21,4				56,0						41,9				36,5		18,7			19,6
ROUTES	Personnel costs - task 1											2,6	0,3							3,9	0,3				
	Personnel costs - task 2	2,1	0,3			1,5	0,3					10,4	1,4	7,3	0,7	3,4	0,3			4,5	0,3				
	Personnel costs - task 3	10,6	2,0									6,4	0,8												
	Personnel costs - task 4	8,7	1,7			8,3	1,7					900	0,2							77,1	5,0				
	Personnel costs - task 5	9,1	1,3									69,4	8,8	31,6	3,0										
	Personnel costs - task 6	8,0	1,5									12,6	1,2	12,6	1,2			3,2	1,5						
	Personnel costs - task 7	9,0	1,7																						
	Total Personnel Costs	47,5	8,4			9,7	1,9					102,2	12,5	51,5	4,9	3,4	0,3	3,2	1,5	85,4	5,5				
	Total Travel Costs	19,5				5,5						19,0		7,0		3,5		5,0		10,5					
	Total Equipment																								
	Total Other goods & services											1,0		1,0											
	Total direct costs	67,0				15,2						122,2		59,5		6,9		8,2		95,9					
	Total Indirect Costs	16,7				3,8						30,6		14,9		1,7		2,1		24,0					
	Total subcontracting																								
	TOTAL BUDGET	83,7				19,0						152,8		74,3		8,6		10,3		119,8					
	EC requested contribution	58,6				13,3						106,9		52,0		6,0		7,2		83,9					
KM SoK	Personnel costs - task 1																								
	Personnel costs - task 2																								
	Personnel costs - task 3																								
	Personnel costs - task 4																								
	Personnel costs - task 5																								
	Total Personnel Costs																								
	Travel Costs																								
	Other goods & services																								
	Total Direct costs																								
	Total Indirect Costs																								
	Total Costs																								
	EC requested contribution																								

WP	Category of cost	PURAM		RATEN		SURAO		RWM		SCK-CEN		SKB		SSTC NRS		STUBA		SURO		TNO		TS ENERCON	
		Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm
SFC	Personnel costs - Task 1											21,2	4,3										
	Personnel costs - Task 2					1,4	0,4			167,4	15,5	251,6	50,5	6,6	3,1								
	Personnel costs - Task 3																						
	Personnel costs - Task 4																						
	Total Personnel Costs					1,4	0,4			167,4	15,5	272,8	54,7	6,6	3,1								
	Total Travel costs					5,0				5,0		22,0		5,0									
	Total Equipment																						
	Total Other goods & services											20,0											
	Large Research Infrastructure (LRI)																						
	Total direct costs					6,4				172,4		314,8		11,6									
UMAN	Total Indirect Costs					1,6				43,1		78,7		2,9									
	Total subcontracting																						
	TOTAL BUDGET					8,0				215,5		393,5		14,4									
	EC requested contribution					4,0				107,8		196,8		7,2									
	Personnel costs - task 1			5,0	2,3																		
	Personnel costs - task 2					5,9	2,0	9,1	1,0	17,5	1,5			2,1	1,0	3,7	1,0						
	Personnel costs - task 3			11,0	5,0	4,4	1,5			29,1	2,5			3,2	1,5							6,0	1,2
	Personnel costs - task 4															1,9	0,5	12,3	3,0				
	Personnel costs - task 5							18,1	2,0					4,7	2,3								
	Total Personnel Costs			16,0	7,3	10,3	3,5	27,2	3,0	46,6	4,0			10,0	4,8	5,6	1,5	12,3	3,0			6,0	1,2
ROUTES	Total Travel Costs			10,5		7,0		8,0		7,0				7,0		5,5		7,0				3,5	
	Total Equipment																						
	Total Other goods & services																						
	Total direct costs					5,9		9,1		17,5				2,1		3,7							
	Total Indirect Costs			6,6		4,3		8,8		13,4				4,2		2,8		4,8				2,4	
	Total subcontracting																						
	TOTAL BUDGET			33,1		21,7		44,0		67,0				21,2		13,8		24,1				11,9	
	EC requested contribution			23,1		15,2		30,8		46,9				14,9		9,7		16,9				8,3	
	Personnel costs - task 1																						
	Personnel costs - task 2			638	0,3	1,2	0,3			3,4	0,3	2,2	0,3	7,4	3,5	1,1	0,3	1,2	0,3			1,5	0,3
KM SoK	Personnel costs - task 3									11,7	1,0			6,3	3,0	7,4	2,0						
	Personnel costs - task 4			5,9	2,7	6,6	1,7					1,9	0,3	3,5	1,7	3,5	1,0	820	0,2				
	Personnel costs - task 5																	20,5	5,0				
	Personnel costs - task 6											9,0	1,2	2,5	1,2			4,9	1,2				
	Personnel costs - task 7																						
	Total Personnel Costs			6,6	3,0	7,8	1,9			15,0	1,3	13,1	1,7	19,6	9,4	12,0	3,2	27,4	6,7			1,5	0,3
	Total Travel Costs			3,5		5,5				5,5		5,5		7,0		7,0		7,0				3,5	
	Total Equipment																						
	Total Other goods & services			1,0														1,0					
	Total direct costs			11,1		13,3				20,5		18,6		26,6		19,0		35,4				5,0	
	Total Indirect Costs			2,8		3,3				5,1		4,6		6,7		4,7		8,9				1,2	
	Total subcontracting																						
	TOTAL BUDGET			13,8		16,6				25,7		23,2		33,3		23,7		44,3				6,2	
	EC requested contribution			9,7		11,6				18,0		16,2		23,3		16,6		31,0				4,3	
	Personnel costs - task 1													4,2	2,0								
	Personnel costs - task 2													8,4	4,0								
	Personnel costs - task 3													8,4	4,0								
	Personnel costs - task 4													25,2	12,0								
	Personnel costs - task 5																						
	Total Personnel Costs													46,2	22,0								
	Travel Costs													13,0									
	Other goods & services																						
	Total Direct costs													59,2									
	Total Indirect Costs													14,8									
	Total Costs													74,0									
	EC requested contribution													51,8									

WP	Category of cost	TUS		UCY		UHelsinki		UKRI-BGS		VTT		VUJE	
		Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm
SFC	Personnel costs - Task 1												
	Personnel costs - Task 2	13,1	2,7							35,3	5,0		
	Personnel costs - Task 3	21,6	4,5							35,3	5,0		
	Personnel costs - Task 4	46,7	9,7										
	Total Personnel Costs	81,5	17,0							70,5	10,0		
	Total Travel costs	11,0								8,5			
	Total Equipment												
	Total Other goods & services	683											
	Large Research Infrastructure (LRI)									7,9			
	Total direct costs	93,2								86,9			
	Total Indirect Costs	23,3								21,7			
	Total subcontracting												
	TOTAL BUDGET	116,4								108,6			
	EC requested contribution	58,2								54,3			
UMAN	Personnel costs - task 1												
	Personnel costs - task 2	4,9	1,0							37,5	2,5		
	Personnel costs - task 3									12,8	1,5		
	Personnel costs - task 4	7,3	1,5										
	Personnel costs - task 5	10,9	2,3										
	Total Personnel Costs	23,0	4,8							50,3	4,0		
	Total Travel Costs	7,0								7,0			
	Total Equipment												
	Total Other goods & services												
	Total direct costs	4,9								37,5			
	Total Indirect Costs	7,5								14,3			
	Total subcontracting												
	TOTAL BUDGET	37,5								71,6			
	EC requested contribution	26,3								50,1			
ROUTES	Personnel costs - task 1												
	Personnel costs - task 2	1,4	0,3	1,8	0,3					3,5	0,3		
	Personnel costs - task 3	14,4	3,0	3,8	0,6							6,7	2,0
	Personnel costs - task 4	7,9	1,7							55,8	4,7		
	Personnel costs - task 5												
	Personnel costs - task 6									31,2	2,6		
	Personnel costs - task 7												
	Total Personnel Costs	23,7	4,9	5,6	0,9					90,5	7,5	6,7	2,0
	Total Travel Costs	7,0		5,5						7,0		5,0	
	Total Equipment												
	Total Other goods & services												
	Total direct costs	30,7		11,1						97,5		11,7	
	Total Indirect Costs	7,7		2,8						24,4		2,9	
	Total subcontracting												
	TOTAL BUDGET	38,4		13,9						121,9		14,6	
	EC requested contribution	26,9		9,7						85,3		10,2	
KM SoK	Personnel costs - task 1												
	Personnel costs - task 2												
	Personnel costs - task 3												
	Personnel costs - task 4												
	Personnel costs - task 5												
	Total Personnel Costs												
	Travel Costs												
	Other goods & services												
	Total Direct costs												
	Total Indirect Costs												
	Total Costs												
	EC requested contribution												

WP	Category of cost	TOTAL		Andra		not allocated		ARAO		BEL V		BGE		CEA		CHRD		CIEMAT		CNRS		COVRA	
		Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm
KM Guidance	Personnel costs - task 1	78,6	14,0																				
	Personnel costs - task 2	48,7	8,3																				
	Personnel costs - task 3	208,6	42,0																				
	Total Personnel Costs	335,9	64,3																				
	Travel Costs	59,0																					
	Other goods & services																						
	Total Direct costs	394,9																					
	Total Indirect Costs	98,7																					
	Total Costs	493,7																					
	EC requested contribution	307,8																					

KM Training	Personnel costs - task 1	16,7	2,0															1,1	0,3				
	Personnel costs - task 2	30,5	3,5															3,3	0,8				
	Personnel costs - task 3	19,2	2,3	2,5	0,3													1,1	0,3				
	Personnel costs - task 4	203,3	23,5	25,0	2,5													11,1	2,5				
	Personnel costs - task 5	142,5	27,5	25,0	2,5													11,1	2,5				
	Total Personnel Costs	412,2	58,8	52,5	5,3													27,7	6,3				
	Travel Costs	70,0		7,0														8,0					
	Other goods & services																						
	Total Direct costs	482,2		59,5														35,7					
	Total Indirect Costs	120,5		14,9														8,9					
	Total Costs	602,7		74,4														44,7					
	EC requested contribution	363,0		52,1														31,3					

TOTAL	Total Personnel Costs	27 721,4	4828,5	2 359,3	291,6	150,0	15,0	5,1	1,2	163,6	15,3	546,4	48,0	1 405,0	182,6	70,0	73,5	2 432,4	554,0	3 015,5	606,0	391,1	36,8
	Total travel costs	2 323,4		185,5		40,0		5,0		28,5		49,0		68,5		15,0		117,5		187,0		48,5	
	Total Equipment	472,4		28,0														93,6		109,9			
	Total Other goods & services	2 914,3		535,5						57,2				231,8		1,0		149,0		396,7		15,1	
	Total Large Research Infrastructure (LRI)	121,9																					
	TOTAL OTHER DIRECT COSTS	5 812,1		749,0		40,0		5,0		85,7		49,0		300,3		16,0		360,0		673,7		63,6	
	TOTAL DIRECT COSTS	33 533,4		3 108,3		190,0		10,1		249,3		595,4		1 705,3		86,0		2 792,4		3 689,1		454,7	
	Total Total Indirect Costs	8 383,4		777,1		47,5		2,5		62,3		148,9		426,3		21,5		698,1		922,3		113,7	
	Total subcontracting	688,6		250,0																			
	TOTAL BUDGET	42 605,4		4 135,4		237,5		12,6		311,6		744,3		2 131,6		107,5		3 490,5		4 611,4		568,4	
	EC requested contribution	23 067,3		2 968,7		237,5		8,8		201,9		461,9		1 089,6		53,8		1 771,1		2 368,9		294,7	

WP	Category of cost	CVREZ		Dekom		EEAE		ENRESA		CPST		FZJ		GRS		IAE		INCI		IRSN		IST-ID		IST-LPSR		JRC	
		Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm
KM Guidance	Personnel costs - task 1																									10,3	1,0
	Personnel costs - task 2																									5,2	0,5
	Personnel costs - task 3																									20,6	2,0
	Total Personnel Costs																									36,1	3,5
	Travel Costs																									7,0	
	Other goods & services																										
	Total Direct costs																									43,1	
	Total Indirect Costs																									10,8	
	Total Costs																									53,9	
	EC requested contribution																										
KM Training	Personnel costs - task 1																									2,6	0,3
	Personnel costs - task 2																									2,6	0,3
	Personnel costs - task 3																									2,6	0,3
	Personnel costs - task 4																									25,8	2,5
	Personnel costs - task 5																									25,8	2,5
	Total Personnel Costs																									59,3	5,8
	Travel Costs																									8,0	
	Other goods & services																										
	Total Direct costs																									67,3	
	Total Indirect Costs																									16,8	
	Total Costs																									84,2	
	EC requested contribution																										
TOTAL	Total Personnel Costs	36,0	12,0	17,4	2,0	12,4	3,1	97,6	11,8	83,0	29,0	1 713,6	267,0	415,8	46,3	4,8	1,1	16,9	5,6	1 163,4	163,0	24,0	4,4	30,6	4,4	784,0	87,7
	Total travel costs	8,5		8,5		8,0		42,5		24,0		110,5		39,0		5,5		7,0		128,5		7,0		7,0		70,0	
	Total Equipment	20,0										6,0		5,0						10,0							
	Total Other goods & services	13,0								9,0		92,5		3,0				1,0		161,0		4,0				208,6	
	Total Large Research Infrastructure (LRI)																										
	TOTAL OTHER DIRECT COSTS	41,5		8,5		8,0		42,5		33,0		209,0		47,0		5,5		8,0		299,5		11,0		7,0		278,6	
	TOTAL DIRECT COSTS	77,5		25,9		20,4		140,1		116,0		1 922,6		462,8		10,3		24,9		1 462,9		35,0		37,6		1 062,7	
	Total Total Indirect Costs	19,4		6,5		5,1		35,0		29,0		480,6		115,7		2,6		6,2		365,7		8,8		9,4		265,7	
	Total subcontracting							438,6																			
	TOTAL BUDGET	96,9		32,4		25,5		613,8		145,0		2 403,2		578,6		12,9		31,2		1 828,7		43,8		47,0		1 328,3	
	EC requested contribution	48,4		22,7		17,8		313,4		80,0		1 273,9		308,7		9,0		21,8		1 230,4		30,7		32,9		471,2	

WP	Category of cost	JSI		KIT		LEI		MTA EK		NAGRA		NCSRD		NES		NRG		NJF		ONDRAF/NIRAS		Posiva		PSI	
		Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm
KM Guidance	Personnel costs - task 1	8,0	1,5																						
	Personnel costs - task 2	2,7	0,5																						
	Personnel costs - task 3	42,4	8,0																						
	Total Personnel Costs	53,0	10,0																						
	Travel Costs	7,0																							
	Other goods & services																								
	Total Direct costs	60,0																							
	Total Indirect Costs	15,0																							
	Total Costs	75,0																							
	EC requested contribution	52,5																							
KM Training	Personnel costs - task 1																								
	Personnel costs - task 2																								
	Personnel costs - task 3																								
	Personnel costs - task 4																								
	Personnel costs - task 5	26,5	5,0																						
	Total Personnel Costs	26,5	5,0																						
	Travel Costs	3,5																							
	Other goods & services																								
	Total Direct costs	30,0																							
	Total Indirect Costs	7,5																							
	Total Costs	37,5																							
	EC requested contribution	26,3																							
TOTAL	Total Personnel Costs	604,2	107,6	1 408,5	258,7	224,7	44,9	218,0	66,0	1 127,5	156,7	102,2	12,5	51,5	4,9	318,8	29,0	3,2	1,5	734,4	105,5	30,9	5,5	1 724,1	197,6
	Total travel costs	67,5		105,5		37,5		24,9		61,0		19,0		7,0		26,5		5,0		59,0		14,0		62,5	
	Total Equipment			12,5				18,5		57,5														40,5	
	Total Other goods & services	98,4		76,5		2,0		26,6		10,5		1,0		1,0		9,0				21,3				47,9	
	Total Large Research Infrastructure (LRI)																								
	TOTAL OTHER DIRECT COSTS	165,9		194,5		39,5		70,0		129,0		20,0		8,0		35,5		5,0		80,3		14,0		150,9	
	TOTAL DIRECT COSTS	770,1		1 603,0		264,2		288,0		1 256,5		122,2		59,5		354,3		8,2		814,7		44,9		1 875,0	
	Total Total Indirect Costs	192,5		400,7		66,1		72,0		314,1		30,6		14,9		88,6		2,1		203,7		11,2		468,7	
	Total subcontracting																								
	TOTAL BUDGET	962,6		2 003,7		330,3		360,0		1 570,6		152,8		74,3		442,9		10,3		1 018,4		56,1		2 343,7	
	EC requested contribution	561,0		1 017,4		175,1		180,0		782,5		106,9		52,0		235,1		7,2		543,6		33,4		1 177,5	

WP	Category of cost	PURAM		RATEN		SURAO		RWM		SCK-CEN		SKB		SSTC NRS		STUBA		SURO		TNO		TS ENERCON	
		Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm
KM Guidance	Personnel costs - task 1	12,0	2,0			39,0	6,5							3,2	1,5			6,2	1,5				
	Personnel costs - task 2	19,8	3,3			18,0	3,0							1,1	0,5			2,1	0,5				
	Personnel costs - task 3	48,0	8,0			48,0	8,0							16,8	8,0			32,8	8,0				
	Total Personnel Costs	79,8	13,3			105,0	17,5							21,0	10,0			41,0	10,0				
	Travel Costs	12,0				19,0								7,0				7,0					
	Other goods & services																						
	Total Direct costs	91,8				124,0								28,0				48,0					
	Total Indirect Costs	23,0				31,0								7,0				12,0					
	Total Costs	114,8				155,0								35,0				60,0					
	EC requested contribution	80,3				108,5								24,5				42,0					
KM Training	Personnel costs - task 1					788	0,3			11,7	1,0			525	0,3								
	Personnel costs - task 2					788	0,3			23,3	2,0			525	0,3								
	Personnel costs - task 3					788	0,3			11,7	1,0			525	0,3								
	Personnel costs - task 4					7,9	2,5			128,2	11,0			5,3	2,5								
	Personnel costs - task 5					7,9	2,5							5,3	2,5			41,0	10,0				
	Total Personnel Costs					18,1	5,8			174,9	15,0			12,1	5,8			41,0	10,0				
	Travel Costs					8,0				19,0				8,0				8,5					
	Other goods & services																						
	Total Direct costs					26,1				193,9				20,1				49,5					
	Total Indirect Costs					6,5				48,5				5,0				12,4					
	Total Costs					32,6				242,4				25,1				61,9					
	EC requested contribution					22,9				169,6				17,6				43,3					
TOTAL	Total Personnel Costs	79,8	13,3	108,3	49,2	1 409,8	543,2	183,8	24,9	1 415,2	157,3	353,4	65,5	115,4	55,0	17,5	4,7	121,7	29,7	89,6	14,0	83,4	21,5
	Total travel costs	12,0		27,5		187,5		44,0		94,0		36,0		47,0		12,5		29,5		5,0		12,0	
	Total Equipment					58,0				8,0										5,0			
	Total Other goods & services			29,5		154,6				194,1		20,0						1,0		12,8		750	
	Total Large Research Infrastructure (LRI)																						
	TOTAL OTHER DIRECT COSTS	12,0		57,0		400,1		44,0		296,1		56,0		47,0		12,5		30,5		22,8		12,8	
	TOTAL DIRECT COSTS	91,8		165,3		1 809,8		227,8		1 711,3		409,4		162,4		30,0		152,2		112,4		96,1	
	Total Total Indirect Costs	23,0		41,3		452,5		57,0		427,8		102,3		40,6		7,5		38,1		28,1		24,0	
	Total subcontracting																						
	TOTAL BUDGET	114,8		206,7		2 262,3		284,8		2 139,1		511,7		203,0		37,5		190,3		140,5		120,2	
	EC requested contribution	80,3		112,7		1 176,3		200,4		1 136,6		260,5		139,2		26,3		133,2		70,3		63,7	

WP	Category of cost	TUS		UCY		UHelsinki		UKRI-BGS		VTT		VUJE	
		Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm	Cost	pm
KM Guidance	Personnel costs - task 1												
	Personnel costs - task 2												
	Personnel costs - task 3												
	Total Personnel Costs												
	Travel Costs												
	Other goods & services												
	Total Direct costs												
	Total Indirect Costs												
	Total Costs												
	EC requested contribution												
KM Training	Personnel costs - task 1												
	Personnel costs - task 2												
	Personnel costs - task 3												
	Personnel costs - task 4												
	Personnel costs - task 5												
	Total Personnel Costs												
	Travel Costs												
	Other goods & services												
	Total Direct costs												
	Total Indirect Costs												
	Total Costs												
	EC requested contribution												
TOTAL	Total Personnel Costs	147,4	30,7	19,2	4,9	518,6	106,0	1 060,3	192,6	655,1	77,1	6,7	2,0
	Total travel costs	30,0		10,5		30,0		22,0		59,0		5,0	
	Total Equipment												
	Total Other goods & services	8,5				64,6		238,9		17,0			
	Total Large Research Infrastructure (LRI)									121,9			
	TOTAL OTHER DIRECT COSTS	38,5		10,5		94,6		260,9		197,9		5,0	
	TOTAL DIRECT COSTS	185,9		29,7		613,2		1 321,2		853,1		11,7	
	Total Total Indirect Costs	46,5		7,4		153,3		330,3		213,3		2,9	
	Total subcontracting												
	TOTAL BUDGET	232,4		37,1		766,4		1 651,5		1 066,4		14,6	
	EC requested contribution	131,4		21,3		383,2		597,7		571,9		10,2	

3.4.6. Not allocated budget (secured under Coordinator budget – under personnel costs for direct costs)

Not Allocated RDD Direct cost	11 041 446,7
<i>indirect costs</i>	2 760 361,7
Not allocated EC contrib. RDD	6 900 904,2
Not Allocated SS Direct cost	1 489 078,4
<i>indirect costs</i>	372 269,6
Not allocated EC contrib. SS	1 302 943,6
Not Allocated KM costs	1 132 942,3
<i>indirect costs</i>	283 235,6
Not allocated EC contrib. KM	991 324,5
TOTAL NOT ALLOCATED DIRECT COSTS	13 853 467,3
TOTAL NOT ALLOCATED INDIRECT	3 463 366,8
TOTAL EC CONTRIB NOT ALLOCATED	9 432 672,1

4. Members of the consortium

4.1. Beneficiaries

	No	Name	Acronym
Participant	1	Agence nationale pour la gestion des déchets radioactifs	Andra
Description of the legal entity Andra, The French National Agency for Radioactive Waste Management, is a public industrial and commercial organization created by the Act of 30 December 1991 (Nuclear Act related to Nuclear Waste Management). It comes under the supervision of the French Ministries for Energy, Research and the Environment, and is responsible for the long-term management of radioactive waste produced in France. It is in charge of the research program (concept design and long-term evolution) on a deep geological repository for high and intermediate level long lived radioactive wastes. It has also an industrial responsibility of operating the disposal facilities for short lived, low and intermediate level radioactive waste. For that purpose, Andra engaged its research process as of early 1994 and is currently operating an underground research laboratory in argillaceous rock, located in the Meuse/Haute-Marne region, in the vicinity of Bure. At the same time, Andra is further developing the technical concept of a repository. www.andra.fr			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks Andra is the Coordinator of EURAD and will be deeply involved in the EURAD Programme Management Office (PMO-WP1). Andra will also be actively involved in : - WP2-ACED : In tasks 3 & 4, Andra's participation is aiming to describe the HLW cell evolution thanks to reactive transport modelling. These modelling will integrate experimental results and coupling processes between chemistry and environmental conditions. The reassembly of these different modelling will allow providing a coherent, comprehensive and systematic scheme of a HLW cell chemical evolution. - WP3-CORI: Andra will participate in CORI in the different tasks : - o Task 1 : Experiments in the deep geological laboratory in Bure on in-situ leaching tests to investigate the superplasticizer mobility. - o Task 2 : (co-Leader) Determination of the diffusion coefficient of various organic molecules by electro-diffusion tests and integration of the results. degradation and characterization of organic matter, production of a State of the Art about degradation of polymers and releasing of organic species - o Task 3 : Integration of the results on the basis of a geochemical model. - WP4-DONUT: - o Task 1: "S/T coordination, State-of-the-art and training material" - o Task 5: "Benchmarks of methods and tools and methods for coupled processes"; contribution as defining representative cases with couplings and use of numerical tools. - WP5-FUTuRE: - o Task 1: Andra will provide input data (sorption, redox of RN) and contribute to the state of the art report. - o Task 2 : Andra will provide rock samples, pore water and data on associated physico-chemical properties. - o Task 3 : Andra will provide rock samples, pore water and data on associated physico-chemical properties. - WP6- GAS: o involved in task 3 about "Barrier Integrity" and leader of sub task 3.2 (Pathway			

closure and sealing processes). Andra will participate in this task to the state of art document and will provide (i) preserved host rock samples and EBS material and (ii) experimental data sets from previous and from new in-situ experiments in Bure URL. Andra is also involved in task 4 “Repository Performance Aspects” as leader of the task, and will contribute to repository scale numerical simulations. Andra will also contribute as data provider for Task 2 “Transport Mechanisms”

- **WP7- HITEC** Andra is involved in task 1, 2 and 4 and leads the Subtask 2.3 – THM modelling of effect of temperature in near and far field – Benchmark exercise. Andra will participate in the task to the state of art report (Subtask 1.2) and will provide available data on Callovo Oxfordian claystone. In Subtask2.3, Andra will provided in situ data as a benchmark exercise and will also participate to the benchmark exercises. In subtask 4.1 Andra will participate to evaluate how the progress beyond the state-of-the-art allows reducing the uncertainties and increasing the margin by which the safety functions can be fulfilled.
- **WP9- ROUTES** Andra leads Task 2 « Identify challenging wastes to be collaboratively tackled within the Joint Programme - Mapping and shared understanding at EU level of the practical issues on waste management routes » and contributes to other tasks. Andra contribution aims to provide up to date information on the French situation on waste management routes including opened questions and to analyze and consolidate data from various situations within Europe.
- **WP10- UMAN:** Andra will contribute and share experience in tasks 2, 4 and 5. Namely, Andra will lead the subtask 3.4 on characterization and significance of uncertainties related to human aspects, and the topic 3 (Uncertainty management options throughout a GD Programme) of the subtask 5.1 devoted at preparing, supporting and reporting on pluralistic analyses.
- **WP11- KM SoK** – Andra will contribute to the establishment of the EURAD Knowledge platform that will be developed under WP11.
- **WP13- KM Training/Mobility** – Andra will contribute to the establishment / implementation of the Training/Mobility programme under WP13.

a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities

Marie GARCIA (Female) is a European project manager and has a several years’ experience in the management of FP7 and H2020 projects. Was involved in the IGD-TP Secretariat between 2013-2016. Was deeply involved in the JOPRAD project that aimed to study the feasibility of European Joint Programme in the field of radioactive waste management. She will be in charge of coordinating EURAD first implementation phase and will be involved in the PMO WP.

Jacqueline OLTRA (Female), began as International assistant at Andra’s International Department, where she acquired her experience in international exchanges (IAEA, OECD and international partners). After that, she has been involved for several years as Management Assistant, in the management of the general operating expenses and the personnel costs of Andra. Finally, she has joined the European and national research projects Unit to use her skills to support Marie Garcia mainly in the PMO WP activities. Thanks to her knowledge of Project Management, she has developed management tools to coordinate and facilitate EC projects/programmes periodic reporting, in particular.

Gilles ARMAND (Male), Ph.D in rock mechanic at Joseph Fourier University (Grenoble, France) on Rock joint behavior (experimental and constitutive modeling). After a post-doctoral fellowship at McGill University (Canada) and at IRSN (France), he joined the French Radioactive waste management agency (ANDRA) as research engineer in charge of field experiments in geomechanic at the Meuse/Haute-Marne Underground research laboratory. In 2009, he became manager of the Fluid and Solid Mechanics Department at R&D department of ANDRA. His main research fields are: Excavation damaged zone (EDZ) characterization and modeling, hydro mechanical and creep behavior of claystone, THM behaviour and design of support in tunnelling

Benoît COCHEPIN (Male), Ph.D. in material sciences, pilot different numerical projects dedicated to the chemical evolution of waste disposals. These projects aim at incorporating physical phenomena at the real scale that induce mineral transformations, which in return impact transport and retention properties of the host rock. Key qualifications include experience with various reactive transport simulation tools. Key role concerns conceptualizing and performing reactive transport simulations. Contributions to former European project (PAMINA, CEBAMA) and to the international numerical benchmark project of reactive transport tools (SeSBENCH).

Christelle MARTIN (Female), engineer in chemistry, 41 years old. Worked in different companies involved in nuclear activities for 18 years, and at Andra as R&D engineer and project manager since 2007 in the Research and Development Division, Waste Packages and Material Department. In charge of the studies on the physical and chemical behaviour of vitrified waste in repository conditions. She will take part in ACED Subtask 1.5, especially for the analysis of experiments and models about glass/steel interactions.

Isabelle MUNIER (Female), Ph.D. in geochemistry and alteration of materials. Working at Andra as R&D engineer and project manager in the field of analysis, description and evaluation of geochemical degradation of cementitious materials. In charge of degradation processes assessment in the evaluation and performance analysis department. Key qualifications include reactive-transport modelling and performance assessment of intermediate level waste disposal. Key role is contribution to conceptualization of modelling, to expertise geochemical processes, to upscaling between phenomenological to safety assessment.

Guillaume PEPIN (Male), Senior Scientific Engineer, specialized on “Performance and Safety assessment” and “Numerical Simulation”, Head of Performance Assessment Department (20 persons), Research and Development Division, Andra.

- Description/quantification of phenomenological behavior of disposal components scale and geological environment (operating and post-closure period)
 - ✓ Integration of scientific knowledge to {components, physical process, space, time}
 - ✓ Conceptual models and quantification of Thermo-Hydro-Mechanics-Chemical-Radiological behavior
- Performance and safety assessment of disposal system
 - ✓ Physical and numerical conceptualization of safety scenarios
- Improvement/development of numerical tools able to represent multi-physics couplings over large time and space scales

Denise RICARD (Female), graduated in chemistry, PhD in physical chemistry of polymers. After her thesis, worked during 3 years in a laboratory of the engineering department of Technical University of Lisbon in the development of polymer membranes. Before joining Andra, in 2008, worked in during one year in the laboratory of Arts et Métiers Paristech specialized in the ageing of polymers. Since 2008, have been working in the R&D department of Andra as engineer and specialist of organic matter. One of my research topics is the degradation of organic materials (polymers and bitumen) in disposal conditions.

Jean-Charles ROBINET (Male), Ph. D in geosciences at University of Poitiers (France). Specialist in the transport and interactions of solutes in clay-rock systems and multi-scale analysis of natural material structure. Have been working at Andra in the R&D division since 2009. Since 2016, in charge of the Transfer Group responsible for radionuclide speciation and transport from the waste cells to the biosphere. Currently, coordinator of the CTEC (Chemistry and Transfer in Complex Environments) Andra R&D program and co-coordinator of the national NEEDS MIPOR (Porous Media) project. Previously involved in several national and European project (FP- FUNMIG, FP7 CatClay...).

Jean TALANDIER (Male) PhD in mechanics from Paris VI University in 1994, with a specialization in numerical methods for fluid mechanic. Involved in R&D program in Andra since 1995, he is in charge of gas issues for radioactive waste disposal, deputy head of fluid and solid mechanics department since 2012. He manages the research program developed by Andra about gas/water transfer and hydro-mechanical behaviour of swelling clays. Participation in the European projects GASNET (A thematic

network on gas issues in safety assessment of deep repositories for nuclear waste (2001-2004), FORGE 2009-2013 (Fate Of Repository GasEs) as coordinator for Andra, work package leader in European project BEACON (Bentonite Mechanical Evolution).

Jacques WENDLING (Male), Senior Scientific Engineer, specialized on “Performance and Safety assessment” and “Gas transfer”, Deputy Head Manager of Performance Assessment Department (20 persons) of Research and Development Division,.

- Performance and safety assessment for all types of disposal system (surface subsurface, deep underground). Participation in several international cooperation programs in performance and safety assessment, mainly for Lithuania and South Korea
- Lead of two-phase flow numerical program at Andra
- Participation in European Projects:
 - ✓ CAST WP6 “Performance assessment”
 - ✓ Lead of European project FORGE 2009-2013 (Fate Of Repository GasEs) WP1.2 “Repository-scale numerical simulations of gas migration”
 - ✓ Andra’s Research and Development Division representative in European project DOPAS 2012-2016 (Demonstration Of Plugs And Seals)

Pierre HENOCQ (Male), Ph.D in civil engineering on the physical, chemical and electrokinetical properties of the cement-based materials at Laval University in Quebec City (Canada), worked during 7 years as project manager in the R&D department at SIMCO Technologies inc. which is specialized in the service life assessment of concrete structures. Since 2013, works at Andra in the R&D department on the radionuclide migration in the cementitious materials. Also participating to the European project CEBAMA as Andra’s representant in the End-User group and as co-coordinator in the work package CORI in the framework of EURAD-1.

Jean-Michel HOORELBEKE (Male), Safety, Environment and Waste Management Strategy Deputy Director at Andra, has thirty years of experience in the design and safety approach of waste repositories in France, shallow and underground. He is also experienced in designing interim storage facilities for waste and spent fuel. As geological disposal project manager from 1993 to 2007, he has defined and implemented Andra’s iterative approach between knowledge acquisition, repository design, modelling and safety assessment. His experience in waste management strategy includes the proposal in 2008 of a national scheme for the long term management of disused sealed sources in France, the development of an overall optimisation methodology for the French HLW and ILW management system, the undergoing development of a graded approach aiming at enhancing the proportionality of French disposal routes to the harmfulness of wastes. His international experience includes contributions to various IAEA consultancy and technical meetings (ILW...) as well as NEA expert groups (reversibility, predisposal). He was Key Expert for the UE Devco program in Ukraine to develop disposal concepts (INSC PROJECT – U4.01/09 B).

Jean-Noël DUMONT (Male), Special Adviser at Andra. He is in charge of societal aspects for the definition of the disposal strategy for the management of radioactive wastes of the various kinds. Namely, he is the coordinator of Andra's Memory Program, which aims at consolidating and extending memory preservation for the existing and future repositories. Based in the headquarters of Andra near Paris, he has 37 years of experience, with more than 20 years in the waste management business. He is a graduated engineer from Mines-ParisTech.

Vincent MAUGIS (Male), Knowledge Management Officer for Andra. M. Eng. in Knowledge Management and Innovation Engineering (2002), he has carried research and development in knowledge management and decision support for sustainable development policy-making at MIT. Before joining Andra, Maugis has designed and implemented the national knowledge management system for supporting the performance of French healthcare and medico-social facilities as well as intergovernmental knowledge management services for supporting social development policy-making. Within the EJP, Maugis provides scientific and methodological support to the Knowledge Management Workpackages.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- [1] **PHILIPP SCHAEDEL, THOMAS KAEMPFER, GUILLAUME PEPIN, JACQUES WENDLING & JUERGEN BROMMUNDT**: Combining high-resolution two-phase with simplified single-phase simulations in order to optimize the performance of PA/SA simulations for a deep geological repository for radioactive waste, in Norris, S., Bruno, J., Van Geet, M. & Verhoef, E. (eds) *Radioactive Waste Confinement: Clays in Natural and Engineered Barriers*. Geological Society, London, Special Publications, 443, <http://doi.org/10.1144/SP443.4>, 2016
- [2] Henocq, P. (2017). A sorption model for alkalis in cement-based materials–Correlations with solubility and electrokinetic properties. *Physics and Chemistry of the Earth, Parts A/B/C*, 99, 184-193.
- [3] Gas transport properties through intact and fractured Callovo-Oxfordian mudstones, April 2017, Geological Society London Special Publications SP454.7, J. F. Harrington, R. Cuss, J. Talandier
- [4] A Thematic Network on Gas Issues in Safety Assessment of Deep Repositories for Radioactive Waste (GASNET)- Final report, 2003 – EUR20620
- [5] M. L. Schlegel, C. Martin, F. Brucker, C. Bataillon, C. Blanc, M. Chorro, P. Jollivet, Alteration of nuclear glass in contact with iron and claystone at 90 °C under anoxic conditions: Characterization of the alteration products after two years of interaction, *Applied Geochemistry*, 70, 27-42 (2016)
- [6] Marty N. C. M., Munier I., Gaucher E. C., Tournassat C., Gaboreau S., Vong C. Q., Giffaut E., Cochepin B. et Claret F. (2014) Simulation of cement/clay interactions: Feedback on the increasing complexity of modelling strategy. *Transport in Porous Media*. Vol. 104, 2, 385-405.
- [7] Marty N. C. M., Bildstein O., Blanc P., Claret F., Cochepin B., Gaucher E. C., Jacques D., Lartigue J. E., Liu S., Mayer K. U., Meeussen J. C. L., Munier I., Pointeau I., Su D. et Steefel C. I. (2014a) Benchmarks for multicomponent reactive transport across a cement/clay interface. *Computational Geosciences*. Vol. 19, 635-653.
- [8] Radiochemical ageing of epoxy coating for nuclear plants, *Radiation Physics and Chemistry*, Volume 79, Issue 3, March 2010, Pages 362-364.
- [9] Robinet J.C., Coelho, D., Altmann S., (2011) « State of the art on cation diffusion in clay mineral systems ». EC Project CatClay - Public report.
- [10] Dumont J.-N., Charton P., Boissier F.: Andra's Strategy and Approach for Long-Term Memory Preservation of a Deep Geological Repository, *Waste Management Symposium, Phoenix*, (2015)
- [11] Recent relevant publication: The search for proportionality of radioactive waste management solutions to their harmfulness, in *Radioprotection*, Volume 53, Number 3, July-September 2018, pp 67 – 173 (www.radioprotection.org)

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

- JOPRAD, H2020, EURATOM
- CHANCE, H2020, EURATOM
- THERAMIN, H2020, EURATOM
- Cebama, H2020, EURATOM
- CAST, FP7, EURATOM
- CatClay, FP7, EURATOM
- FUNMIG, FP6, EURATOM

1. CMHM facilities

Andra's major research facility is the Underground Research Laboratory located on the eastern boundary of the Paris Basin (Meuse/Haute Marne region) and aiming at studying the feasibility of the reversible geological disposal of high-level and intermediate-level long-lived radioactive waste (Cigéo project) in the Callovo-Oxfordian clay formation. More than 15 years of research and development works have been carrying out in this URL to support the main milestones and reports of the Cigéo project.

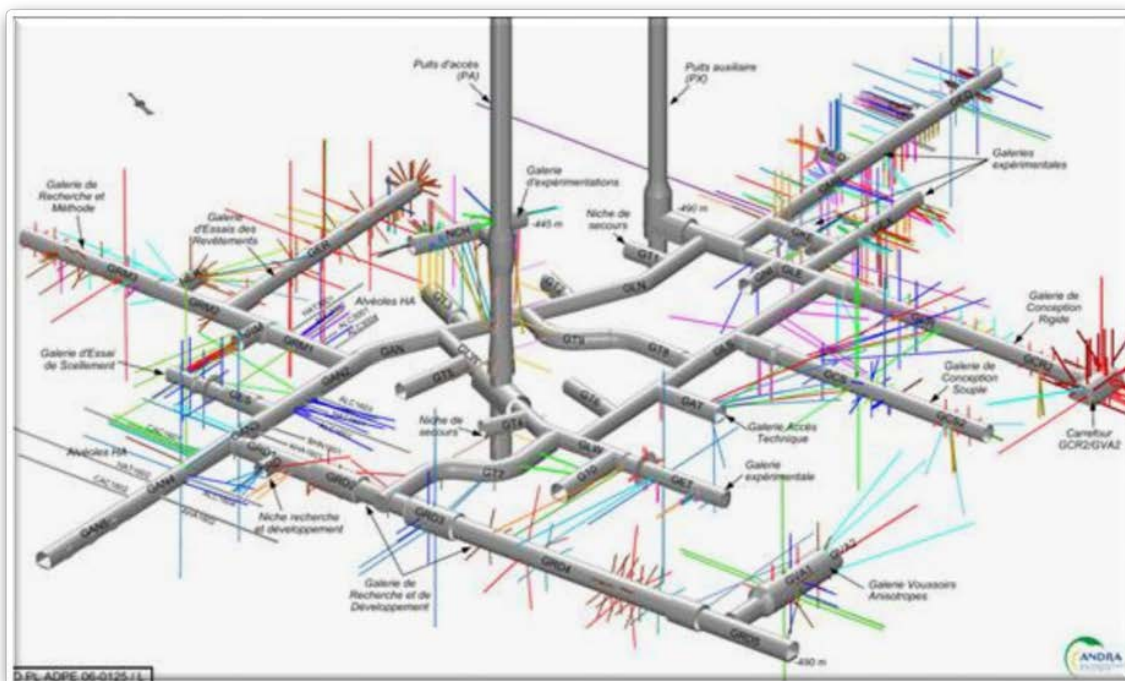


Figure 21: The current MHM URL network consisting in 1.7 km of drifts and about 850 boreholes (various colour lines)

The MHM URL consists in (Figure 1):

- 2 shafts of 500 m ;
- 1 drift 40 m long at –445m (upper part of Callovo-Oxfordian clay formation, more rich in calcite) from the ground surface;
- A current network of 1.7 km of drifts located at – 490m. The sections of drift vary between 18 and 60 m² according to scientific and technological objectives. About 850 boreholes been drilled in all directions (vertical up and down, horizontal, oblique) up to 100 m long, in a wide range of diameter between 22 mm and 350 mm. The purposes of these boreholes are very large:
 - o R&D objectives: geological survey, hydrogeological, geochemical, microbiological and rock mechanical studies;
 - o Characterisation of anthropic impacts: temperature, excavation and ventilation, alkaline plume etc.;
 - o Technical aims: excavation and support (lining) techniques.

More than 11 000 sensors have been installed in the rock, inside boreholes, in the drifts, in the shafts, allowing a continuous monitoring at distance. The type of sensors tested is very large according to concerned Thermal, Hydraulic, Mechanical, Chemical and Radiological domains: from very classical sensors (ex. pressure/temperature) to the development of innovative optic fibre with distributed measurements and sensors for thermal and mechanical long term monitoring.

2. Observatoire pérenne de l'environnement (OPE)

Around the expected site of the Cigéo surface facilities, Andra has designed an ambitious network of monitoring stations including purposed built observatories in forest and agricultural land associated with atmospheric, climatic and water (surface and underground) monitoring stations. Data from these observatories acquired continuously are complemented by grid survey for soil quality and biodiversity. In total an area of 900 km² is surveyed with a focus on a restricted 240 km² in direct proximity of the expected site of the Cigéo surface facilities. An environmental specimen bank is also starting to collect samples during the operating period since a century with the aim to provide samples for retrospective analysis if and when necessary in the future.

This observation network constitutes Andra's long term observatory (called OPE for Observatoire pérenne de l'environnement) which is scheduled to monitor the environment for around 120 years. OPE is also actively interacting with other complementary observatories through national and international environmental programs.

	No	Name	Acronym
Participant	2	Agencija za radioaktivne odpadke	ARAO
Description of the legal entity The ARAO is a public service agency that concludes contracts in connection with its activities with the line ministry competent for the Energy Directorate. The ARAO is the mandatory service of general economic interest provider of management of radioactive waste generated in the territory of Slovenia. Its task is to takeover, transport, and carry out pre-treatment, treatment, conditioning, and storage of radioactive waste generated in industry, research and medicine. The ARAO is authorised to manage and carry out long-term monitoring and maintenance of disposal sites of hydrometallurgical tailings and mine waste tailings and repositories for radioactive waste and spent fuel after their closure. By planning and providing long-term, safe and cost-effective solutions for radioactive waste and spent fuel management, including the construction of the LILW repository, it provides infrastructural and professional support to the use of nuclear and radiation technologies in Slovenia. The radioactive waste management as a mandatory service of general economic interest will, when the infrastructure conditions are met, also provide for the final disposal of the radioactive waste and spent fuel generated during the operation and decommissioning of the nuclear power plant and for the disposal of radioactive waste from all other industrial activities.			
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks ARAO as mandated WMO from Republic of Slovenia will be engaged in Task n°6 – Shared solutions in European countries under Strategic Study WP on “Waste management routes in Europe from cradle to grave (ROUTES)”. Task objectives n°6: - Describe and assess knowledge on and approaches to sharing technology and facilities between members states. - Provide an overview of the interest in and experience with sharing technology/facilities in the different steps of waste management. - Identify gaps and define needs for R&D, strategic priorities and opportunities for collaboration between member states, as applied to challenging wastes as defined in task 1 and LAPs. The Krško Nuclear Power Plant (Krško NPP) is one of the main pillars of the Slovenian power system. The plant is operated by the public company Krško NPP d.o.o. and owned by state-owned Slovenian and Croatian electrical power companies (GEN energija d.o.o. and Hrvatska Elektroprivreda d.d., respectively). In accordance with The Bilateral Slovenian-Croatian Agreement on the Krško NPP, both countries share responsibility for RW and SF management. In Resolution on the 2016–2025 National Program for Managing Radioactive Waste and Spent Nuclear Fuel (ReNPRRO16-25) in Republic of Slovenia the conceptual idea of shared facilities and regional cooperation in waste management, including the dual-track approach, was clearly implemented. In Slovenia radioactive waste (RW) and spent fuel (SF) management must be implemented in such a way so as to ensure modern principles of RW and SF management. Especially relevant principles for the task objectives are: - The principles of international cooperation Slovenia is aware of the responsibility and opportunity presented at the regional and global levels to safely and sustainably resolve issues related to radioactive waste and spent fuel management together with other countries. In its actions, account should be taken of the principles adopted in this policy and regional and international agreements. National responsibility for radioactive waste and spent fuel management shall be considered in parallel with active participation in international regional efforts to make progress towards joint regional programmes for disposal. - The principle of seeking a joint solution Slovenia is aware of the responsibility for the management of radioactive waste and spent fuel and its disposal and shall, in accordance with The Bilateral Slovenian-Croatian Agreement on the Krško NPP, strive to ensure an effective joint solution for the decommissioning and disposal of radioactive waste and spent fuel from the Krško NPP with Republic of Croatia. For long-term spent fuel management, a dual-track strategy has been adopted as a reasonable solution in the present situation. The dual-track approach in Slovenian strategy includes both first, the option of			

multinational disposal is kept open, and second, the basic reference conceptual scenario for national geological disposal is included. With regard to disposal and sharing of facilities, the ARAO participates at the EU level in two programmes which address the possibility of building a multinational/regional repository for spent fuel and high-level waste (ERDO-WG and IGD-TP) and is also involved in the work of the International Framework for Nuclear Energy Cooperation (IFNEC). Due to special status of the Krško NPP, ARAO has gained lots of experience in sharing of facilities during sitting and construction permit approval process for possible joint Slovenian and Croatian LILW repository (negotiations in progress) and construction of joint dry storage facility for SF in Křsko NPP. ARAO has gained a lot of experience also in sharing of potential regional/multinational disposal facilities through cooperation with other WMO and stakeholders (IAEA, OECD/NEA, WNA, IFNEC, ERDO-WG, Reginal Seminar, ...).
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities CV for Leon Kegel, ARAO leon.kegel@arao.si Working in ARAO in Planning and Development Section for 10 years in the area of long-term policy and strategy development for RW&SF management including long-term storage and final disposal facility development with associate costs assessment. Head of project for development of technical expert basis for National Programme for Radioactive Waste and Spent Fuel Management for period 2016-2025 under EC Directive 2011/70. Head of project for preparation of joint Slovenian-Croatian Program of NPP Krško Decommissioning and Program of SF & RW Disposal.
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content • Kegel L., Žagar T.: Preparation of Decommissioning Program for NPP with Shared Ownership, International conference on Advancing the Global Implementation of Decommissioning and environmental Remediation Programmes; Madrid, Spain, May 2016, • Kegel L., Žagar T.: Preparation of the National Programme for the Spent Fuel and Radioactive Waste Management Taking Into Account Possibility of Potential Multinational/Regional Disposal Facilities Development, International conference on the Safety of Radioactive Waste Management; IAEA, Vienna, Austria, November 2016 • Kegel L.: Slovenian Approach on Costing LILW Repository (including costs for shared LILW repository), "Technical Meeting on Financing Schemes for Radioactive Waste Disposal Programmes", Vienna, Austria, May 22 –26, 2017
a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal • Preparation of joint Slovenian-Croatian Program of NPP Krško Decommissioning and Program of SF & RW Disposal from Krško NPP • ARAO membership in ERDO-WG from 2009 • ARAO membership in IFNEC RNFSWG dealing with multinational disposal facilities • IAEA INPRO preparation of the Study on Cooperative Approaches to the Back End of the Nuclear Fuel Cycle (NFC): Drivers and Institutional, Economic and Legal Impediments - The Multinational Repository Concept: Opportunities and Benefits for Consideration by Potential Service Providers
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; N/A
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task. N/A

Participant	No	Name	Acronym
	3	Bel V	Bel V
Description of the legal entity Bel V is a technical subsidiary of the Federal Agency for Nuclear Control (Belgian Safety Authority). By virtue of its activities and its relations to the FANC, Bel V is the Belgian Technical Safety Organisation. The FANC relies on the technical expertise of Bel V for carrying out inspections in nuclear installations in Belgium. Bel V acts as well as expert for the safety assessments of nuclear projects and participates actively in working groups that are organized in the framework of international organizations. Its financial resources are allocated in part to research and development activities.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks WP UMAN: Bel V will act as WP leader. As national TSO, the oversight of uncertainty management approaches and activities carried out by proponents or licensees of waste management facilities is part of Bel V's core business activities. As WP leader, Bel V will coordinate Task 1 dedicated to WP coordination, interactions with KM WP & integration. Bel V will contribute to Subtask 2.1 on the generic strategies for managing uncertainties by providing a regulatory perspective on uncertainty management strategies and approaches. In Subtask 3.5, Bel V will collect and synthesize relevant information on uncertainties associated with spent fuel including regarding the experience gained through its activities in the Belgian national programme. In Task 4 on uncertainty management options, Bel V will identify regulatory preferences on the management options and contribute to the analysis of options and the identification of needs for future activities that will be synthesised in Task 1. In Task 5 on the interactions between all categories of actors, Bel V, as coordinator of the WP, will participate in key meetings related to Topics 1 to 4 and the organisation of the seminars and review the deliverables. WP ACED: Bel V will participate in Subtask 2.2 of this WP. In this framework, Bel V will contribute to piloting the new experiment focusing on the evolution of grout cement/CEM I and carbon steel interfaces at 80°C. In the framework of its R&D programme, Bel V has developed knowledge and expertise in this topic, notably by being involved in and co-funding the following PhD's: • PhD on the effect of temperature on geochemistry, microstructure and diffusion at cement/clay interfaces (P. Lalan 2013-2015); • PhD on the development of a coupled experimental, numerical and statistical homogenization approach towards an accurate feedback relationship between porosity and diffusive properties of model cementitious materials in the field of reactive transport modelling (N. Seigneur 2012-2016) Bel V involvement in the previous EC-H2020 SITEX projects (where Bel V coordinated the TSO SRA development) has also contributed to develop expertise in this topic. WP ROUTES: Bel V will be involved in Task 2 of this WP, devoted to identifying challenging wastes to be collaboratively tackled within the Joint Programme and mapping and share understanding at EU level of practical issues on waste management routes. As a TSO Bel V overlooks safety aspects related to radioactive waste management in Belgium and has thus developed knowledge and experience on existing and missing waste management routes. Moreover, Bel V is involved in the management of safety issues on waste management (e.g. drums affected by ASR gel formation, bitumen drums) that would be worth to share in the framework of this WP.			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Mr. Frank Lemy holds a degree in Mining Engineering from the Faculté Polytechnique de Mons (Belgium) and a Ph.D. in Rock Mechanics from the Laval University (Canada). He has worked for 5 years as researcher and lecturer in the fields of geomechanics and engineering geology at the Laval University and ETH Zürich (Switzerland). He has held for more than 5 years a position of expert in radioactive waste management at FANC (Belgian Nuclear Safety Authority) and has been involved since 2008 in the Belgian surface and geological disposal projects. He has also participated in several international R&D projects and working groups dealing with the safety of repositories (PAMINA, FORGE, SITEX, IGSC, HIDRA,...). He has participated as a task leader of the TSO working group in the JOPRAD project, that paved the way to the EURAD. He is currently working as a safety analyst at			

Bel V in the fields of waste management, geology and civil engineering and coordinates the technical review of the post-closure safety assessment of the Belgian surface disposal repository. He is responsible for the development and implementation of a R&D programme for supporting the regulatory review of the safety case for a geological disposal facility.

Mr. Valéry Detilleux holds a Ph.D. in physical chemistry from the Université catholique de Louvain (Belgium). He works at Bel V as a safety analyst, where he is involved in the review of safety assessments for radioactive waste treatment, conditioning and disposal facilities. He is responsible for the development and implementation of a R&D programme for supporting the regulatory review of the safety case for a geological disposal facility. He was actively involved in the former EC-SITEX and SITEX-II projects. In the framework of SITEX-II, he coordinated the development of the TSO Strategic Research Agenda. Moreover, he participated in international working groups such as IAEA GEOSAF II and IAEA PRISM.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

Publications:

- Bernier, F., Lemy, F., De Cannière, P. & Detilleux, V. (2017). Implications of safety requirements for the treatment of THMC processes in geological disposal systems for radioactive waste. Journal of Rock Mechanics and Geotechnical Engineering, Volume 9, Issue 3, June 2017, Pages 428-434.
- Lemy F. & Bernier F. (2013). Regulatory Expectations Regarding the Safety Case: Moving from Conceptualization to Implementation. Euradwaste'13 Conference, Vilnius, 14-16 October 2013.
- Bernier F. & Lemy F. (2013). Implications of the Regulatory Framework and Activities on R&D Supporting Repository Implementation. The Safety Case for Deep Geological Disposal of Radioactive Waste: 2013 State of the Art, 2nd International Safety Case Symposium, 7-9 October 2013, Paris, France.
- Detilleux V., Depuydt J., Noterman N., Van De Velde T., Marloye D., De Smet F. (2017). Gel formation in conditioned waste drums: overview of the issue and lessons learned by the Regulatory Body, Proceedings of the EUROSAFE Forum 2017, 247-252
- Lalan P., Dauzères A., De Windt L., Bartier D., Sammaljärvi J., Barnichon J.-D., Techer I., Detilleux V. (2016) Impact of a 70 °C temperature on an ordinary Portland cement paste/claystone interface: An in situ experiment, Cement and Concrete Research, 83, 164-178

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

Besides its participation in various national and international projects related to radioactive waste management (e.g. IAEA-PRISM, PRISMA, HIDRA I&II, GEOSAF and MODARIA, EC-MICADO and PAMINA), Bel V was actively involved in the following projects that paved the way to the EURAD proposal:

- SITEX I & II (WP leader), JOPRAD (task leader)

Moreover, Bel V is involved in the following group, whose activities are connected to tasks in which Bel V will participate in the framework of EURAD (e.g. WP UMAN):

- NEA IGSC

Finally, as a TSO, Bel V is a.o. involved in the following activities in support to the national regulatory authority:

- Review of the license application for the radioactive waste surface disposal facility in Dessel, Belgium
- Review of safety assessment methodologies submitted in the framework of the national geological disposal programme
- Review of license applications and modification requests for facilities where nuclear waste are generated and managed (e.g. NPPs, radioactive waste and spent fuel storage facilities), as well as the regular inspection of these facilities.

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work

The new experiment in which Bel V will be involved in the framework of WP ACED will take place in the IRSN URL at Tournemire.

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

N/A

	No	Name	Acronym
Participant	5	Commissariat à l’Energie Atomique et aux Energies Alternatives	CEA
Description of the legal entity The French Alternative Energies and Atomic Energy Commission (CEA) is a key player in research, development and innovation in four main areas: defence and security, low carbon energies (nuclear and renewable energies), technological research for industry, fundamental research in the physical sciences and life sciences. CEA represents 16,000 permanent staff, spread among 9 research centers in France. Drawing on its widely acknowledged expertise, the CEA actively participates in collaborative projects with a large number of academic and industrial partners. Amongst its missions, CEA (Nuclear Energy Division) is working on the optimization of the current nuclear industry. In this framework, CEA is carrying out research for the management of radioactive wastes and spent fuel.			
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks CEA is involved in 5 work packages of the Joint Programme. Regarding Cement-Organics-Radionuclide-Interactions (WP CORI) and Fundamental Understanding of radionuclide mobility (WP Future), CEA will provide dedicated experiments to study the mobility of the radionuclides of interest in cement and compacted clay rocks, benefiting of its skills in this domain. CEA has developed a large experience on the vitrified wastes, and their long-term behaviour under disposal conditions. Hence, CEA will also contribute to the assessment of chemical evolution of High Level Waste disposal cell by characterizing and modelling long-term interactions in a glass/steel/clay system (ACED). Furthermore, CEA has been involved since many years on the characterization of thermo-mechanical behaviour of bentonite, in the framework of European projects and collaboration with Andra. Enriched by this experience, CEA proposes to characterize the thermo-mechanical behaviour of clay host-rocks (WP HITEC). At last, CEA, who has conducted large scope of research on spent nuclear fuel behaviour under dry storage in the framework of 1991 French law, will provide experimental data on the behaviour of spent fuel rod under dry storage in incidental scenario (no tight cladding) (WP Spent fuel).			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Dr. Philippe Dillmann (male) is “Directeur de Recherche” at the French CNRS, doctor and engineer in materials science and “<i>Habileté à Diriger des Recherches</i>”. He is director of the “Laboratoire Archéomatériaux et Prévision de l’Altération” (CNRS and CEA), deputy director of the UMR3685 and UMR5060 of the CNRS. He conducts researches for 20 years on long term alteration of metals and glasses. He funded the Working Party 21 of the European Federation of Corrosion, dedicated to the long term corrosion. Philippe Dillmann is involved in the Scientific Committee of several French and International Institutions, among them, the Labex LaScArcBdx, the Fondation des Sciences du Patrimoine, the European Federation of Corrosion, the Centre Européen d’Archéométrie (Belgium). Dr. Stéphane Gin (male) received a Master degree from Orléans University, France, and a PhD degree from Poitiers University, France in 1994. Since 1995, he works at the French Atomic Energy and Alternatives Energy Commission (CEA) of Marcoule, France, starting his career as scientist on nuclear and commercial glass corrosion problems. In 2001, he took the lead of the “Long term behavior of HLW glass” group within the Department of treatment and conditioning of nuclear waste at CEA. From 2012 to 2013, he was visiting scientist at Pacific Northwest National Laboratory, USA. Dr Gin is also part of advisory boards on high-level waste management in Belgium, the UK, and the USA. After graduating as chemist engineer in 2001, Virginie Blin (female) joined the Laboratory of Radionuclide Migration Measurement and Modeling (L3MR) where, during 10 years, she is in charge of several radionuclides retention and diffusion studies, both in claystone and cementitious materials, and particularly of <i>in situ</i> radionuclides diffusion experiments carrying out a in the Andra’s Meuse/Haute-Marne Underground Laboratory. End of 2011, she takes the head of the Laboratory. Since end of 2017, she is project manager of a CEA R&D project, which deals with long term behavior of IL-LL waste packages and engineered/natural barriers of deep disposal. Dr Nathalie Macé (female) has defended in 2006 a PhD thesis on the “effect of temperature onto selenite retention by an altered cement paste and its constitutive cementitious phases” (University of Orsay (Paris			

XI). From 2007 to 2009, she has a Post-doctoral position on “Micro-scale Investigations of the Speciation and the Mobility of Uranium in Cementitious Materials (MISUC)”. This work has been funded as an EURATOM Marie-Curie fellowship and performed in the Laboratory for Waste Management of the Paul Scherrer Institut, (Villigen, Switzerland). In 2010, she joined the L3MR Laboratory of CEA, where she is in charge of studying the radionuclides retention and diffusion in cementitious matrices (individual cement phases, hydrated cement paste, mortar and concrete).

Dr. Romain V.H. Dagnelie (male) received his PhD degree in 2009 at the University Paris-XI (Orsay, France), where he studied photochemistry and detection of gaseous organic pollutants. In 2010, he joined the Laboratory of Radionuclide Migration Measurement and Modelling. His research interests include the transport of radionuclides in the environment, with a focus on behaviour of organic molecules in the context of radioactive waste disposal. To that aim, he is developing adsorption and diffusion experiments at various scales, including field experiments in deep underground research laboratories.

Dr. Sébastien Savoye (male) is a senior expert at CEA, doctor in geochemistry and “Habilitation à Diriger des Recherches”. He is expert in experiments and modelling of retention/diffusion of radionuclides through various porous media (claystones, compacted clays, cement-based materials, bitumen) under large experimental conditions (partial water saturation, high temperature, high ionic strength, acidic or alkaline fluids and redox perturbation). He was coordinator of the European Project entitled “CatClay” and involved in the EU Recosy project dedicated to the redox issues.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- “Origin and consequences of silicate glass passivation by surface layers”, Gin, Stephane; Jollivet, Patrick; Fournier, Maxime; et al. NATURE COMMUNICATIONS Volume: 6, Article Number: 6360 Published: FEB 2015
- “Diffusion of organic anions in clay-rich media: effects of anion exclusion on retardation”; Dagnelie R.V.H, Rasamimanana S., Blin V., Radwan J., Thory ., Robinet J-C., Lefèvre G. Chemosphere, submitted.
- “Use of quantitative digital autoradiography technique to investigated the chlorine-36-labelled radiotracer transport in concrete”; N. Macé, P. Fichet, S. Savoye, J. Radwan, C. Lim, S. Lefèvre, J. Page and P. Henocq. Applied Geochemistry, submitted.
- “Adsorption of polar organic molecules on sediments: Case-study on Callovian-Oxfordian claystone”, S. Rasamimanana, G. Lefèvre, R. V. H. Dagnelie, Chemosphere, Volume 181, August 2017, Pages 296-303
- “Effect of water saturation on the diffusion/adsorption of ^{22}Na and cesium onto the Callovo-Oxfordian claystones”, Savoye S., Lefevre S., Fayette A., Robinet J.Ch, 2017, *Geofluids*, 1683979, <https://doi.org/10.1155/2017/1683979>
- “Behavior of a defective nuclear fuel rod in dry storage conditions studied with a new experimental”, L. Desgranges, M.P. Ferroud-Plattet, R. Alloncle, I. Aubrun, J.M. Untrau, P. Lhuillery, *Nuclear Technology*, vol. 163, 2008

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

Since 1999, PRECCI project is the national program lead by CEA on the study of spent fuel long-term behaviour, under storage and disposal conditions. This national project is supported by EDF/R&D and Andra. CEA provides research to respond to Andra’s needs regarding the development of a geological disposal of ILW and HLW (national Cigéo Project).

CEA coordinated European Projects connected to EURAD: SFS (“Spent Fuel Stability under Repository Conditions”, 5th FP) and CATCLAY (*processes of CATion migration in CLAYrocks*, 7th FP). CEA contributed to NF-PRO (6th FP) and RECOSY (7th FP) EU projects. CEA participated to various experiments conducted by Andra in the underground Laboratory of Bure, on bentonite used as sealing material.

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

Hot laboratory in CEA Cadarache Centre for the study of spent fuel behaviour (in a closed system, or in air)

Laboratory in CEA Saclay Centre for the study of radionuclide migration in porous media

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task. N/A

	No	Name	Acronym
Participant	4	Bundesgesellschaft für Endlagerung	BGE
Description of the legal entity BGE is the federal company for radioactive waste disposal, implementer and German waste management organization. The BGE is entrusted with the task of implementing site selection procedures for a final repository, particularly for heat-generating radioactive waste. Additionally, the BGE is operator of the Asse II shaft mine, the Konrad final repository and the Morsleben final repository.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks WP HITEC: BGE intends to develop a time dependent anisotropic THM model for argillaceous rock which incorporates strength and stiffness anisotropy, a time-dependent deformation, a dependency of permeability on irreversible strains, a hydro-mechanical coupling for saturated and/or unsaturated conditions and a thermo-mechanical coupling able to predict the thermally induced opening of fractures in claystone. The planned contribution of BGE focuses on the Task 2 related question "How good are the current THM models in representing the stress changes at repository relevant conditions?" by the constitutive modelling of THM behaviour of COX and Opalinus Clay within an open source process level code. The aim is to close existing gaps in regard to the hydro-mechanical coupling with respect to the temperature effects and increase the understanding of the relationships between involved phenomena. WP GAS: BGE envisages in collaboration with UFZ to develop a TH ² M constitutive material model for bentonite which takes into account the two phase flow formulation and the pathway dilation process and incorporate some of the state of the art THM formulation for bentonite actually developed in the scope of the European project BEACON. The results will provide a better understanding of the consequences of gas migration in terms of demonstrating the barrier integrity. WP UMAN: As Task Lead BGE will develop and distribute a questionnaire in order to identify the different actors and collect information about their roles and interests. Also BGE will be in charge of the writing of the deliverable. BGE will contribute to the compilation and review of uncertainty management options, provide an input regarding the options considered in the German programme (considering in particular the construction, operation, and closure of a repository mine). BGE will organize and participate in the workshops, provide an input on the pros and cons from the viewpoint of the German WMO, contribute to the analysis of options, to the identification of needs for future activities and to the writing of the deliverable. WP KM – State-of-Knowledge: BGE will provide the WP Lead. Together with the other participants specifications for the development of a knowledge platform will be elaborated and a "prototype" platform will be set up on the basis of these developed specifications. This platform will be hosted by BGE.			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Panja Feuker, Diplom-Geologist (M. Sc.): Geology/Palaeontology, 47, female Key qualifications Project management of international projects in geothermal energy and mining. Planning and designing of international projects. Environmental impact studies in Hydrogeology/Hydrology. Professional Experience: Initialization, implementation and coordination of international projects in mining and geothermal energy. Project Management and evaluation of mining and geothermal projects. Evaluation of environmental impact studies in mining. Language skills: German (native), English (fluent), Spanish (fluent) WP: KM			

Astrid Göbel, Diplom-Geologist (M. Sc.): Geology/Geochemistry, Natural Resources, 51, female

Key qualifications Project Management, evaluation and strategic controlling of repository projects, development of standards and processes. Crisis and Contingency Management. Quality Assurance Management.

Professional Experience: Initialization, implementation and coordination of RD&D (planning, JOPRAD, EJP1). Project Management, implementation and evaluation of disposal projects. Key questions on Radioactive Waste Disposal. Committee work (national/international).

Language skills: German (native), English (fluent)

WP: GAS, HITEC, KM, UMAN

Philipp Herold, Dipl.-Ing: Mining Engineer, Project Manager, 33, male

Key qualifications: Underground mining engineering, Mining ventilation planning and simulation. Planning and design of retrieval technologies, design of sealing elements.

Professional Experience: Planning and conception of ventilations systems and underground drifts. Planning of hoisting system for Belgian disposal concept. Underground transport system.

Language skills: German (native), English (fluent)

WP: HITEC

Gunnar Hoefer, Diplom-Geograph (M. Sc.): Physical Geography and Landscape Ecology, Geology, Soil Science, Hydrology, Water Resources Management & Environmental Law, 47, male

Key qualifications Knowledge Management. Project Management. Geodata Management. Geoscientific impact planning of site specific interims storage facilities. Environmental impact planning of site specific interims storage facilities.

Professional Experience: Environmental reporting, environmental impact studies, development of the project site selection, geoinformatics, geodata management planning, personnel planning, approval management, advanced training planning, knowledge management, data management.

Language skills: German (native), English (fluent)

WP: KM

Christian Müller, PhD: Geoscientist, Research Associate, 40, male

Key qualifications Geomechanical and THM modelling of geological structures (rock salt, clay and granite) as well as geotechnical barriers. Main applications are the performance and safety assessment and the interpretation/ validation against laboratory and in-situ experiments.

Professional Experience: Rock characterisation and rock modelling. Geomechanical modelling. THM modelling.

Language skills: German (native), English (fluent)

WP: GAS

Nina Müller-Hoeppel, PhD: Civil Engineer, Department Head, 60, female

Key qualifications: Conception and development of engineered barrier systems. Project Management, planning and coordination of large scale research projects. Participation in the development of computer programs performance assessment.

Professional Experience: Senior expert for geotechnical stability of the Morsleben repository mine. Participation in several R&D projects related to the backfilling and sealing, including materials development. Senior expert for geotechnical stability systems for the Asse mine.

Language skills: German (native), English (fluent)

WP: UMAN

Eric Kuate Simo, MSc.: Civil Engineer, Research Associate, 29, male

Key qualifications: Geotechnical engineering. Structural engineering. Geomechanical modelling. THM modelling.

Professional Experience: Geomechanical and THM modelling of geological structures (rock salt, clay and granite) as well as geotechnical barriers. Performance and safety assessment and the interpretation, Thermal design of deep geological HLW repositories.

Language skills: French (native), German (fluent), English (fluent)

WP: GAS, HITEC

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

Jobmann, M., Bebiolka, A., Burlaka, V., Herold, P., Jahn, S., Lommerzheim, A., Maßmann, J., Meleshyn, A., Mrugalla, S., Reinhold, K., Rübel, A., Stark, L. & Ziefle, G. (2017): Safety Assessment Methodology for a German High-level Waste Repository in Clay Formations. Journal of Rock Mechanics and Geotechnical Engineering, Volume 9, Issue 5, Pages 856-876.

Jobmann, M.; Breustedt, M.; Li, S.; Polster, M. & Schirmer, S. Investigations on THM effects in buffer, EDZ and argillaceous host rock DBE TECHNOLOGY GmbH, 2013

Jobmann, M.; Burlaka V. Herold, P.; Kuate Simo, E.; Maßmann, J.; Meleshyn, A.; Rübel, A. & Ziefle, G. Projekt ANSICHT, Systemanalyse für die Endlagerstandortmodelle, Methode und exemplarische Berechnungen zum Sicherheitsnachweis DBE TECHNOLOGY GmbH, BGR, GRS, 2017

Jobmann, M.; Flügge, J.; Gazul, R.; Hammer, J.; Herold, P.; Krone, J.; Kuate Simo, E.; Kühnlenz, T.; Laggiard, E.; Lommerzheim, A.; Meleshyn, A.; Müller, C.; Rübel, A.; Wolf, J. & Zhao, H. Investigation on long-term safety aspects of a radioactive waste repository in a diagenetic clay formation BGR, GRS, DBE TECHNOLOGY, 2017

Jobmann, M. & Meleshyn, A. Evaluation of temperature-induced effects on safety-relevant properties of clay host rocks with regard to HLW/SF disposal Mineralogical Magazine, 2015, 79, 1389-1395

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

GENESIS: Safety-based design of a generic repository in claystone, 2007

This project investigated where and under which conditions the disposal of heat-generating waste in different clay formations in Germany is possible and reasonable. The aim was to determine a layout of the underground disposal configuration for all types of waste to be considered with optimal drift spacings without exceeding the temperature limit of the host rock. In addition, investigations of the thermo-mechanical behaviour of the rock were used to evaluate the stability of a corresponding mine in the clay formation under consideration.

ERATO: Reference concept for a repository for radioactive waste in claystone, 2010

In this project, the currently most advantageous disposal options were developed and, based on these, a reference mine planning for a selected clay rock formation in Germany was prepared.

TEMTON: Investigations on the effect of a temperature load on clay formations in Germany in the near and far field, 2013

In this project, a constitutive model which consists on the determination of permeability change of claystone based on the current stress state was developed. This model was used within the framework of the TED heater test in the underground laboratory in Bure, France. In addition, it was quantified how the geotechnical barrier made of bentonite could be modified so that the large amounts of heat of the radioactive waste to be introduced could be dissipated into the clay formation in a suitable manner. This concerns the thermal properties of a bentonite barrier that can actually be achieved.

ISIBEL/ISIBEL-II: Review and evaluation of the instruments for a safety assessment of repositories for high level waste, 2013

Within the scope of this joint project of BGR, GRS and BGE, a safety and demonstration concept for a repository in a salt formation was developed which is based on a repository concept designed according to thermo-mechanical aspects. These design calculations were carried out using process level modelling.

ANSICHT: Safety Assessment Methodology for a German High-level Waste Repository in Clay Formations, 2016

Within the scope of this joint project, BGR, GRS and BGE developed a safety and demonstration concept for a repository in a claystone formation in Germany. Based on the safety philosophy developed in the

ANSICHT project, a repository concept and a qualitative backfilling and sealing concept were developed. On the basis of these principles, two location-specific FEP catalogues (North and South Germany) were developed which describe all essential processes taking place in and around the repository. An essential part of the work consisted in the verification of the integrity of the geological barrier and the closure system by means of numerical simulations at process level and engineering verification procedures.

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

- 8 High End Workstations: 2 CPUs, 12 kernels, 56 threads, 128 GB RAM
- Numerical codes: OGS, FLAC3D, PFC3D, 3DEC, TOUGH2

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task

	No	Name:	Acronym
Participant	6	Centro de investigaciones energéticas, medioambientales y tecnológicas	CIEMAT
Description of the legal entity			
Brief participant description:			
The CIEMAT (Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas) is a public research body assigned to the Ministry of Science, Innovation and Universities, focusing on energy and the environment as well as in many vanguard technologies and in various areas of fundamental research. The mission of the CIEMAT is to contribute to the sustainable development of the country and the quality of life of its citizens, through the generation and application of scientific and technological knowledge. During the last decade, CIEMAT develop a strategy into the institutional project Physico-Chemistry of Actinides and Radioactive waste Management, participating in many projects related to the research on radioactive waste repositories, radionuclide transport processes, spent fuel and have been involved in National R&D Programs financed by ENRESA (the Spanish National Agency for Radioactive Waste Management) and the Nuclear Safety Council, as well as in European Union Programs in both R&D and the EURATOM Treaty. Besides CIEMAT has a wide experience in E&T in Nuclear Technology and Radiation Protection such as preparation and development on an annual basis of the Education and Training Program related to nuclear technology, radiation protection and in all the rest of R & D areas. Within the European and international networks dealing with these topics the following projects, among others, in which CIEMAT participated, can be highlighted: CEBAMA, nTOF-ND-ADS, MUSE, PDS-XADS, Red-Impact, SARNET, PHEBEN2, ARTIST, CABRI, ACSEPT, HotLab, SFS, NF-PRO, MIKADO, ACACIAS, EUROPART, ADOPT, ACTAF, FEBEX I, PEBS, CEBAMA, BEACON FEBEX II, NF-PRO, FUNMIG, CROCK, BELBAR, RESEAL II, FORGE, 1st Nuclides, REDUPP, MATISSE, TIARA, ECVET, ENETRAP, DEVCO, ACTINET Thematic Network.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks			
CIEMAT will contributed to RD&D Work Packages: <u>Mechanistic understanding of gas transport in clay materials (GAS)</u> WP GAS -Task 2.2 “Advection (displacement vs. dilation)” is dedicated to improving the understanding of advective gas transport regimes in clay materials. CIEMAT will focus on the identification of the phenomena that govern gas flow behaviour and the determination of the range of actual conditions (gas pressure, stress/deformation, saturation) at which each gas transport regime occurs on EBS buffer material. The group began to carry out this type of tests in 1998 and has continued them improving the control and analysis conditions. Different barrier materials have been tested in the context of different projects. Close relationship with UPC (TLP) modellers will address the initial experimental work, which is expected to provide valuable data sets to validate the models and to define the future experiments. <u>Influence of temperature on clay-based material behaviour (HITEC)</u> Task 1.2 State of the art. CIEMAT will be responsible for this task since it has been involved in projects related with the effect of temperature on barriers for more than 20 years. The group recently participated in the related project PEBS. Task 3.1 Assessment of the impact of high temperatures over long time periods on the clay buffer properties, including materials coming from large-scale in situ tests and from specific laboratory tests. The group has participated as leading organisation in the dismantling and postmortem analysis of in situ tests (FEBEX, EB) and of laboratory TH tests with FEBEX and MX-80 bentonites, two of the materials included in EURAD-1. Task 3.2 Determination of parameters at temperatures >100°C. CIEMAT will determine the water retention			

curve of two bentonites with a methodology previously tested in the FEBEX-DP project that will be fine-tuned for high temperature.

Task 3.3 Small-scale experiments simulating the conditions of the barrier in a repository. The group has performed this kind of tests since 1992, continuously improving the control and analysis conditions. Different barrier materials have been tested in the context of different projects.

Assessment of Chemical Evolution of ILW and HLW Disposal Cells (ACED)

Subtask T1.5: Analysis of experiments and numerical model studies on interfaces, which is included in Task 1: Establishing the state of the art (SOTA) & integration.

As a part of the main objective of ACED is “to improve methodologies to obtain multi-scale quantitative models for the chemical model at cell disposal scale based on existing and new experimental data and process knowledge”. For that is proposed “compile and integrate the process level knowledge and description of reactivity at the interfaces between materials relevant for ILW and HLW disposal cells”. An important basis to do it is “the state-of-the-art scientific knowledge and experimental evidence on chemical processes acting at the interface of 2 materials”. CIEMAT will contribute to the analysis of existing experimental data on relevant processes occurring at the steel/iron-clay (bentonite) materials in the context of HLW, based in its previous experience in the context of NF-PRO, PEBS and FEBEX-family projects. The analysis will include existing work on natural/archaeological analogues that may provide useful information for long-term processes. The final input would be the conceptual model describing processes at the interface that serves to support modelling (Tasks 3 and 4).

Subtask T2.1: Steel/clay material interface reactivity, which is included in Task 2: Interface scale: Reactivity of steel/material interfaces.

A laboratory experimental program for the study of metal-compacted FEBEX bentonite interaction started in august 2006 in CIEMAT, focused on the characterization of geochemical processes occurring in the bentonite barrier and their influence on corrosion of the carbon steel container as in the transitory stage of a DGR. Six identical experimental cells (named FB1 to 6) containing bentonite blocks in contact with Fe powder in order to enhance corrosion phenomena were designed and mounted at CIEMAT. The upper closing of the cells was made by means of a stainless steel plug. Inside this plug there was a deposit in which water circulated at room temperature (25 °C). The bottom part of the cells was a plane stainless steel heater set at a temperature of 100 °C. Then, a temperature gradient is established. The hydration is made through the upper plug of the cell with water taken from a stainless steel pressurized deposit. The cells were instrumented with capacitive-type sensors placed inside the clay at two different levels, at 18 and 74 mm from the heater. Four cells (FB1 to 4) were dismantled after 0.6, 1, 1.6 and 4.5 years under NF-PRO and PEBS projects. Two of these cells are still in operation, one being hydrated with granite water (FB5) and the other one without hydration (FB6). FB5 and 6 will be dismantled and analysed in the context of ACED work package.

Additionally, in 2008, an experiment involving iron and bentonite was designed and assembled in the CIEMAT laboratories to study the diffusion of corrosion products in the buffer material and analyse structural changes in the bentonite, considering a conservative scenario: saturated bentonite, aerobic conditions and high corrosion rates. For that, a block of FEBEX bentonite compacted to a dry density of 1.65 g/cm³ was used for this experiment. Six holes ($\phi=1\text{cm}$) were drilled in the bentonite and filled with a cylindrical stainless-steel sinter surrounded by iron powder. The experiment was assembled in a square cell (120 x 120 mm and 16 mm-high) made out of methacrylate and stainless steel 316L. Hydration of bentonite with granite-type water (Ca-HCO₃) occurred through the sinters. The aim of this experiment is to evaluate the potential alteration of bentonite and the mobility of iron in the most conservative scenario. The corrosion of the metals will be analysed as well.

The value of the experiments is that they will provide useful information on the spatial (by comparison with in situ experiment, e.g. FEBEX-DP) and temporal (as explained above the experiments are the lasts of a series of identical experiments dismantled sequentially after different times of operation) evolution of the mineral alteration and geochemical impact on the bentonite barrier due to the interaction with iron materials. The experiments are set at different hydration and temperature conditions simulating different stages of the repository operation.

The expected outcome of the analysis of long-term interaction tests involving metal and clay as engineered barrier (bentonite) is the assessment of the impact on primary safety functions of EBSs of the metal corrosion products in tests under THC controlled conditions such as Types of corrosion, Corrosion rates, Corrosion products, Fe sorption and mobility, Chemical fronts/mass transport, secondary phase formation.

The results will serve as a base for modelling studies (e.g. Tasks 3 and 4). UDC modelled previous FB experiments and the dismantling of the FB5 and 6 experiments will help to assess the iron/bentonite interaction previous model.

Spent Fuel characterisation and evolution until disposal (SFC);

CIEMAT is coordinating the WP together with NAGRA and Uppsala University due to that CIEMAT will be involved in main coordination activities in task 1.

In task 2 CIEMAT will contribute to the activities: Task 2.1 Compare and benchmark state-of-the art codes for SNF depletion calculations based on the selected assemblies, by Monte Carlo simulations for PWR and BWR assemblies using the EVOLCODE system (MCNP and ORIGEN/ACAB). Performing sensitivity studies and propagate nuclear data uncertainties to define confidence limits based on the present status of nuclear data libraries and identify nuclear data requiring improvement CIEMAT will contribute by Sensitivity analyses and nuclear data uncertainties propagation and identifying fuel irradiation history parameters that influence the source terms and propagate uncertainties of these parameters to the observables. CIEMAT will perform studies on Impact of fuel irradiation history parameters uncertainties on inventory calculations with sensitivity analyses. CIEMAT will perform deliverables related to these activities. Task 2.2 CIEMAT will develop and test a prototype of a combined neutron and gamma-ray monitor based on the CLYC inorganic scintillator. Task 2.3 CIEMAT will contribute to the activities of 2.3.4 with theoretical calculation of radionuclide inventories and to the activities of 2.3.5 on evaluation of deviations between analytically and numerically determined inventories studied in this subtask. Task 2.4 CIEMAT will contribute to the activities 2.4.2 and 2.4.4. CIEMAT will evaluate “SNF data set package A/B” by using the “sophisticated” code.

In task 3 CIEMAT will estimate key variables in cladding performance like creep, hydrides distribution and hydrides radial reorientation (i.e., embrittlement) with thermo-mechanical FRAPCON code. In addition, simulations will be conducted in a comprehensive frame of uncertainty quantification by using the BEPU (Best Estimate Plus Uncertainties) methodology. Realistic thermal histories will be explored by using the ANSYS-FLUENT package (3D thermo-fluid dynamics code). Furthermore CIEMAT will study the influence of oxygen pressure and temperature in the alteration of the spent nuclear fuel (SNF) and setting. Experiments will be performed with UO₂/doped UO₂, MOX and irradiated fuel in collaboration with NNL. The reaction system to characterize in-situ the fuel will be set under non-active condition and developed to work in the hot-cells. Finally CIEMAT will participate in the subtask 3.3 by modelling of the fuel rod history with FRAPCON-xt from the reactor to the long term dry storage with focus on the stress (causing PCMI that drives PCI) from two major sources: postulated UO₂ swelling due to oxidation in the presence of an oxidizing agent and/or alfa-decay. Additionally, SNF alteration under interim dry storage conditions and degradation effects of the cladding will be investigated experimentally with UO₂/doped UO₂, MOX. Micro indentation measurements, Raman, SEM, micro-XRD will be performed.

In task 4 CIEMAT will lead the activities perform and will contribute by Identification of credible accident scenarios studies and Mechanical analysis. Use of the source terms from Task 2 to evaluate the accidental scenario. Finally Re-criticality modelling for different accident scenarios will be achieved and the identification and quantification of major sources of uncertainties

Cement-Organics-Radionuclide interactions (CORI).

CIEMAT will lead task 4 and it will participate in Task 3 (Organic-Cement Interactions) and Task 4 (Organic-Cement-Radionuclide Interactions). The objective of the work proposed in Task 3 is to provide information on the mobility of organics present in cements, under the conditions of a waste repository. The focus will be brought on the isosaccharinic acid, ISA, as main cellulose degradation product, and

superplasticizers (polycarboxylates, PC) and their degradation products. The main materials considered for these studies will be CSH (possibly CASH), CEM I, and CEM V. The possibility of including portlandite and ettringite will be evaluated. The water chemical conditions will be representative for each material and for the cement, two degraded states will be considered.

In Task 4 it will be investigated the role of the presence of organics on radionuclide (RN) retention/migration under cementitious conditions, trying to combine different experimental techniques and thermodynamic sorption modelling. In Task 4, the behavior of ternary systems will be studied by different techniques: batch sorption tests on powdered materials and small consolidated cement blocks, diffusion tests (through-diffusion or in-diffusion) and sorption modelling. The RN of interest for CIEMAT are ^{63}Ni (II); ^{152}Eu (III) (as possible homologue of Am(III)) and ^{238}Pu and ^{233}U as redox sensitive elements. Diffusion tests are planned in collaboration with HZDR. The combination of batch sorption and diffusion experiments will be used as a methodology to assess the mobility of RN-organic complexes in cements: therefore, batch data will be used as the basis for design diffusion tests (chemistry, RN concentration, organic concentration). The priority for transport experiments will be for those elements whose retention resulted more affected by the presence of organics.

Fundamental understanding of radionuclide retention (FUTuRE)

CIEMAT will participate in Task 2 (Mobility) and Task 3 (Redox). The main objectives of the work proposed 2 are: 1) to analyse transport mechanisms of RN in compacted/consolidated clays and the dependence of diffusion coefficient as a function of the temperature; 2) to analyse the reversibility of sorption processes in (compacted) clays and to understand which properties of the clay (and RN) may affect mostly the (ir)reversibility of the retention. 3) To point out the differences between batch/compacted systems. A complete geochemical and mineralogical characterization of different clays will be initially carried out by different techniques. Special consideration will be given to the following radionuclides (RN): Ra (or homologues), Ni, Zn, Ac(IV, VI), Tc and Se.

CIEMAT work-plan in Task 3 aims to identify, and to describe theoretically, the surface mechanisms responsible for the retention of redox sensitive radionuclides (RN) as Se, Tc and U, in systems composed by mixtures of clays and other minerals, especially Fe oxides to relate mineral characteristics and RN reactivity. A bottom-up approach is proposed to describe the retention mechanisms in complex systems, starting from the detailed study of RN sorption in the single systems (batch sorption tests in individual minerals) to more realistic conditions (mixtures, complex materials and compacted samples) to identify new variables and processes as complexity increases. A complete experimental and modelling work is proposed, and experiments will be carried out under controlled redox conditions.

CIEMAT will contribute as well to the two **Strategic Studies Work Packages** such as Waste Management routes in Europe from cradle to grave (ROUTES) and Understanding of uncertainty, risk and safety (UMAN).

Knowledge Management Work Packages

The main tasks of the Knowledge Management and Training Division of CIEMAT in EURAD-1 are related with the Knowledge Management Programme. CIEMAT in collaboration with UPM and supported by ENRESA are yearly delivering a post-graduate course on RWMD since 1989 covering detailed technical questions about the management of both low-and-intermediate-activity wastes and the high-activity level, together with the wastes generated during decommissioning and dismantling of installations, as well as the general and institutional aspects relevant in Spain. CIEMAT has a extensive know-how in E&T in Nuclear Technology and Radiation Protection since the fifties. Particularly, we can result the professionalizing Master programme in Nuclear Engineering and Applications since 1969 and the Radiation Protection Expert course. Also CIEMAT has a wide experience in dissemination of knowledge in RD&D activities of the research centre through both, the social media and the traditional and in crosscutting activities that will provide capacity building, stakeholder engagement, and outreach/communication. International experience on RD&D open platforms developed under UE FP7 projects (Matisse, Tiara, ECVET, ENETRAP...) integrating the capacity building strategy in the R&D projects.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

1. Becquerelite mineral phase: Crystal structure and thermodynamic and mechanical stability by using periodic DFT. Francisco Colmenero, Ana Maria Fernandez, Vicente Timón and Joaquin Cobos. July 2018. RSC Advances 8(43):24599-24616.
2. Effect of the oxidation front penetration on in-clad hydrogen migration. F. Fera, L.E. Herranz. Journal of Nuclear Materials, 500, 349-360., 2018.
3. Temperature Dependent Gibbs Free Energies of Reaction of Uranyl Containing Materials Based on Density Functional Theory. Francisco Colmenero, Ana Maria Fernandez, Vicente Timón and Joaquin Cobos, February 2018. The Journal of Physical Chemistry C 122(10)
4. Raman study of the oxidation in (U, Pu)O₂ as a function of Pu content. Jone M. Elorrieta, D. Manara, Laura J Bonales, Joaquin Cobos. September 2017. Journal of Nuclear Materials 495.
5. Gens, A., Wieczorek, K., Gaus, I., Garitte, B., Mayor J.C., Schuster, K., Armand, G., García-Siñeriz, J.L., Tricl, T. (2017). Performance of the Opalinus Clay under thermal loading: experimental results from Mont Terri rock laboratory (Switzerland). Swiss Journal of Geosciences, 110: 269–286, doi: 10.1007/s00015-016-0258-8.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

1. Modern Spent Fuel DISolution and Chemistry in Failed COntainer Conditions (DISCO). Project ID: 755443. H2020-Euratom-1.2. - Contribute to the Development of Solutions for the Management of Radioactive Waste.
2. Bentonite Mechanical evolution (BEACON) Horizon 2020 Framework Programme. Grant Agreement: 745942. European Commission. 2017-2021.
3. Cement-based materials, properties, evolution, barrier functions (CEBAMA). 662147NFRP-062014. (2015–2019).
4. Understanding and Physical and Numerical Modelling of the Key Processes in the Near-Field and their Coupling for Different Host Rocks and Repository Strategies (NF-PRO). FP6-EURATOM-NUWASTE. (FI16W-CT-2003-02389).

ENETRAP European network for education and training in radiation protection - (III, II, I) Project ID: 516529, Project ID: 232620. Funded under: FP6-7-EURATOM.

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

The CIEMAT is an interdisciplinary institution which covers a wide range of topics, from basic research to nuclear technologies. A significant infrastructure and major items of technical equipment, relevant in the field characterization and stability studies on radioactive waste management under pre and disposal conditions.

The nuclear facilities include ordinary laboratories, hot-laboratories (IR-30, IR09 and IR36) where it is possible to perform the hot-experiments. The IR30 has three glove-box, five fume cupboards, an UV-V spectrometer, a potentiometric titrator, oscillating shakers, centrifuges. And IR36 is equipped with two gamma spectrometer (Ge detectors), an alpha spectrometer, ICP-MS, HPLC-DAD and a HPLC-MS/MS. Moreover, CIEMAT dispose of a laboratory equipped to perform a RAMAN spectrometry and IR09 with X-ray diffraction. Additionally, CIEMAT facilities include a gamma irradiation site. The NAYADE IRRADIATION UNIT is a 1.2 m and 4.5 m deep square pool, providing a height of water enough to serve like biological shielding for 100.000 Ci of Cobalt-60. At the present, Náyade Unit has 4.000 Ci distributed in 60 sources in six lots according to its activity. Therefore at CIEMAT we have the possibility to carry out a high kind of irradiation experiments to assess the stability of selected systems, even a simplified simulated irradiation loop.

CIEMAT has laboratories to study gas transport processes in porous media, both under steady and transient conditions and advanced laboratory on unsaturated soil mechanics to perform THM tests on materials often used in radioactive waste disposal such as bentonite and argillaceous rock.

CIEMAT develops an annual E&T Plan open to all player (academia, research institutions and industry), but specially focused on research and industry, that promotes the research as well as encouraging the search of solutions for addressing the main great global challenge in a multidisciplinary approach. In addition, it offers the training of scientific personnel and technologists, as well as support to research groups and companies for their participation in national and international RD&D projects.

CIEMAT participate also in different national and international projects of capacity building, analysing of infrastructures, mobility of students and professionals, establishing links among institutions and promoting specific education in nuclear field. Also CIEMAT has experience in the implementation of e-learning systems (LCMS), developing e-learning content, MOOCS, and delivering e-learning, blended and face-to-face courses in energy areas.

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

	No	Name	Acronym
Participant	7	Chornobyl Research and Development Institute	ChRDI
Description of the legal entity The Chornobyl Research and Development Institute (ChRDI) is a key scientific organization in the following areas: radiation safety, environmental safety, nuclear and renewable energy, handling of radioactive materials of the nuclear fuel cycle, fundamental and technological research in the field of chemical sciences, physical sciences, environmental sciences. ChRDI has extensive experience in the management of radioactive waste and spent nuclear fuel, including emergency and accidental radioactive materials. Permanent staff of the Institute work in stationary conditions in the city of Kyiv and on the territory of the Chornobyl Exclusion Zone, as well as like mobile emergency personals on radioactive and chemical «dangerous» objects. Based on own experience and recognition of other science and technical organizations, ChRDI actively participates in joint projects and programs with foreign and domestic academic and industrial partners. ChRDI (Department of Nuclear Technology and Radiation Safety) is the main task for safe handling of spent nuclear fuel, monitoring of the state of biological protection, including emergency radioactive materials. In this context, ChRDI conducts research for the management of radioactive waste and spent fuel.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks ChRDI is involved in Spent Fuel Characterization (WP SFC) Subtask 4.2 Consequence Analysis of Postulated Accidents, ChRDI will conduct special studies and provide data for 20 years of research. The results of 20-year studies include: analysis of the status of temporary storage facilities (intermediate storage) in which radioactive waste was contained (dynamics for 20 years) and those where radioactive waste was stored without pre-treatment and conditioning and was placed directly in the reinforced concrete compartments of the near-surface storage (dynamics for 20 years). Analysis of the causes of radiation accidents and their consequences during interim storage of radioactive waste. The ChRDI also has large experience in handling of radioactive materials, their identification, characterization and transport to the places of disposal. Important is the experience of the ChRDI when assessment of engineering structures and places of long-term storage of radioactive materials, degradation of the state of multilayer containers and engineer barriers over time and under the influence of ionizing radiation, other external factors (from the moment of the accident at the Chernobyl Nuclear Power Plant).			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Dr. Iryna Poliakova (female) received a degree of Master of physics from Kyiv National Taras Shevchenko University (Department of Nuclear Physics), Ukraine in 2003 and a PhD degree from Academy of Postgraduate Education and Management under the Ministry of Ecology and Natural Resources of Ukraine, Ukraine in 2017. Since 2017 she works at the ChRDI as Head of the Department of Nuclear Technology and Radiation Safety. In 2003, began her career as an engineer at the Radioactive Waste Management Company at State Corporation «Radon». Participates in many scientific studies and state and international projects related to the nuclear-fuel cycle waste, technical decisions on the safe storage of radioactive materials, and environmental protection. Among the projects: -The Radiation Protection in Uranium Industry in Accordance with the IAEA's International Safety Standards and Council Directive 2013/59/EURATOM. (International project IAEA - Ukraine) - 2014-2015; - Segregation of emergency radioactive waste arising from a radiation accident at Fukushima-1 (Japan). - 2012 - 2014 (International project Japan-Ukraine); - Manufacturing and certification of packing transport containers PKTIV-120H, intended for transportation and temporary storage of waste ionizing radiation sources in near-surface storage facilities of radioactive waste of Ukraine at special enterprises of the State Corporation «Ukrainian State Association "Radon»- 2012 (International project France-Ukraine);			

- Manufacturing and certification of mobile modular protective camera for discharging of spent sources of ionizing radiation of types Э1 - Э3, Э1М - Э4М, БГИ-30, БГИ-45, БГИ-60А, БГИ-75А, БГИ-90А, БГИ-45У, БГИ-60У, БГИ-75У, БГИ-90У with the subsequent localization of spent sources of ionizing radiations in the packaging transport container PCTIV-120Н.- (International project France-Ukraine). - 2012-2014.

-Removal of spent sources of ionizing radiation from installations K-100000 and MPX-γ-25M of the Institute of Physics of the National Academy of Sciences of Ukraine - 2008 to 2009 (International project USA - Ukraine).

Author of Patents:

Patent № 113939 «Method of storage of liquid radioactive waste», 27.02.17.

Patent № U2017082019 «Installation for simulating (reconstitution) the environment of the mine and research of devices and elements of aerogas, dust and dosimetric control taking into account the parameters of the environment», 08.08.2017.

Dr. Pavlo Korchagin (male) received a Master degree from Kyiv National Polytechnic Institute, Ukraine, and a PhD degree from Polytechnic Institute, Ukraine in 20033. Since 2016, he works at the ChRDI. He began his career as a scientist in the radiological laboratory of the Institute of Nuclear Research, Ukraine. After the accident at the Chernobyl Nuclear Power Plant in 1986, he was transferred to the Chernobyl Exclusion Zone, eliminating the consequences of the radiation accident. He has considerable theoretical and practical experience in dealing with radioactive waste, spent nuclear fuel, and emergency waste. One of the authors of the Law of Ukraine "On Radioactive Waste Management". Has many scientific and technical solutions in issues related to deep geological disposal. Participates in many international projects.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

Poliakova I., Korchagin P. «Creation of the infrastructure for long-term storage and disposal of radioactive waste resulting from the Chornobyl catastrophe», Monograph. Twenty-five years of the Chernobyl disaster. Safety of the Future: National Report of Ukraine /Editorial: V. Baloga (editor in chief), V. Holosha (deputy editor-in-chief), O. Yevdin (Deputy Editor-in-Chief), G. Perepelyatnikov (executive secretary, M. Borisyuk, A. Ishchenko, etc. - K.: KIM, 2011. - p. 259-262. (Ukr.).

Poliakova I. «Evaluation of the protective properties of the container for the storage of spent sources of ionizing radiation», Collection of scientific works of the Institute of Geochemistry of the environment. - Kyiv, 2013. - Issue. 22. - p. 179-187. (Ukr.).

Korchagin P., Poliakova I. «Assessment of long-term safety of radioactive waste disposal sites», Materials of the scientific and technical conference «Problems of Radioactive Waste Management in Ukraine» IX International Forum «Protection Technology». - Kyiv, 2010. - p. 51-54. (Ukr.). "Diffusion of organic anions in clay-rich media: effects of anion exclusion on retardation"; Dagnelie R.V.H, Rasamimanana S., Blin V., Radwan J., Thory ., Robinet J-C., Lefèvre G. Chemosphere, submitted.

Andrievsky V., Poliakova I., Tokarevsky V., Turbaevsky V. «The problems of handling of radioactive technological products in the production of nuclear fuel in Ukraine», Ecological Sciences: Scientific and Practical Journal. - Kyiv, No. 1-2 /2016 (12-13) - p. 109-11. (Ukr.).

Korchagin P., Zamostyan P., Shestopalov V. Monograph «Treatment of radioactive waste in Ukraine: problems, experience, perspectives», Kiev, Ivan Fyodorov Publishing House, 2000, -178 p.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

1. Awareness-raising and informational campaign within the framework of the program of spent isolated ionizing radiation sources handling. Amnesty of ionizing radiation sources. In partnership with Oak Ridge National Laboratory, USA, 2016.
2. Segregation of Emergency Radioactive Waste Arising From a Radiation Accident at Fukushima-1 (Japan). - 2012 - 2014 (International project Japan-Ukraine).
3. Scientific and technological research partnership for sustainable development (Science and Technology Research Partnership for Sustainable Development, SATREPS). In partnership with

Fukushima University, 2015. 4. Project of the NATO Trust Fund for the Disposal of Radioactive Waste in Ukraine. Elimination of Vakulenchuk Radioactive Waste Repository. On the order of NATO Support and Procurement Agency (NSPA). In partnership with NT-Engineering company, 2016. 5. The concept of reforming the Chornobyl Exclusion Zone "Reform of the Exclusion Zone". In partnership with the State Agency of Ukraine on Exclusion Zone Management, 2016. 6. Rebranding of the Chornobyl Exclusion Zone "Chernobyl - Territory of Change". In partnership with the Ministry of Ecology and Natural Resources of Ukraine and the State Agency of Ukraine on Exclusion Zone Management, 2015. 7. The research project on the cultivation of energy crops in the exclusion zone has been initiated as a part of the development of the concept for reforming the Chornobyl Exclusion Zone (the Zone) and the use of alternative and renewable energy sources, 2015.
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; Radiological Laboratory in the Chornobyl Exclusion Zone.
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

No	Name	Acronym
Participant 8	Centre Nationale de Recherche Scientifique	CNRS

Description of the legal entity

The CNRS (National Centre for Scientific Research) is a government-funded research organization under the administrative authority of French Ministry in charge of research. As the largest fundamental research organization in Europe, CNRS is involved in all fields of knowledge. Interdisciplinary programs and actions offer a gateway into new domains of scientific investigation and enable CNRS to address the needs of society and industry. CNRS is organized in 1053 research units spread throughout France. These units are either intramural or in partnership with universities, other research organizations, or industry. CNRS is involved in research on nuclear waste mainly through four of its ten institutes (IN2P3, INC, INSMI, INSU). Additionally, CNRS has an academic research network SCINEE (Nuclear Science for energy and environment) including French universities and leads a national program on nuclear energy NEEDS (Nuclear Energy Environment Waste Society) with national R&D partners (ANDRA, EDF, ORANO, FRAMATOME, IRSN, BRGM, CEA) including material for nuclear waste and nuclear waste geological disposal.

CNRS has specific roles in ACED, DONUT, GAS, HITEC, FUTuRE, CORI, SFC and UMAN.

The Hubert Curien Pluridisciplinary Institute (IPHC) is a French Research Institute belonging to both the Nuclear and Particle Physics National Institute (IN2P3) of National Scientific Research Center (CNRS) and the University of Strasbourg. With some 400 employees, IPHC is one of the biggest Institute of Strasbourg University. Founded in 2006, IPHC spans a wide range of scientific disciplines and includes four Departments, namely, the Department of Ecology, Physiology and Ethology, the Department of Subatomic Research, the Department of Analytical Sciences, and the Department of Radiobiology, Hadron Therapy and Molecular Imaging. IPHC is a successful example of an ambitious institute that aims to gather diverse scientific expertise and advanced equipment, and to bring out multidisciplinary research projects contributing at the highest scientific and technological levels to development of basic scientific knowledge and to applications addressing key societal challenges in areas such as energy, health and the environment. CNRS/IN2P3/IPHC has specific roles in FUTuRE.

CNRS/IN2P3/Subatech

The laboratory SUBATECH is a mixed research unit, operated conjointly by the legal entities CNRS, the IMT-A and the University of Nantes. In the EURAD EURAD only personnel of IMT-A (linked third party to CNRS) and of the CNRS contribute. The laboratory is located in Nantes/France on the campus of IMT-A. The laboratory has been ranked “excellent” by the national evaluation commission HCERES. The laboratory produces about 120 papers largely in high impact journals with about 6000 citations per year. About 5 papers per year are on the thematic of EURAD. Principal research orientations are in nuclear physics and in radiochemistry. Nuclear waste management and disposal is a key research subject of this laboratory, supported also by a Chair, financed by industry. The laboratory pilots as well the recent ERASMUS mundus project SARENA, which is the only ERASMUS mundus on nuclear energy in Europe and it offers a strong contribution to teaching in nuclear waste management. CNRS/IN2P3/Subatech has specific roles in ACED, FUTuRE, CORI and UMAN.

CNRS/INC/CEMHTI

The CEMHTI laboratory (CEMHTI: Conditions extrêmes et Matériaux : Hautes Températures et Irradiations, UPR3079) (Orléans, France) is managed by Catherine Bessada. It has a total of 70 permanent researchers, engineers and technicians. The activities are organized in 4 teams of researches mainly focused on the study of materials and their characterization in extreme conditions of temperature and irradiation. One of these poles called DEFIR (Defects, Impurities Radiotracers: Properties, materials and imaging) is managed by Marie-France Barthe and dedicates its research activities in the field /study of nuclear materials and their behaviour under irradiation. The researchers have good expertise in experimental studies of the irradiation induced damage and the interactions of light elements with defects in different

materials (SiC, UO₂, W, Fe based alloys...) by using positron annihilation spectroscopy and ion beam analysis techniques available around the different accelerators operated and developed in the “Particle beam Platform” : cyclotron, Pelletron and slow positron beams.
CNRS/INC/CEMHTI has specific roles in SFC.

CNRS/INC/ICSM

The activities of ICSM are mainly devoted to the elaboration and characterization of several kinds of optimized actinide bearing precursors prepared by wet chemistry routes, then to their conversion into the final actinide-based oxides by heating. A particular interest is focused either on the sintering capability of the materials during densification process and also to the evaluation of the chemical durability of the materials when submitted to dissolution/leaching/alteration tests in order to understand their behavior during their reprocessing or in the field of their long-term storage in underground repository site. In particular, two laboratories have developed new ways of in situ and in operando monitoring of evolving solid/liquid interfaces during dissolution or leaching tests by combining microscopy and spectroscopy based techniques.

CNRS/INC/ICSM has specific roles in SFC.

CNRS/INC/IC2MP

The Institute of Chemistry of Poitiers: Materials and Natural Resources (IC2MP) is a multidisciplinary research institute that specializes in the study of materials, the natural environment, and reactions. The Institute particularly focuses on the synthesis, decontamination and exploitation of natural resources. The Institute is composed of a total of ~250 persons including a staff of 100 researchers (75 faculty members from the University of Poitiers and 25 CNRS), 50 Engineers & Technician staff, ~80 PhD students and ~20 postdoctoral researchers.

CNRS/INC/IC2MP has specific roles in FUTuRE and GAS.

CNRS/INSIS/3SR

Laboratoire 3SR - Sols, Solides, Structures, Risques - conducts cutting edge research in solid mechanics, with application to structural, civil and environmental engineering, as well as energy and health. It is a « Unité Mixte de Recherche » meaning that it is under the administrative and scientific tutelage of three institutions: one national research body CNRS-INSIS, as well as two local universities, l'Université Grenoble Alpes and Grenoble-INP. This research lab is divided into three research teams. The research done in Laboratoire 3SR is in the general field of Solid Mechanics. More specifically, the main domains of the research carried out in Laboratoire 3SR concern:

- Technological and Environmental Risks:
- For surface and sub-surface storage
- For gravity and seismic risk
- For underground collapse (structure-climate interaction)
- Safety of sensitive structures
- The Mechanical Behaviour and Maintenance of:
- Structures and geotechnical engineering works
- Complex materials (granular media, porous media, fibrous and woven materials, reinforced, biological and bio-inspired materials, etc.)

In all these domains are approached by experiments and modelling which are done both at the material scale, as well as at the engineering scale. Experimental work is carried out with the objective of understanding, analysing and informing theoretical and analytical models taking into account physical-mechanical coupling over multiple scales. Laboratoire 3SR has numerous original and relevant experimental installations in the fields of mechanics of materials, geomaterials as well as structures, with some installations being totally unique worldwide.

CNRS/INSIS/3SR has specific roles in HITEC.

CNRS/INSMI/LJAD

The LJAD laboratory is structured around 6 teams: Algebra, Topology and Geometry
Geometry, Analysis and Dynamics, EDP and Numerical Analysis, Numerical Modeling and Fluid Dynamics, Probability and Statistics, Interfaces of Mathematics and Complex Systems. Bringing together 135 researchers and teacher-researchers, 16 administrative staff and research assistance engineers and 74 doctoral and post-doctoral students, the laboratory is also a partner of INRIA, of the CEA (CEA) under the

LRC Fusion of the Doctoral School (EDSFA) and participates in many ANR projects. This project takes place in the LJAD team Partial Differential Equations and Numerical Analysis (around 40 permanent researchers and 20 PhD students) which has developed for a few years a group on geosciences applications including 2 permanent researchers, Konstantin Brenner and Roland Masson, and several doctoral and postdoctoral students.

CNRS/INSMI/LJAD has specific roles in DONUT.

CNRS/INSMI/LMAP

The Porous Media Group of LMAP (University of Pau and Pays de l'Adour (UPPA) & CNRS UMR 5142) is involved in the development and the implementation of advanced mathematical and numerical methods for modeling multi-scales reactive multiphase flow in reservoirs including thermo-hydro-mechanical impacts, pore scale modeling and simulation of complex fluid flows, numerical homogenization. We investigate high-performance parallel processing as a tool to develop a new generation reservoir simulator implemented in the environment of the parallel open-source software DuMuX.

CNRS/INSMI/LMAP has specific roles in DONUT

IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks

See detailed sheets per CNRS laboratory

a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities

See detailed sheets per CNRS laboratory

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

See detailed sheets per CNRS laboratory

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

See detailed sheets per CNRS laboratory

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work.

See detailed sheets per CNRS laboratory

	Name	Acronym
8/CNRS	Institut Pluridisciplinaire Hubert Curien UMR 7178 CNRS/IN2P3 – University of Strasbourg	CNRS-IPHC
Description of the legal entity The Hubert Curien Pluridisciplinary Institute (IPHC) is a French Research Institute belonging to both the Nuclear and Particle Physics National Institute (IN2P3) of National Scientific Research Center (CNRS) and the University of Strasbourg. With some 400 employees, IPHC is one of the biggest Institute of Strasbourg University. Founded in 2006, IPHC spans a wide range of scientific disciplines and includes four Departments, namely, the Department of Ecology, Physiology and Ethology, the Department of Subatomic Research, the Department of Analytical Sciences, and the Department of Radiobiology, Hadron Therapy and Molecular Imaging. IPHC is a successful example of an ambitious institute that aims to gather diverse scientific expertise and advanced equipment, and to bring out multidisciplinary research projects contributing at the highest scientific and technological levels to development of basic scientific knowledge and to applications addressing key societal challenges in areas such as energy, health and the environment.		
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks Tasks will be handled by the Radiochemistry IPHC team, which has a long experience in actinide / lanthanide chemistry studies and has developed innovative methodologies to elucidate speciation of actinides and heavy metals at mineral / water interface and effect of organic matter. Main IPHC tasks are as follows. (1) Experimental investigations on surface complexes of uranyl formed at the low concentration level in relevant uranyl-solution-compacted clay systems (COX and Opalinous clay), in presence of phosphate ligands, small organic molecules and competing trace metals (Ni and Fe), by means of ATR-FTIR spectroscopy and complementary techniques (CPM and ESI-MS). (2) ATR-FTIR experiments to investigate sorption reversibility of uranyl sorbed in the uranyl-solution-compacted clay systems (COX and Opalinous clay) and uranyl-solution-hematite systems studied. These two main tasks match with the subtasks in the EURAD proposal entitled “Mobility of Radionuclides in the compacted clay” and “Reversibility of sorption”.		
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Del Nero Mirella Date of birth: 10 August 1965, Female PhD in Geochemistry CNRS Researcher at the Hubert Curien Pluridisciplinary Institute (IPHC) Department of Subatomic Research, Radiochemistry group, UMR7178 French National Research Center (CNRS) - Strasbourg University, Strasbourg, France. 35 international publications, 93 oral/poster communications Scientific profile description I am a multidisciplinary scientist using (geo)chemistry to understand the migration behavior of actinides (An) and other trace metal elements (TME) in natural systems. My main research interest is exploring the chemical speciation of An / TME in mineral-solution systems relevant to geosphere. I have taken on major scientific challenges related to the field of environmental chemistry of An and TME, <i>i.e.</i>, molecular-level identification of species, in situ speciation at (nano)mineral-solution interfaces, effect of natural organic matter, by using experimental set-ups based on advanced surface spectroscopy techniques (<i>e.g.</i>, ATR-FTIR) or ultrahigh resolution mass spectrometry technique (ESI-FTMS). Another area of interest is applying mechanistic data on the sorption / speciation of An and TME acquired in laboratory to field data in order to provide new insights into micro-pollutant transfers in the environment.		
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content Fleury G., Del Nero M., Barillon R. 2017. Molecular fractionation of a soil fulvic acid (FA) and competitive sorption of trace metals in hematite-solution systems: effect of the FA-to-mineral ratio. <i>RSC Advances</i>, 7, 43090 – 43103. Fleury G., Del Nero M., Barillon R. 2017. Effect of mineral surface properties on the sorptive fractionation mechanisms of soil fulvic acids: molecular-scale ESI-MS studies. <i>Geochim. Cosmochim. Acta</i>, 196, 1-17. Galindo C., Del Nero M. 2013. Trace Level Uranyl Complexation with Phenylphosphonic Acid in Aqueous Solution: Direct Speciation by High Resolution Mass Spectrometry. <i>Inorganic Chemistry</i>, 52, 4372-4383.		

Del Nero M., Galindo C., Bucher G., Georg S., Mazan V., Barillon R. 2013. Speciation of oxalate at corundum colloid-solution interfaces and its effect on colloid aggregation under conditions relevant to freshwaters. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 418, 165-163.

Del Nero M., Galindo C., Barillon R., Madé B. 2011. TRLFS Evidence for Precipitation of Uranyl Phosphate on the Surface of Alumina: Environmental Implications. *Environmental Science and Technology*, 45(9), 3982–3988.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

- INTERREG 2016-2018 EU Program. Participation to the project “URCforSR: Upper Rhine Cluster for Sustainability Research”. Leaders: Universities of Freiburg and Basel.
- EC2CO / ECODYN 2017-2018 Program of CNRS / INSU (Earth Sciences Institute). Leader of the project “ECOMU: An interdisciplinary approach for evaluating eco-toxicological impacts of soil metal micro-pollutants of a former uranium mine (Rophin, France)”.
- FaiDoRA (weak doses, risks, alerts) 2016 Program of the Interdisciplinary Mission of the CNRS. Leader of the project “BIOECO-MET: A new methodology for evaluating bioavailability and impacts of soil micro-pollutants”.
- Master-Project 2018-2017 “Radionuclides in their environment” of CNRS / IN2P3 (Nuclear and Particle Physics National Institute). Co-leader of the project “Ecodynamics of heavy metals in the environment”.

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

Relevant Equipments :

- Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy (ATR-FTIR) : a surface spectroscopy technique to investigate in-situ chemical species sorbed at trace level at the mineral-solution interface and to obtain their IR spectra
- Coherence Probe Microscopy (CPM): a non-destructive microscopy technique to conduct in-situ and depth-resolved investigations on the morphology of surface species / precipitates formed at the mineral-solution interface
- Electrospray ionisation Fourier Transform Mass Spectrometry (ESI-FTMS)
- A powerful mass spectrometry technique for identifying chemical aqueous species / molecules in complex mixtures and obtaining their rough chemical formula.

	Name	Acronym
8/CNRS	Centre Nationale de Recherche Scientifique Laboratory SUBATECH	CNRS-SUBATECH
Description of the legal entity The laboratory SUBATECH is a mixed research unit, operated conjointly by the legal entities CNRS, the IMT-A and the University of Nantes. In EURAD only personnel of IMT-A (linked third party to CNRS, see section 4.2) and of the CNRS contribute. The laboratory is located in Nantes/France on the campus of IMT-A. The laboratory has been ranked “excellent” by the national evaluation commission HCERES. The laboratory produces about 120 papers largely in high impact journals with about 6000 citations per year. About 5 papers per year are on the thematic of EURAD. Principal research orientations are in nuclear physics and in radiochemistry. Nuclear waste management and disposal is a key research subject of this laboratory, supported also by a Chair, financed by industry. The laboratory pilots as well the recent ERASMUS mundus project SARENA, which is the only ERASMUS mundus on nuclear energy in Europe and it offers a strong contribution to teaching in nuclear waste management.		
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks WP 1 PMO: participation in project coordination, B. Grambow WP 3 ACED/Task 2.1, 2.2 and 3.1: contribute to the characterization of the interface experiments (glass/steel; steel/clay, cement/steel) using isotopic tracing techniques WP 4 CORI /task 1.1: coordinator, 1.2 contribution to SOTA, 1.3 preparation of training material, 2.0 study of alpha/ Gamma Radiolytic degradation of Superplasticizers using available irradiation facilities and characterization of degradation products in solution and gas phase and 4.0 characterization of the interactions of organics, radionuclides and cement: The main objective is studying the effect of ISA on the mobility (uptake and transport) of U(VI) in hardened cement pastes: study the diffusion behaviour in HCP samples in presence of ISA for two degradation states, (II and III) WP 5 FUTURE/Task 2: contribute to the identification / quantification of the uptake processes of elements of interest considering both the “real” (and notably the behaviour of the naturally-occurring elements) and model systems. WP 6 GAS/Task 2.1: Subatech will perform computational atomistic modelling to investigate the molecular mechanisms of gas sorption in clay-based materials with further extension to a mesoscale and multiscale modelling and will contribute to characterize the nanoporous structure properties and its effect on H2 sorption (IR/Raman spectroscopy, X-Ray diffraction, QENS, etc.). WP 9 UMAN/Task 3.1: Subatech is subtask leader to provide a high-level integrated picture of the various types of uncertainties that are potentially relevant for safety.		
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Abdesselam Abdelouas (CNRS/IMT-A, male) is Professor of Radiochemistry and Nuclear Materials at IMT, Atlantique, and Head of the Radiochemistry Group at Subatech Laboratory, Nantes. He graduated from the University of Strasbourg, and spent a US DoE-funded Postdoc working on radioactive waste management. He was named an Expert for the European Commission in the field of Education & Training for the nuclear sector. He is also Adjunct Professor at Mody University, India. He is coordinator of the recently accepted ERASMUS mundus project SARENA. He will participate in WPs ACED and GAS Bernd Grambow (CNRS/IMT-A, male) is Professor of Excellence at IMT Atlantique, Nantes, holding a Chair on nuclear waste disposal and former director of Subatech laboratory. He received his PhD from the FU Berlin, and held research positions at the Pacific Northwest National Laboratory, Hahn Meitner Institute Berlin, and Forschungszentrum Karlsruhe. He is an expert in radiochemistry, nuclear waste disposal science, geochemical modeling, and radionuclide migration in the environment. He will participate in the PMO and in UMAN. Catherine Landesman (CNRS/SUBATECH, feminine) is senior research scientist at SUBATECH laboratory. She received her PhD from the University Paris XI, Orsay as radiochemist. She was working at CEA and IRSN before joining the CNRS. She is specialist in radionuclide interaction with cementitious materials and has participated in many EURATOM projects. Johan Vandenborre (CNRS/SUBATECH, masculine) has received his PhD in radiochemistry in 2005 from the University Paris XI. He worked onto the radiolytic mechanisms from 10 years with 2 Ph.D. leading and about 15 publications onto this research area. He has worked mainly with the ARRONAX cyclotron which can provide He-ion beam irradiations and gamma source facility. He has developed many		

analytic tools in order to perform measurements onto solid (Raman Spectroscopy), Solution (UV-Vis Spectrophotometry) and Gas (μ -Gas Chromatography) during irradiation. The aim of this research is the determination of the radiolytic degradation of many species (such as carbonate, calcite, uranium dioxide, Tc) either as solid either in solutions.

Gilles Montavon (CNRS/SUBATECH, masculine), B.Sc. in Chemistry (Strasbourg University), PhD in radiochemistry (Paris-Sud University), is a senior scientist at CNRS in the radiochemistry group of the Subatech laboratory. He leads a team interested in the behaviour of radioelements at ultra-trace concentrations for medical and environmental purposes. He is (co-) author of 82 articles published in peer-reviewed journals (h-index 25). Member of the HCERES as an expert in radiochemistry, he participates in various steering committees for research programs (labex IRON, OSUNA/POLLUSOLS, ZATU)

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

G. Montavon, A. Sabatié-Gogova, C. Bailly, N. Bessaguet, S. Ribet, D. Durce, E. Giffaut, C. Landesman, B. Grambow Retention of iodide by the Callovian-Oxfordian formation; an experimental study. Applied Clay Sciences, 87, 142-149 (2014)

Chen, Z. Guo, X. Wang, S. Razafindratsima, J.C. Robinet, G. Montavon, C. Landesman Approaches to surface complexation modeling of Ni(II) on Callovo-Oxfordian clay stone. Applied Clay Science 101 (2014) 369–380

Z. Chen, G. Montavon, S. Ribet, Z. Guo, J.C. Robinet, K. David, C. Tournassat, B. Grambow, C. Landesman Key factors to understand in-situ behavior of Cs in Callovo–Oxfordian clay-rock (France) Chemical Geology 387 (2014) 47–58

Grambow B, Geological Disposal of Radioactive Waste in Clay, Elements 12(4):239-245 · 2016

Costagliola, A., J. Vandenborre, G. Blain, V. Baty, F. Haddad, and M. Fattahi, Radiolytic Dissolution of Calcite under Gamma and Helium Ion Irradiation, The Journal of Physical Chemistry C, 121 (2017) 24548-24556.

Bernd Grambow , Johan Vandenborre , Tomo Suzuki-Muresan , Violaine Philippini , Abdesselam Abdelouas , Philippe Deniard , Stéphane Jobic, Solubility equilibrium and surface reactivity at solid/liquid interfaces of relevance to disposal of nuclear waste, J. Chem. Thermodynamics 114 (2017) 172–181

Rachid Bouakkaz, Abdesselam Abdelouas, Bernd Grambow, Kinetic study and structural evolution of SON68 nuclear waste glass altered from 35 to 125 °C under unsaturated H₂O and D₂O vapour conditions, Corrosion Science, 134, 1-16 (2018)

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

ANR TESAMI (ANR-MAT et PRO-2012)

ANR CISSRAD (ANR-JCJC-2011)

HTRN FP 5 Euratom

NFPRO, FP5 Euratom

Raphael FP 6, Euratom

FUNMIG, FP6-Euratom

Carbowaste FP6 Euratom

MICADO FP6 Euratom (coordinator)

FRIST Nuclides FP7, EURATOM

CEBAMA H2020, EURATOM

JOPRAD H2020, EURATOM

« Groupements de laboratoire » ANDRA (GL Transfert, 2007-2013 ; GL CTEC 2016-2019)

NEEDS, coordinator of project « Déchets nucléaires »

Master project “stockage des déchets” of CNRS/IN2P3

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

Hot laboratory and LA-ICP-MS, IR/Raman spectroscopy, X-Ray diffraction for work with radioactive and non radioactive substances in WPs CORI, ACED, GAS and FUTURE

Irradiation facilities: The Gamma Source (137Cs) Gamma-Service Medical, model GSM D1 (E = 0.67 MeV) is an irradiation facility set in the ARRONAX laboratory. Moreover, the ARRONAX cyclotron provides High energetic He-particle beam (26 < E < 62 MeV) useful for our radiolytic degradation experiments. Onto the same place analytical Tools were developed to measure species into solution and gas produced.

	Name	Acronym
8/CNRS	CEMHTI: Conditions extrêmes et Matériaux : Hautes Températures et Irradiations	CNRS-CEMHTI
Description of the legal entity The CNRS (National Centre for Scientific Research) is a government-funded research organization under the administrative authority of French Ministry in charge of research. As the largest fundamental research organization in Europe, CNRS is involved in all fields of knowledge. Interdisciplinary programs and actions offer a gateway into new domains of scientific investigation and enable CNRS to address the needs of society and industry. CNRS is organized in 1053 research units spread throughout France. These units are either intramural or in partnership with universities, other research organizations, or industry. CEMHTI – UPR3079 The CEMHTI laboratory (CEMHTI: Conditions extrêmes et Matériaux: Hautes Températures et Irradiations, UPR3079) (Orléans, France) is managed by Catherine Bessada. It has a total of 70 permanent researchers, engineers and technicians. The activities are organized in 4 teams of researches mainly focused on the study of materials and their characterization in extreme conditions of temperature and irradiation. One of these poles called DEFIR (Defects, Impurities Radiotracers: Properties, materials and imaging) is managed by Marie-France Barthe and dedicates its research activities in the field /study of nuclear materials and their behaviour under irradiation. The researchers have good expertise in experimental studies of the irradiation induced damage and the interactions of light elements with defects in different materials (SiC, UO₂, W, Fe based alloys...) by using positron annihilation spectroscopy and ion beam analysis techniques available around the different accelerators operated and developed in the “Particle beam Platform”: cyclotron, Pelletron and slow positron beams. Website: http://www.cemhti.cnrs-orleans.fr/		
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks Several people from CEMHTI will be involved in the present project including researchers, engineers and technicians in the work packages Spent Fuel Characterization and Evolution Until Disposal for the subtasks 1.2, 1.3, and 3.2. Marie-France Barthe will be in charge of the scientific work performed in the project and Pierre Desgardin will be involved for positron annihilation spectroscopy and with Thierry Sauvage for helium implantations and characterization using CEMHTI accelerators. The aim is to provide new insights in the He behaviour in simulated spent fuel.		
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities <u>Marie-France Barthe</u> (contact person, CEMHTI) (F) Female, 53 years, Director of researches at CNRS, deputy manager of CEMHTI, <u>Research activities:</u> study of the properties (nature, formation, recombination, ..) of native and irradiation induced point defects by using positron annihilation spectroscopy in semiconductors (Si, SiC, Diamond...) or insulators (SiO₂) to understand their electrical properties and in nuclear materials (waste management, GENIV, Fusion reactors : UO₂, SiC, iron based alloys, W) to understand their microstructure evolution under irradiation, with special interest in the role of defects in the behaviour of light elements like helium and hydrogen in these nuclear materials (UO₂, SiC, W). Formation and Teaching activity: - Lecturer in “Material under irradiation”, and “Positron annihilation Spectroscopy”, University of Orléans (2008-present) - Supervisor of numerous undergraduate (12) and PhD (11) students. <u>Research management:</u> Deputy director, and Head of the research team “DEFIR” in CEMHTI, - Co-director of the “Materials” Project in the NEEDS (Nuclear, Energy, Environment, Defects, Society) French programme. - Leader of Work package and CNRS contact in Euratom projects: F-Bridge (Basic Research for Innovative Fuel Design for GEN IV systems; 2008-2012), (INSPYRE (Investigations Supporting MOX Fuel Licensing in ESNII Prototype Reactors; 2017-2021) - Coordinator of project in “Programme Energie” (CNRS): CHETEXT (2007-2009): Tungsten for fusion: Behaviour of Helium and Hydrogen under irradiation in W, experimental and theoretical studies , - Scientific coordinator for CEMHTI activities in FP7 Euratom projects: F-Bridge (2008-2011), GETMAT (2008-2013), PERFORM60 (2009-2013) - Scientific coordinator for CEMHTI activities in ANR projects : NADIA (2008-2010), RAMIRIS (2008-2010) Publications: 128 publications, 150 Communications in conferences or workshops (107 in international conferences with 11 invited talks), See http://www.researcherid.com/rid/C-6751-2008,		
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or		

software), or other achievements relevant to the call content

Substrate temperature and ion kinetic energy effects on first steps of He⁺ implantation in tungsten: Experiments and simulations, L. Pentecoste, A-L. Thomann, P. Brault, T. Lecas, P. Desgardin, T. Sauvage, M-F. Barthe, Acta Materialia 141 (2017) 47-58
Lattice location and annealing behaviour of helium atoms implanted in uranium dioxide single crystals, T. Belhabib, P. Desgardin, T. Sauvage, et al, J. of Nucl. Mat. 467, 1-8 (2015)
Coupled experimental and DFT plus U investigation of positron lifetimes in UO₂, J. Wiktor, MF Barthe, G. Jomard, et al, Phys. Rev. B90 184101 (2014)

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

The DEFIR team in CEMHTI has been involved or is still involved in FP7 and H2020 projects such as F-BRIDGE, PERFORM60, GETMAT, MATISSE, MYRTE, SOTERIA, EUROFUSION and INSPYRE.

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

Particle beams platform in CEMHTI: This platform operates different types of accelerators. Two of them accelerate light ions (H and He) in the energy range from 0.5 to 3 MeV for the Pelletron and from 7 to 45 MeV for the cyclotron. Various irradiation tools are developed on the beamlines of these machines, especially the DIADDHEM and DIAMANT setups dedicated to the introduction of He and its characterization (release as a function temperature, depth profiles) using nuclear reaction $^3\text{He}(d, \text{H})\alpha$. This platform develops and performs the maintenance of slow positron beams used for the characterization of defects in materials. This platform is included in the EMIR French infrastructure.

	Name	Acronym
8/CNRS	Institut de Chimie Séparative de Marcoule	CNRS-ICSM
Description of the legal entity The activities of ICSM are mainly devoted to the elaboration and characterization of several kinds of optimized actinide bearing precursors prepared by wet chemistry routes, then to their conversion into the final actinide-based oxides by heating. A particular interest is focused either on the sintering capability of the materials during densification process and also to the evaluation of the chemical durability of the materials when submitted to dissolution/leaching/alteration tests in order to understand their behavior during their reprocessing or in the field of their long-term storage in underground repository site.		
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks In particular, two laboratories have developed new ways of in situ and in operando monitoring of evolving solid/liquid interfaces during dissolution or leaching tests by combining microscopy and spectroscopy based techniques.		
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Nicolas Clavier, CR1 Education: PhD in Radiochemistry, University Paris Sud 11 (2004). CNRS tenure researcher since 2006 at the Institute for Separation Chemistry, Marcoule (ICSM – UMR 5257). Member of the Evolving Interfaces in Materials group. Research interests and expertise: fabrication and sintering of nuclear ceramics (fuels, waste form, dedicated instrumentation), radiochemistry, in situ HT characterization techniques (ESEM, Raman, XRD), vibrational spectroscopy of An-bearing compounds Adel Mesbah, CR1 Education: graduated in Chemistry from the University of Constantine in Algeria in 2003. Ph.D. in the physics and chemistry of materials from the University of Henri Poincare – Nancy in 2008. CNRS researcher at ICSM in the laboratory of evolving interfaces in materials (UMR 5257, Marcoule). Research interests and expertise: elaboration and structural characterization by diffraction techniques of actinide-based materials, in particular related to the nuclear fuel cycle. Renaud Podor, IR0 Education: PhD in Solid state chemistry, University of Henri Poincare – Nancy, in 1994. CNRS engineer since 2009 at the Institute for Separation Chemistry, Marcoule (ICSM – UMR 5257). Head of the laboratory dedicated to the study of materials under environmental conditions at ICSM (UMR 5257, Marcoule). Research interests and expertise: material science, in situ HT characterization techniques (ESEM) and in situ / in operando monitoring of evolving interfaces.		
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content 1. L. CLAPAREDE, N. CLAVIER, N. DACHEUX, A. MESBAH, J. MARTINEZ, S. SZENKNECT, P. MOISY : “Multiparametric dissolution of thorium-cerium dioxides solid solutions” Inorg. Chem., 50, 11702-11714, 2011 2. D. HORLAIT, N. CLAVIER, S. SZENKNECT, N. DACHEUX, V. DUBOIS : “Dissolution of cerium(IV)-lanthanide(III) oxides : comparative effects of composition, temperature and acidity” Inorg. Chem., 51, 3868-3878, 2012. 3. S. SZENKNECT, A. MESBAH, D. HORLAIT, N. CLAVIER, S. DOURDAIN, J. RAVAUX, N. DACHEUX : “Kinetics of structural and microstructural changes at the solid/solution interface during dissolution of cerium(IV)-neodymium(III) oxides” J. Phys. Chem. C, 116, 12027-12037, 2012. 4. D. HORLAIT, F. TOCINO, N. CLAVIER, N. DACHEUX, S. SZENKNECT : “Multiparametric study of Th _{1-x} Ln _x O _{2-x/2} mixed oxides dissolution in nitric acid media” J. Nucl. Mater., 429, 237-244, 2012. 5. D. HORLAIT, L. CLAPAREDE, F. TOCINO, N. CLAVIER, J. RAVAUX, S. SZENKNECT, R. PODOR, N. DACHEUX : “Environmental SEM monitoring of Ce _{1-x} Ln _x O _{2-x/2} mixed-oxides microstructural evolution during dissolution” J. Mater. Chem. A, 2, 5193-5203, 2014.		
a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal ANR COMPACT (2008-2011) New actinide based samples: from precursors to model materials PACEN (2010-2013) then NEEDS projects - Resources FP (2013-2018)		

Solubility and thermodynamic study of uranium or thorium bearing minerals and analogues (phosphates, titanates, silicates, oxides and hydroxides)

GENIORS (2017-2021, H2020)

GEN IV Integrated Oxide fuels recycling strategies, in charge of conversion and dissolution of uranium bearing ceramics

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

The equipment available in the ICSM laboratories (laboratory of evolving interface in materials and laboratory of environmental microscopies and diffraction) allow the elaboration, complete characterization by various techniques (XRD, SEM, TEM, spectroscopies) and sintering of lanthanide, uranium or thorium based materials. Several devices are available to perform the static or dynamic dissolution/leaching/alteration experiments on the prepared radioactive materials. Finally, operando or in situ following of the evolving interfaces is also possible combining ESEM, X-ray reflectometry, Grazing XRD, Raman spectroscopy and AFM.

8/CNRS	Name	Acronym
	Institute of Chemistry of Poitiers: Materials and Natural Resources	CNRS-IC2MP
Description of the legal entity The Institute of Chemistry of Poitiers: Materials and Natural Resources (IC2MP) is a multidisciplinary research institute that specializes in the study of materials, the natural environment, and reactions. The Institute particularly focuses on the synthesis, decontamination and exploitation of natural resources. The Institute is composed of a total of ~250 persons including a staff of 100 researchers (75 faculty members from the University of Poitiers and 25 CNRS), 50 Engineers & Technician staff, ~80 PhD students and ~20 postdoctoral researchers.		
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks The work envisaged in FUTUR WP, devoted to the experimental analysis of water and anion diffusion in partially saturated clay media, perfectly the fit in the scope of the priorities of the research thematic developed and the IC2MP regarding the understanding of reactivity of natural media in relation with the exploitation of natural resources. The work envisaged in GAS WP is devoted to the experimental study of the micro-structural and mineralogical changes of claystones in relation with self-sealing and gas migration on the one hand, and to the micro-macro upscaling and development and implementation of a numerical HM model accounting for gas migration and self-sealing. It fits in the scope of the priorities of the research thematic developed and the IC2MP regarding the understanding of the microstructure of clays and clayey rocks as well as upscaling of their hydro-mechanical properties.		
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Eric Ferrage is 40 years old and obtained his Ph.D. in 2004 from the ISTERre Institute in Grenoble (France). In 2005, he was awarded a two-year Marie Curie Intra-European fellowship for a postdoc stay at the Natural History Museum of London (UK). Since his CNRS recruitment in 2007 his research activities contribute to the understanding of the interactions of clay minerals with water and solutes using experimental measurements and theoretical calculations. Eric Ferrage has published 59 international peer-reviewed publications and has contributed to ~120 communications including 20 invited presentations in international or national conferences. Richard Giot is 40 years old and obtained his Ph.D. in 2004 from the LaEGO/ENSG (Nancy, France) He is a specialist of rock mechanics, in particular numerical modelling and HM couplings in clayey rocks. In 2005, he was recruited as a professor assistant at ENSG and attached to LaEGO for research activities. He obtained its HDR in 2013 and was recruited as full professor in 2016 at University of Poitiers (ENSI Poitiers) with research activities at the IC2MP. Richard has published 22 international peer-reviewed publications.		
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content -Tertre E., Savoye S., Hubert F., Prêt D., Dabat T. & Ferrage E. (2018) Diffusion of water through the dual porosity swelling clay mineral vermiculite. Environmental Science & Technology, 52, 1899-1907. -Ferrage E. (2016) Investigation of the interlayer organization of water and ions in smectite from the combined use of diffraction experiments and molecular simulations. A review of methodology, applications, and perspectives. Clays and Clay Minerals, 64, 346-371. -Tertre E., Delville A., Prêt D., Hubert F. & Ferrage E. (2015) Cation diffusion in the interlayer space of swelling clay minerals. A combined macroscopic and microscopic study. Geochimica & Cosmochimica Acta, 149, 251-267. -Hubert F., Bihannic I., Prêt D., Tertre E., Nauleau B., Pelletier M., Demé B. & Ferrage E. (2013) Investigating the anisotropic features of particle orientation in synthetic swelling clay porous media. Clays and Clay Minerals, 61, 397-415. -Michot L.J., Ferrage E., Jiménez-Ruiz M., Boehm M. & Delville A. (2012) Anisotropy features of water and ions dynamics in synthetic Na- and Ca-smectite with tetrahedral layer charge. A combined QENS and molecular dynamics simulations study. Journal of Physical Chemistry C, 116, 16619-16633. - Giot R., Auvray C., Talandier J. 2018. Self-sealing of claystone under X-ray nanotomography. The Geological Society Special Publications. Revision submitted.		

- Dazas B., Ferrage E., Delville A. & Lanson B. (2014) Interlayer structure model of tri-hydrated low-charge smectite by X-ray diffraction and Monte Carlo modeling in the Grand Canonical ensemble. *American Mineralogist*, 99, 1724-1735.
- Fauchille, A. L., Hedan, S., Prêt, D., Cosenza, P., Valle, V., & Cabrera, J. (2014). Relationships between desiccation cracking behavior and microstructure of the Tournemire clay-rock by coupling DIC and SEM methods. In Soga, K., Kumar, K., Biscontin, G., & Kuo, M. (Eds.). (2014). *International symposium on Geomechanics from Micro to Macro*. CRC Press. ISBN 9781138027077, 1-3 September, Cambridge, pp 1421-1424.
- Ferrage E. (2016) Investigation of the interlayer organization of water and ions in smectite from the combined use of diffraction experiments and molecular simulations. A review of methodology, applications, and perspectives. *Clays and Clay Minerals*, 64, 346-371.
- Matskova, N., Pret, D., Gaboreau, S., Cosenza, P., Brechon, R., Gener, I., & Gelin, F. (2017). Towards a Balance of Pore Size Distribution of Non-Conventional Hydrocarbon Reservoirs: a Combination of Bulk Techniques Applied to Comparable Sub-Samples Localized by 3D X-ray μ -Tomography. *Unconventional Resources Technology Conference (URTEC)*.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

- CNRS Interdisciplinary programme NEEDS “porous media” (2016-2018) “Multiscale diffusion of water and solutes in clays”.
- CNRS National ECCO programme (2014-2016) “Diffusion and adsorption in clay matrices”.
- CNRS Interdisciplinary programme NEEDS “porous media” (2014-2015) “Simulation of virtual porous media for clay minerals”.
- French National Funding Agency (ANR) (2009-2012) “Structure and dynamics of interlayer water and ions in smectites”.
- CNRS National FORPRO programme (2011-2013) “Influence of water adsorption on pore network modification in clays”.
- CNRS National FORPRO programme (2011-2013) “Hydro-Mechanics of clay systems”.
- CNRS Interdisciplinary programme NEEDS “porous media” (2016-2018) “Multiscale diffusion of water and solutes in clays”.
- French National Funding Agency (ANR) (2009-2012) “Structure and dynamics of interlayer water and ions in smectites”.
- CNRS National FORPRO programme (2011-2013) “Influence of water adsorption on pore network modification in clays”.

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

All the facilities for the characterization of clay samples and for diffusion experiments are already available at the IC2MP.

	Name	Acronym
8/CNRS	Laboratoire Sols, Solides, Structures et Risques	CNRS-3SR
Description of the legal entity Laboratoire 3SR - Sols, Solides, Structures, Risques - conducts cutting edge research in solid mechanics, with application to structural, civil and environmental engineering, as well as energy and health. It is a « Unité Mixte de Recherche » meaning that it is under the administrative and scientific tutelage of three institutions: one national research body CNRS-INSIS, as well as two local universities, l'Université Grenoble Alpes and Grenoble-INP. This research lab is divided into three research teams. The research done in Laboratoire 3SR is in the general field of Solid Mechanics. More specifically, the main domains of the research carried out in Laboratoire 3SR concern: • Technological and Environmental Risks: • For surface and sub-surface storage • For gravity and seismic risk • For underground collapse (structure-climate interaction) • Safety of sensitive structures • The Mechanical Behaviour and Maintenance of: • Structures and geotechnical engineering works • Complex materials (granular media, porous media, fibrous and woven materials, reinforced, biological and bio-inspired materials, etc.) In all these domains are approached by experiments and modelling which are done both at the material scale, as well as at the engineering scale. Experimental work is carried out with the objective of understanding, analysing and informing theoretical and analytical models taking into account physical-mechanical coupling over multiple scales. Laboratoire 3SR has numerous original and relevant experimental installations in the fields of mechanics of materials, geomaterials as well as structures, with some installations being totally unique worldwide.		
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks Laboratoire 3SR has been working for many years on the theme of deep repository of radioactive wastes, both on the characterization of host rocks (several sites in Europe) and on modelling the mechanical behaviour and couplings. Taking into account multiple couplings is one of its research axes. It incorporates imaging skills (X-ray tomography, neutron CT, image correlation DIC) to describe and quantify physical processes. It develops its own modelling tools, notably using multi-scale approaches, to move from behaviour on the scale of the microstructure of the material to behaviour on the macroscopic scale and then that of the engineer, taking into account the phenomena of failure.		
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Pierre Bésuelle studies the behaviour of geomaterials and more particularly of rocks, with particular emphasis on the phenomena of failure by strain localization and hydro-mechanical couplings. He has developed original experimental tools for characterizing mechanical behaviour by combining field measurements. It also develops double scale constitutive laws by numerical homogenization of type FEM², the whole in an enriched medium formalism in order to model the failure in an objective way. He has been responsible for one of the teams in the laboratoire 3SR and is currently deputy director of the laboratoire 3SR.		
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content • Bésuelle P., Viggiani G., Desrues J., Coll C., Charrier P., 2013, A laboratory experimental study of the hydromechanical behavior of Boom Clay, Rock Mechanics and Rock Engineering, DOI 10.1007/s00603-013-0421-8. • Di Donna, A. and Laloui, L., Response of soils subjected to thermal cyclic loading: experimental and constitutive study, Engineering Geology, Elsevier B.V., pp. 12, Vol. 190, ISSN: 0013-7952, DOI: 10.1016/j.enggeo.2015.03.003, 2015. • van den Eijnden A.P., Bésuelle P., Collin F., Chambon R., Desrues J., 2016, Modeling the strain localization around an underground gallery with a hydro-mechanical double scale model; effect of anisotropy, Computers and Geotechnics, Volume 85, pp. 384-400.		

- Stavropoulou E., Andò E., Tengattini A., Briffaut M., Dufour F., Atkins D., Armand G., 2018, Liquid water uptake in unconfined Callovo Oxfordian clay-rock studied with neutron and X-ray imaging. *Acta Geotechnica*. 10.1007/s11440-018-0639-4.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

projet Needs “Varape” 2016-2018: taking into account the material variability of a natural clay rock within the framework of a double scale modelling

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

Laboratoire 3SR is equipped with a multi-scale X-ray CT apparatus where tests can be conducted to image the processes in progress. He has experience working at the ILL in Grenoble to conduct *in situ* neutron CT.

8/CNRS	Name	Acronym
	Laboratory J.A. Dieudonné of Mathematics	CNRS-LJAD
Description of the legal entity The Laboratory J.A. Dieudonné of Mathematics (LJAD) - UMR 7351 CNRS - includes 6 research teams, around 120 researchers and 40 PhD students. This project takes place in the LJAD team Partial Differential Equations and Numerical Analysis (around 40 permanent researchers and 20 PhD students) which has developed for a few years a group on geosciences applications including 2 permanent researchers, Konstantin Brenner and Roland Masson, and several doctoral and postdoctoral students.		
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Roland Masson (male) is full professor at the department of Mathematics J.A. Dieudonné of the University Nice Sophia Antipolis, and leader of the Numerical Analysis and PDEs team. He got his Ph.D at the University Paris VI in 1999 and his Habilitation at the University Paris East in 2006. He has been leader of the applied mathematics department of IFP New Energy from 2000 to 2011. His main research topics deal with discretization methods and solution algorithms for Partial Differential Equations with applications to geosciences. He coordinated and participated to several national projects and industrial collaborations, and has published more than 80 papers.		
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content N. Birgler, R. Masson, L. Trenty, A domain decomposition method to couple nonisothermal compositional gas liquid Darcy and free gas flows, Journal of Computational Physics, 368,1 pp. 210-235, 2018.		
a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal ANR CHARMS « Quantitative Reservoir Models for Complex Hydrothermal Systems » in the challenge Clean, Safe and Efficient Energy (Energie Propre Sûre et Efficace), ongoing project dealing with the simulation of geothermal systems 2016-2020 http://www.anr-CHARMS.org/ .		
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; None		

8/CNRS	Name: Laboratory of Mathematics and its applications UMR 5142	Acronym: CNRS-LMAP
Description of the legal entity The Porous Media Group of LMAP (University of Pau and Pays de l'Adour (UPPA) & CNRS UMR 5142) is involved in the development and the implementation of advanced mathematical and numerical methods for modeling multi-scales reactive multiphase flow in reservoirs including thermo-hydro-mechanical impacts, pore scale modeling and simulation of complex fluid flows, numerical homogenization. We investigate high-performance parallel processing as a tool to develop a new generation reservoir simulator implemented in the environment of the parallel open-source software DuMu^X.		
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks Since several years, our research interests encompass computational models for porous media flow, transport and deformation phenomena, model coupling and decoupling as well as advanced discretization and solution techniques. Moreover, we are involved in several third-party funded research projects. The group has the experience of numerical simulation of gas migration in the framework of nuclear waste disposal. Indeed, the group was a member from 2002 to 2015 of the French research group MoMaS (Mathematical Modeling and Numerical Simulation for Nuclear Waste Management Problems) and is also part of the French research group MaNu (Mathematics for Nuclear energy). Moreover, from 2009 to 2013, we were involved in the FORGE (Fate Of Repository GasEs) European project (http://www.bgs.ac.uk/forge/home.html). A homemade C++ upscaling code and a finite-volume method implemented in the DuMu^X framework were coupled to study gas migration through engineered and geological barriers for a deep repository of radioactive waste. Since 2012, we have been interested in the coupling between multiphase flow and geochemistry. In the context of the environment DuMu^X, we have developed and implemented a sequential coupling approach solving firstly a fully implicit two-phase flow problem and then a reactive transport problem. Several strategies including sequential iterative approach (SIA) and direct substitution approach (DSA) have been implemented in a high performance computing framework and tested for the resolution of the reactive transport problem. The accuracy and effectiveness of these approaches have been undertaken through numerical investigation for two and three dimensional spaces tests. However, sequential approaches introduce operator splitting errors and some questions about the coupling between all the physical processes have also to be studied to corroborate if some very coupled phenomena can be solved sequentially or if they need to be treated implicitly. Consequently, in view of our above-mentioned competencies, we propose to focus on the two following subtasks: • Development and implementation of a parallel fully-coupled, fully implicit method to solve a non-isothermal reactive multiphase multicomponent flow to achieve improved stability. In comparison with sequential strategies, it will allow the use of larger time steps and secondly, the errors of mass conservation due to the operator splitting will be erased. • Development and implementation of an efficient sequential numerical algorithm for coupling multiphase multicomponent flow and reservoir geomechanics.		
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Two permanent people will be involved in the project: • Etienne Ahusorde (CNRS Associate Scientist, LMAP) obtained a Graduate Diploma in Engineering in Mathematics and Mechanical modelling at MATMECA, University of Bordeaux in 2004. After graduation, he performed his PhD in Mechanics at the University of Bordeaux. Since 2010, he is associate scientist for the CNRS. His research activities are mainly dedicated to the numerical simulation of multiphase reactive flows in porous media. His scientific production consists of 19 research papers in peer reviewed journals and approximately 35 oral presentations at national and international conferences and workshops, 3 of which as invited lectures. • Brahim Amaziane (Associate Professor, LMAP) received a PhD of applied mathematics in 1988 from the University of Lyon (France). His research was carried out at INSA Lyon and partly at INRIA Paris and partly at the University of Wyoming, Laramie, USA. His thesis focused on numerical homogenization of two-phase flow in porous media. Since 1988, he works at the University of Pau and Pays de l'Adour as an assistant professor and since 2005 as an associate professor. His scientific production consists of 60 articles in international peer-reviewed journal, about 40 papers in proceedings of international conferences, co-editor of 9 books of international		

conference proceedings, co-editor of 4 special issues of the journal Mathematics and Computers in Simulation (MATCOM) and 2 special issues of the journal Applicable Analysis (AA).
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content 1. Ahusborde E., Amaziane B., El Ossmani M., Improvement of numerical approximation of coupled two-phase multicomponent flow with reactive geochemical transport in porous media, Accepted for publication in Oil and Gas Science and Technology, 2018. 2. Ahusborde E., Amaziane B., El Ossmani M., Finite volume scheme for coupling two-phase flow with reactive transport in porous media, Springer Proceedings in Mathematics and Statistics, Vol 200, 407-415, 2017. 3. Ahusborde E., El Ossmani M., A sequential approach for numerical simulation of two-phase multicomponent flow with reactive transport in porous media, Mathematics and Computers in Simulation, Vol 137, 71-89, 2017. 4. Ahusborde E., Amaziane B., Jurak M. Three-dimensional numerical simulation by upscaling of gas migration through engineered and geological barriers for a deep repository for radioactive waste, Geological Society Special Publication, Vol 415, 123-141, 2015. 5. Amaziane B., El Ossmani M., Jurak M., Numerical simulation of gas migration through engineered and geological barriers for a deep repository for radioactive waste, Comput. Vis. Sci., Vol 15, 3-20, 2012.
a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal 1. 2014-2016: Associate researcher position of Mustapha El Ossmani untitled “Development of a code for numerical simulation of multiphase flows with reactive transport in porous media” (100 K€ funded by ISIFoR: Carnot Institute, Sustainable Engineering of georesources and the Agglomeration Community of Pau-Pyrénées (Territorial Council)). 2. 2017-2020: PhD thesis of Ivana Radišić untitled “Mathematical modeling and numerical simulation of multiphase multicomponent flow with reactive transport in porous media” (funded by the University of Zagreb and the University of Pau and Pays de l'Adour). 3. 2016-2019: PhD thesis of Mohamed Id Moulay untitled “Three-dimensionnal modeling and numerical simulation of multiphase reactive flows in porous media” (funded by ISIFoR and the University of Pau and Pays de l'Adour). 4. 2011-2014: PhD thesis of Viatcheslav Vostrikov untitled “Numerical simulation of two-phase multi-component flow with reactive transport in porous media” (funded by CEA and the University of Pau and Pays de l'Adour). 5. 2009-2013: FORGE project (Fate Of Repository Gases http://www.bgs.ac.uk/forge/). This project funded by the European Union's Seventh Framework Euratom Programme under grant agreement no 230357 studied key gas migration issues in repository performance assessment (200 K€).
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; Our group has access to several computing infrastructures: 1. At local level, we have access to the cluster “Pyrene” of the University of Pau and Pays de l'Adour composed of about 1000 cores. 2. At regional level, we have access to the cluster “Avakas” of the MCIA (Aquitaine Mesocenter for Intensive Computing) composed of about 3500 cores. 3. At national level, we have access to the HPC resources of CINES (National Computing Center for Higher Education) composed of about 85000 cores.

Participant	No	Name	Acronym
	9	Centrale Organisatie Voor Radioactief Afval N.V.	COVRA
Description of the legal entity COVRA is a national radioactive waste management organisation of the Netherlands. COVRA is a state-owned enterprise of which the stocks are held by the Ministry of Finance. It is the only company in the Netherlands that is qualified to collect, treat and store radioactive waste and prepare and implement the final disposal. Its legal form is a 'Naamloze Vennootschap' (public limited company).			
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks - DONUT is WP on the development and improvement of numerical methods and tools for modelling of coupled processes. COVRA has just finished its safety case in 2017, in which the safety assessment uses numerical methods and tools for modelling of coupled processes to describe a disposal facility in Boom Clay. COVRA will prepare benchmarks for the evaluation of the methods and numerical tools described considering their relevance in the scope of multi-physical assessment from the point of view of the implementer. Specifically COVRA plans to develop a benchmark for numerical models with steep chemical gradients across solid interfaces. This contribution can be of help with the evaluation of the efficiency and computational cost of different numerical models/solvers for models with a steep chemical gradient across interfaces between solid materials. - Assessment of Chemical Evolution of ILW and HLW Disposal Cells (ACED) is the WP to improve methodologies to obtain multi-scale quantitative models for the chemical model at cell disposal scale based on existing and new experimental data and process knowledge and to improve the description of the most relevant processes driving the chemical evolution into robust mathematical frameworks. COVRA is a co-task leader in this WP and made the first assessment of information from existing or currently running experiments from the first questionnaire that was sent around to interested organizations during the pre-project phase and is responsible for the State of the Art regarding relevant processes that influence the long-term chemical evolution in disposal cells for vitrified HLW and for cemented ILW. Both types of processed waste are owned by COVRA which facilitates access to essential details for parameters that can be used for the models. COVRA contributes to relevant sample material, new experimental data to improve the description of relevant processes, writes the conceptual and mathematical models, and executes calculations at waste package scale and disposal cell scale. - Mechanistic understanding of gas transport in clay materials (GAS) is the WP to improve the mechanistic understanding of gas transport processes in natural and engineered clay materials and to evaluate the gas transport regimes that can be active at the scale of a geological disposal system and their potential impact on barrier integrity and repository performance. COVRA acts as an end-user for this WP and contributes to the conceptualization of gas transport currently treated in COVRA's assessment in natural clay in order to contribute to inform the experimentalists / process-level modellers about the configurations and ranges of conditions that are relevant for disposal systems. - If only because of the long times scales involves, radioactive waste management involves. uncertainty management. Dealing with uncertainties and communicating about them, therefore, forms an integral part of the work COVRA does. The goal of the UMAN work package is to develop a common understanding among the different categories of actors (WMOs, TSOs, REs & Civil Society) on uncertainty management and how it relates to risk & safety. In cases where a common understanding is beyond reach, the objective is to achieve mutual understanding on why views on uncertainties and their management are different for different actors. COVRA will look at the methodological approaches to uncertainty and sensitivity analysis. It will participate in technical meetings, share its experience with uncertainty and sensitivity analysis methods and review the deliverable on this topic . - The WP WM routes in Europe will describe and compare the different approaches to characterization, treatment and conditioning and to long-term waste management routes, and identify opportunities for collaboration between MS (member states). It will identify safety-relevant issues and their R&D needs			

associated with the waste management routes (cradle to grave), including the management routes of legacy and historical waste, taking into account that programmes are at different stages of development, have with different amounts and types of radioactive waste to manage and considering interdependencies between the routes. COVRA will coordinate the task to evaluate the potential for developing and using shared technologies and facilities. COVRA was involved EC project SAPIERR and has coordinated SAPIERR II, both projects concerning sharing facilities. COVRA chairs the ERDO working group that investigates and promotes sharing R&D, technology and facilities.

a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities

- Dr. Jeroen Bartol (1984). Researcher at COVRA. Jeroen studied at Utrecht University and Free University Amsterdam where he received a bachelor degree in Earth Science (2007), a master's degree in Geophysics (2008). In 2017, he completed his PhD at Utrecht University. Subject of his PhD was the vertical motions and plate boundary evolution in the Anatolia-Black Sea region. Areas of expertise are geology, sedimentology, numerical (finite element/difference) modelling, rheology and the interaction between surface (e.g. surface uplift/erosion) and subsurface processes (e.g. diapiric process) and he has multiple years of experience as a software developer. He is a member of the NEA Salt Club
- Dr. Erika A.C. Neeft (1974). Researcher at COVRA. Erika was the technical coordinator for the Dutch national programme on geological disposal. Currently, she describes the safety and design requirements for the engineered barrier system and calculates the processes of disposed waste in a concrete supported disposal facility in poorly indurated clay. She is a member of the NEA Clay Club and the management board of the NEA Thermodynamic Database and is assigned by the Dutch government to participate in the IAEA International Project on Demonstration of the Operational and Long-Term Safety of Geological Disposal Facilities for Radioactive Waste (GEOSAF Part III). She holds a MSc degree in Earth Sciences from Utrecht University and a PhD in reactor physics (transmutation of nuclear waste) from Delft University of Technology.
- Dr. Ir. Ewoud V. Verhoef (1973). Deputy director of COVRA. Ewoud has lead the Dutch national programme on geological disposal, is the acting chair of the ERDO working group on developing multinational waste management organisation in Europe, and is a member of the executive group of the European technology platform on the disposal of radioactive waste (IGD-TP). He is member of the board of Royal Netherlands Society of Engineers, section Nuclear technology, and the Netherlands Nuclear Society. Ewoud studied chemical technology at Delft University of Technology, where he also received his PhD on research on the influence of policy and legislation on waste management processes.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- Ewoud Verhoef, Erika Neeft, Neil Chapman, Charles McCombie, OPERA Safety case (2017). ^{COVRA report} that presents overview of the results and conclusions of the safety case for a geological disposal facility in the Boom Clay in the Netherlands.
- Special issue on Geological disposal of Netherlands Journal of geosciences to geological disposal of radioactive waste Volume 95, Issue 3, September 2016.
- E.A.C. Neeft, Final overview of CAST, CAST report 7.23 (2018) ^{Overview to summarize the results and achievements of CAST and their implications for building confidence in the safety of geological disposal}
- R.B. Polder, W.H.A. Peelen, B.Th.J. Stoop, E.A.C. Neeft - Early stage beneficial effects of cathodic protection in concrete structures, Materials and Corrosion 62[2] (2011) 105-110.
E.A.C. Neeft, J.K.H. Visser, W.H.A. Peelen, A.J. van Vliet, J.A. Larbi, Measurements and simulations of the distribution of moisture in concrete, TNO-034-DTM-2009-02726 (2009) 1-81

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

- OPERA 2011-2017. Coordination of the national research programme on Geological disposal in the Netherlands. www.covra.nl/downloads/opera
- Cast 2013-2018. WP Leader in EC funded project on C-14 source term www.projectcast.eu
- ERDO-wg. 2009 – present. Chairing and participation in the workgroup. www.erdo-wg.eu

- IGD-tp. Technology platform for the implementation of geological disposal. Member of the executive group. www.igdtp.eu
- OECD-NEA. Member of the RWMC, management Board of NEA thermodynamic database, the salt club and the clay club. www.oecd-nea.org/rwm/

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

As COVRA is responsible for carrying out all steps in the radioactive waste chain, from collection to the eventual disposal, it has hands on experience with and infrastructure for characterization, treatment and conditioning, storage. It has treatment and storage buildings for all types of radioactive waste. It has two laboratories to perform experiments and two COMSOL licences to perform the modelling work.

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task

N/A

	No	Name	Acronym
Participant	10	Centre for Physical Sciences and Technology	FTMC
Description of the legal entity State research institute acting as TSO in EURAD			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks Department of Nuclear Research of FTMC (Engl. FTMC) implements the technological possibilities important for public and NPP needs, performs training and expertise in the fields of nuclear physics, nuclear and mass spectroscopy. The activities are mostly concentrated on numerical analysis (MCNP6, MCNPX, SCALE 6.2, GEANT4, OSCAR LIETDOS, THYROID), criticality, radiation shielding safety, nuclide composition analysis of spent nuclear fuel and radioactive waste and experimental measurements of generation of radionuclides (AMS, IRMS, ICP-MS, nuclear spectrometry equipment: HPGe Detectors, Alpha Particle Spectrometer, X-ray spectrometer, FHT 770 T 6 α , β counter, LSC). Further the mechanism of radionuclide transportation through engineering barriers for the surface repository or geological disposal case, evaluation of safety and reliability of radioactive waste management technology is performed in the department. One of the aims - optimization of nuclear facility radioactive waste RW management based on scientifically approved and environmentally – friendly technology, applying grouping and separation of RW by using modeling and experimental research of nuclide content of radioactive waste from NPPs as well as improvement and application of scaling factor (nuclide vector) methods. In this proposal FTMC (Engl. FTMC) will contribute to: 1. Spent Fuel properties Characterization until disposal (SFC): FTMC will define and verify procedures to determine the source terms of SNF assemblies with realistic confidence limits and will work on comparing the performance of “sophisticated” and “best-practice industry” codes (SCALE6.2 and MCNP6) based on SKB-50 data. The aim of the task to define, verify and recommend state-of-the-art procedures to determine the source terms of SNF assemblies with realistic uncertainties, further (in the second wave of EURAD) the procedures will be applied for other type reactors (RBMK and VVER) to calculate source terms. 2. Cement-Organics-Radionuclides-Interactions (CORI) work package: will perform overview about the organics degradation and release of soluble organic species (PVC and Cellulose), will perform hydrolytic degradation of PVC/Cellulose and identification of degradation products, will study the competitive effect of Fe(II)/Fe(III) onto radionuclides (Am-243 and Pu-242) sorption in the presence of organics (low molecular weight organic acids / phthalate / adipate) in contact with CEM I/ CEM V cement-based materials (pH 12.5); 3. UMAN - EU cooperation activities explaining the uncertainty, risk and safety of different factors. Work will include assessment of uncertainties related to radiological characterisation of radioactive waste generated during NPP operation and decommissioning activities at the different stages of management programme (impact of predisposal steps). Different reactor waste inventory case is specific because of different experience of decommissioning – such analysis of uncertainties relevant to the safety analysis and the safety case will be performed for the first time. The processes cannot be modelled with sufficient precision, or their partial input to the final waste activity cannot be known with adequate accuracy. Therefore general approach is to use the modelling and measurement techniques, complementing each other and therefore reducing the uncertainty and increasing the confidence of activity determination. 4. ROUTES – FTMC will be engage in an activity involving a waste management network in Europe from cradle to grave by touching historical / non-documented waste. FTMC will provide input of Lithuanian situation identify challenging waste streams; describing/comparing waste characterisation approaches; identify WAC’s used; disseminating technological waste management solutions for other member states. 5. FTMC will participate in KNOWLEDGE MANAGEMENT activities ensuring access to existing Knowledge (State-of-Knowledge), guiding the development of capability in line with core competencies (Guidance and Training), and improving access to quality tools, resources and communities of practice to share and learn from each other (Dissemination). This project is in compliance with the EU Council Directive 2011/70 on the safe management of all			

radioactive waste and spent fuel. In 2015 the Government of the Republic of Lithuania has prepared a National Program for the Development of Radioactive Waste Management. EURAD will help to implement strategic goals of the program.

a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities:

1. Dr. **R. Plukienė** (female) has 16 years' experience in modeling of the nuclide composition in nuclear systems (SCALE 6.2 MCNPX, MCNP6, MonteBurns, ORIGEN, HELIOS codes) and nuclear spectroscopy. She is senior researcher in the mass spectrometry laboratory of FTMC. She was actively participating in nuclear power plant decommissioning projects: responsible for modeling of KNPP constructions and radiological inventory calculation in the project „Evaluation of the Material Backlog and Radiological Inventory of KNPP Units 1 to 4“; responsible for RBMK scaling factor determination in the project: "Assistance to INPP by Technical Support Organisations in the Field of Radiological Characterisation for Block A1 (Reactor and auxiliary systems). Currently she is involved in European Commission „Horizon 2020“ project „Baltic Region Initiative for Long Lasting Innovative Nuclear Technologies (BRILLIANT)“ and performing investigation on open/partly closed and closed fuel cycle options in the Baltic region. She was leader of the international programme COST P9 „Radiation Damage in Biomolecular Systems project in our institution (2004-2007). She will be responsible for development of SFC WP activities in EURAD-1 from FTMC. Spent nuclear fuel simulations will be performed by using SCALE6.2 and MCNP6 codes. Estimated volume of works is 3.8 pm (0.36% of SF WP EURAD funds).
2. Dr. **R. Druteikienė** (female) has 20 years' experience in the field of investigation of the peculiarities of radionuclide migration and accumulation abilities in the environmental systems. Currently she is head of mass spectrometry laboratory, chief researcher at FTMC. During the last year her scientific activities are related to investigation of thermodynamically and kinetically controlled processes, surface reactions and microbial processes in the radioactive waste storage barriers. She is actively participating in national and international projects on radioactive waste characterization. She will be responsible for CORI WP activities in EURAD-1 from FTMC. Investigations of cemented radioactive waste are foreseen to ensure the durability of radioactive waste storage. An estimated volume of works is 10 pm (2% of the CORI WP EURAD).
3. Dr. **A. Plukis** (male) has 20 years' experience in nuclear systems modeling, the radiation safety assessment (SCALE 6.2 MCNPX), nuclear spectroscopy and the ion beams use. Currently he is deputy head of department of nuclear research, head of experimental nuclear physics laboratory, chief researcher at FTMC. His main scientific research area is in applied nuclear physics and nuclear power plant decommissioning, modeling of the target for RIB production, neutron cross-section measurement in nToF (CERN), research of kinetics in organic compounds with high quantum luminescence efficiency stimulated by high linear energy transfer particles (neutrons or protons) and photons and development of new systems for low background particle detection. He was leader of several international and national projects: “Characterization of Waste after Decommissioning of Reactor“ (2005 – 2006, project of bilateral French – Lithuanian cooperation programme “Gilibert”); ECONET: Measurements of Yields of the Delayed Neutrons from Nuclear Fission - Splitting Reactions (project of tripartite scientific cooperation (France-Russia-Lithuania); European Commission FP6 project „EURISOL-DS“ (2005 - 2009) for our institution. He is actively participating in national and international projects on radioactive waste characterization. He will be responsible for UMAN WP in EURAD-1 from FTMC. FTMC will collect and synthesize relevant information on inventory uncertainty of various radioactive waste (LLW, ILW, SF/HLW) will contribute to safety analysis of waste package concepts. Volume of work 2 pm (0.9% of UNCERTAINTY WP of EURAD funds).
4. Dr. **L. Juodis** (male) has 18 years research experience in nuclear spectroscopy, heuristic optimization algorithms, radioactive waste management, radiation protection, nuclear fuel thermo-mechanical properties and investigations of the fission product release from the fuel matrix, assessment of internal contamination of reactor primary circuits. He is senior researcher in the experimental nuclear physics laboratory of FTMC. 2010 – 2016, L. Juodis was a coordinator of FTMC work group for assessment the report of environmental impact of Belorussian NPP and participated in governmental commission for solving the nuclear safety and environment protection

problems related with nuclear facilities planned to build in the neighborhood of Lithuania, leader of Ignalina program project "Assistance to INPP by Technical Support Organisations in the Field of Radiological Characterisation for Block A1 (Reactor and auxiliary systems) and leader one of project workpackages of „Horizon 2020“ project „Baltic Region Initiative for Long Lasting InnovAtive Nuclear Technologies (BRILLIANT)“ at FTMC. He will be responsible for EU cooperation activities ROUTES WP for our institution. Covering the waste management network in Europe from cradle to grave (conditioning, treatment, storage, disposal): priority topic: historical / non-documented waste. The planned volume of work is 2.69 pm (1.32% of ROUTES WP EURAD funds).

5. Dr. **G. Duškesas** (male) has 17 years' experience in the radioactive waste management, radiation protection and expertise of decommissioning of commercial reactors, he was leader of the CARBOWASTE project in our institution, was a contributor to IAEA technical document "Determination and use of scaling factors for waste characterization in nuclear power plants", and is a leader of work package on irradiated graphite characterization at IAEA project GRAPA now. He is research associate in the experimental nuclear physics laboratory of FTMC. He is actively participating in national and international projects on radioactive waste characterization. He is responsible for FTMC activities in Knowledge management program.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

1. Remeikis, Vidmantas; Plukis, Artūras; Juodis, Laurynas; Gudelis, Arūnas; Lukauskas, D.; Druteikienė, Rūta; Lujanienė, Galina; Lukšienė, Benedikta; Plukienė, Rita; Duškesas, Grigorijus. (2009) Study of the nuclide inventory of operational radioactive waste for the RBMK-1500 reactor, Nuclear engineering and design, Vol. 239(4), p. 813-818.
2. Barkauskas, Vytenis;. (2016) Actinide-only and full burn-up credit in criticality assessment of RBMK-1500 spent nuclear fuel storage cask using axial burn-up profile, Nuclear Engineering and Design, Vol. 307, p. 197-204.
3. Garankin, Jevgienij;Plukis, Arturas; Plukienė, Rita; Lagzdina, Elena; Remeikis, Vidmantas. (2018) Identification of Particles of Ionizing Radiation by the Analysis of Fluorescence Pulse Form of Thin Pen Film Scintillator, IEEE Transactions on Nuclear Science Vol. 65(2), p. 739 - 743, DOI: 10.1109/TNS.2017.2785683, <http://ieeexplore.ieee.org/document/8231166>
4. Remeikis, Vidmantas ; Lagzdina, Elena; Garbaras, Andrius; Gudelis, Arūnas; Garankin, Jevgienij; , Plukienė, Rita; Juodis, Laurynas; Duškesas, Grigorijus; Lingis, Danielius; Abdulajev, Vladimir; Plukis, Artūras. (2018) Rapid Analysis Method for the Determination of ¹⁴C Specific Activity in Irradiated Graphite, PLOS ONE, p. 1-16, <https://doi.org/10.1371/journal.pone.0191677>
5. Druteikienė, Rūta; Lukšienė, Benedikta; Pečiulytė, Dalė; Mažeika, Kęstutis; Gudelis, Arūnas; Baltrūnas, Dalis Antanas. (2014) Behaviour of ⁹⁹Tc in aqueous solutions in the presence of iron oxides and microorganisms. Applied radiation and isotopes Vol. 89, p. 85-94. ISSN 0969-8043

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

2008 – 2013, European Commission FP7 project „Treatment and Disposal of Irradiated Graphite and Other Carbonaceous Waste“ (CARBOWASTE).

2017-2019, Ignalina program project "Assistance to INPP by Technical Support Organisations in the Field of Radiological Characterisation for Block A1 (Reactor and auxiliary systems).

2016-2017, 2200-U12 JOPRAD – EC project (Contract Number: 653951), devoted to the solution of the problems of geological disposal of the spent nuclear fuel.

2007– 2013, European Commission FP7 Collaborative Project REDOX PHENOMENA CONTROLLING SYSTEMS (RECOZY) under grant agreement No.212287.

2013-2015, project No MIP-066/2013 funded by Research Council of Lithuania Radionuclides Migration Parameters Fluctuations in Radioactive Waste Storage Barrier (RADPAR).

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

Applied nuclear physics modeling software: MCNP6, MCNPX, SCALE 6.2, GEANT4 program packages used for different applications solving tasks of particle interaction with material and particularly for determination of nuclide activity in radioactive waste by scaling factor (nuclide vector) method; Computer codes for the evaluation of the contamination levels of various radionuclides in the nuclear power plant equipment, buildings, waste and environment: OSCAR - assessment of radioactive contamination of reactor primary circuit, LIETDOS - simulation of radionuclides migration in the environment, exposure doses for humans and biota; THYROID - assessment of the inhabitants' thyroid exposure doses after the accidents in the nuclear power plants). The modeling software is used for nuclear and radiation safety analysis; generation of radionuclides and mechanism of their transportation through engineering barriers, evaluation of safety and reliability of radioactive waste management technology application, assessment of radionuclide accumulation and migration in the environment.

Mass spectrometry laboratory (AMS, IRMS, ICP-MS) conducts the long-term research and experimental development in physics and technology, achieve the international level competence; to apply mass spectrometry methods to the environmental research, nuclear safety, radioecology fields; to participate in international research programs; to cooperate with domestic and foreign institutions of higher education in preparing highly qualified specialists. The various methods of spectrometry (UV/Vis, IR, Fourier and Raman spectroscopy) and chromatography (gas chromatography equipped with flame ionization detector GC (FID), gas chromatography with mass spectrometer detector, high performance liquid chromatography coupled with spectrophotometric and mass detectors (HPLC-DAD-TOF) are used for quantitative and qualitative analysis of organic compounds.

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

N/A

	No	Name	Acronym
Participant	11	Centrum vyzkumu Rez	CV REZ
Description of the legal entity The research organisation Centrum vyzkumu Rez (CV REZ) was founded on 9th October 2002 as 100% subsidiary company of UJV Rez, a.s. (NRI – <i>Nuclear Research Institute</i>). The main aim of the research organisation is research, development and innovations in the field of power generation (especially nuclear). CV REZ owns unique research infrastructure such as experimental research reactors LVR-15 and LR-0 and technological experimental circuits. Significant modernization of the infrastructure is being realized within years 2012-2017 due to realization of the SUSEN project (realized in the framework of the Operational Programme Research and Development for Innovations of the European Regional Development Fund). As of January 1st, 2016 the company CV REZ had a total of 330 employees. The core activities of CV REZ involve fundamental and applied research on experimental research reactors LVR-15 and LR-0. Another activities are arising from the participation of CV REZ in the international Jules Horowitz Reactor project. No less important are national and international projects (especially H2020 projects). CV REZ is a member of the European Energy Research Alliance (EERA) and since 2010 represents the Czech Republic in the EERA managing body – Executive Committee, thereby participating in the realization of the Strategic Energy Technology Plan (SET-Plan). CV REZ is also a member (and co-founder) of the Technology Platform ‘Sustainable Energy CR’.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks Research Centre Rez (CV REZ) will be providing the gamma irradiator Little Cobalt where the superplasticizers or cement paste samples will be irradiated. Moreover the temperature and the emission of the released gasses will be monitored and regularly analysed. Cement pastes will be tested non-destructively before and after the irradiation. Brushed and/or polished fragments of tested samples will be analysed by SEM, LOM or XRD microscopic analyses. All measured data and work proceeding will be discussed with the other partners in the work team, e.g. with UJV, CTU or SÚRAO.			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Dr. Zbynek Hlavac (male) – main contact of the participant, responsible for the concrete testing activities, graduated at Faculty of Civil Engineering, Brno University of Technology, with Ph.D. degree as a specialist for concrete non-destructive testing. He has experiences in building materials and structures testing and assessment, he prepared more than 30 scientific articles in conference proceedings and technical journals. Since 2013 he works as a researcher in Diagnostics & Qualification department of Centrum vyzkumu Rez s.r.o. (Research Centre Rez Ltd.) Jaroslava Kořátková (female) graduated at the Faculty of Civil Engineering, Czech Technical University in the field of Material Engineering. She works for Research Centre Rez as a researcher whilst continuing in her Ph.D. studies. Her work is focused on the on the research relating concrete for nuclear power plants and disposal repositories with focus on material development, material ageing and non-destructive testing. She has vast experience in publishing scientific articles, including articles in impact journals, peer reviewed journals or conference proceedings. Vít Rosnecký (male) is a technician who takes care about the gamma irradiation facility Little Cobalt in Research Centre Rez Ltd. since 2015. Is responsible for the dosimetry control and radiation protection at his work place in Rez. Has 6-years experience with the work with radionuclides and radioactive sources (Eckert & Ziegler Cesio Ltd.). Jitka Mikšová (female) has large experience in the field of radioactive waste repositories. She works in te Research Centre Rez Ltd. since 2014. Her publication activity contains more than 17 papers related to the radioactive waste management. She participates in the European meetings related to the radioactive waste disposal since the year 2014.			

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

Koťátková J., Hlaváč Z., Rosnecký V., Mohyla R., Jansa J. The Effect of Superplasticizers on the Properties of Gamma Irradiated Cement Pastes. *Ceramics-Silikáty* 62 (3), 306-310 (2018)

J. Koťátková, J. Zatloukal, P. Reiterman, J. Patera, Z. Hlaváč, P. Brabec, The Effect of Elevated Temperatures and Nuclear Radiation on the Properties of Biological Shielding Concrete, *Key Engineering Materials* 677(2016) 8-16.

Hlaváč, Z.; Rosnecký, V.; Bublíková, P.; Koťátková, J.; Janura, R.; Gregor, K.; Zahrádka, P. STUDY OF RADIATION AND LOCA IMPACT ON CONCRETE PROPERTIES, 2017. Nuclear Technologies for the 21st Century Web site. <http://www.cvrez.cz> (accessed Sep 11, 2018).

Besnus, F.; Metcalf, P.; Mikšová, J.; Wasselin-Trupin, V.; Pfingsten, W.; Smidts, O.; Tokaresvski, O. The ETSON study on treatment processes for the sustainable management of radioactive waste, 2016. International Conference on the Safety of Radioactive Waste Management Web site. https://gnssn.iaea.org/meetings/wasteconference2016/Shared%20Documents/Session%20a%20-%20WPr/Oral/Papers/02a-06-206_Besnus_PAPER.pdf (accessed Sep 11, 2018).

Pellegrini, D.; Bernier, F.; Detilleux, V.; Hériard Dubreuil, G.; Narkuniene, A.; Miksova, J.; Rocher, M. SITEX, the European network of technical expertise organisations for geological disposal, 2016. International Conference on the Safety of Radioactive Waste Management Web site. https://gnssn.iaea.org/meetings/wasteconference2016/Shared%20Documents/Session%203d%20-%20HLW/Oral/Papers/03d-07-184_Pellegrini_PAPER.pdf (accessed Sep 11, 2018).

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

SUSEN project. By joining the European Union, the Czech Republic became one of the member states benefiting from targeted support within European regional policy. For the period 2007–2013, all regions of the Czech Republic (except the capital city of Prague) are included in the Convergence target. In compliance with the objectives of European regional policy, one of the priorities of the Czech Republic is to improve the competitiveness of the state and its orientation to a knowledge economy. The operational program Research and Development for Innovations (henceforth “OP R&DI”) is one of the important operational programs contributing to meeting the foregoing objectives. The global objective of OP R&DI is to strengthen the research, development and innovative potential of the Czech Republic which will contribute to growth of competitiveness and create highly-qualified jobs to make the regions of the Czech Republic become important points of concentration of such activities in Europe. The Sustainable Energy Project (SUSustainable ENergy, SUSEN) is implemented as a regional R&D centre in Priority Axis 2 and its objective is to act as a relevant research partner for cooperation within the sphere of application including the establishment of partnerships and cooperation with important European research centres. The project is built on four foundation piers represented by the following research programs further divided into research activities:

1. Technological Experimental Circuits (TEO)
2. Structural and System Diagnostics (SSD)
3. Nuclear Fuel Cycle (NFC)
4. Material Research (MAT)

Current project will be using the large infrastructure built by the SUSEN project.

Non-destructive control of biological shielding concrete, supported by a grant of the Ministry of Interior of Czech Republic for Inhabitants Safety. Non-destructive testing methods suitable for reactor pressure vessel (PVR) cavity testing are investigated. A robotic system will be developed for ionization channel (in PVR cavity) inspection. 2015-2018.

Irradiation In-pile and out-of-pile stop signal reaction time (SSRT) studies (for EPRI) Pre-irradiated tensile specimens, 10 dpa, PWR environment, hydraulic loading, deformation rate $10^{-6}/10^{-7} \text{ s}^{-1}$, Tests of the surveillance specimens of the materials RPVs of the Czech and Slovak NPPs (on going) Integrated surveillance program for RPVs of the Ukrainian NPPs (on going) According to the description above, it is clear that the project, which is presented under the EURATOM program, completely relating to activities undertaken in the CV REZ. Material research (resp. cross -cutting fusion research) has an important role in the CV REZ activities. This also follows from the focus of research which is realized within the project SUSEN.
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; Infrastructures of CV REZ The project will be using the large infrastructure of the European project Sustainable Energetic SUSEN. The gamma irradiator Little Cobalt (GOMK) is situated in Husinec Rez near Prague. It is targeted for the research of the space issues in the conditions of the very low air pressure and temperature. The cobalt source Co 60 of the gamma rays is a quasi-point type of the source with nominal activity 200 TBq.
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task. N/A

	No	Name	Acronym
	Participant 12	Danish Decommissioning	Dekom
Description of the legal entity Danish Decommissioning (DD) is a state-owned company under the Ministry of Higher Education and Science. DD was established in 2003 and has the responsibility of decommissioning the Danish nuclear research facilities, managing waste from other Danish users of radioactive materials, and participating in the process leading to a longterm solution for the Danish RW. DD has the responsibility for safe handling and storage of all Danish RW, except from NORM. Since 2003 it has been part of the official Danish policy to investigate the possibility to find an international solution for 233 kg of spent research fuel; this has been mentioned again in a recent Parliamentary resolution on long term waste management (B 90, May 2018.) B 90 also stresses the importance of DD participating in international research and development projects on RW management (storage and repository). DD has for several years been a member of the ERDO-WG, focusing on both shared predisposal and disposal solutions. See more information on www.dekom.dk			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks Participant in Waste Management Routes Task 6. Since 2003 it has been part of the official Danish policy to investigate the possibility to find an international solution for 233 kg of spent research fuel; this has been mentioned again in a recent Parliamentary resolution on long term waste management (B 90, May 2018.) B 90 also stresses the importance of DD participating in international research and development projects on RW management (storage and repository). DD has for several years been a member of the ERDO-WG, focusing on both shared predisposal and disposal solutions. See more information on www.dekom.dk			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Mr. Ole Kastbjerg Nielsen is managing director in Danish Decommissioning, and has 15 years of experience with decommissioning and waste management. 2003-2008 he was employed as Head of Administration and Safety, and since 2008 he has taken the position of Managing Director. He is actively involved in the ERDO-WG, and with long term waste management in more general, a.o. shared solutions. Before DD, Ole Kastbjerg Nielsen was employed for 11 years in the Danish EPA, the first years in the chemical-toxicological division, and for the last six years as Programme Coordinator for environmental projects in the Russian Federation, supported by a Danish government programme. Educational background: Social Science. Mrs. Heidi Sjølin Thomsen has been employed in Danish Decommissioning for 10 years, with waste management as her primary responsibility. She is a RW expert with very deep knowledge about all aspects of the Danish RW, pre-disposal and disposal related subjects. She is project leader for the process towards a long term solution for the Danish RW. Educational Background: Geology Ole Kastbjerg Nielsen and Heidi Sjølin Thomsen have both been actively involved in the pre-feasibility study for a Danish repository (see below) and investigations in relation to a possible long term storage.			
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content Beslutningsgrundlag for et dansk slutdepot for lav- og mellemaktivt affald, udarbejdet af en arbejdsgruppe under Ministeriet for Sundhed og Forebyggelse, november 2008. Danish Decommissioning: Pre-feasibility study for final disposal of radioactive waste. Disposal concepts. Main Report, COWI May 2011. Dansk Dekommissionering og GEUS: Beslutningsgrundlag for et dansk mellemlager for lav- og mellemaktivt affald, februar 2015. Dansk Dekommissionering: Sikkerhed, økonomi og drift for en dansk mellemlagerløsning for radioaktivt affald, COWI august 2016.			

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

Pre-feasibility study for final disposal of radioactive waste, see above publications.

Pre-feasibility study for long term storage of Danish RW, see above publications.

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

No relevant infrastructure or technical equipment identified, as this is a strategic study.

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

Not relevant.

	No	Name	Acronym
Participant	13	GREEK ATOMIC ENERGY COMMISSION	EEAE
Description of the legal entity Greek Atomic Energy Commission (EEAE) is the competent regulatory authority for the control, regulation and supervision in the fields of nuclear energy, nuclear technology, radiological and nuclear safety and radiation protection. EEAE is operating as a public entity and enjoying full administrative and financial independence in relation to its duties. It operates under and is supervised by the Minister of Education, Research and Religious Affairs. EEAE was initially established by an Act in 1954. The organization has been re-established with a different scheme in 1987. In 2014, with the Law 4310 (Government Gazette Folio No. 258/A/08.12.2014), a separate chapter, chapter E, titled "Nuclear Energy, Technology and Radiation Protection - Greek Atomic Energy Commission" is included. The obsolete framework is replaced by a new operation framework of EEAE. The new framework brings important improvements, regarding, inter alia, EEAE independence, enforcement means, inspectors role and inspection procedures, licensing authority and transparency enhancement. The new EEAE operation regime is in line with the international and European requirements for radiation protection and nuclear safety regulatory authorities, enhances the independent and effective regulation of this field and addresses some of the IRRS mission findings. EEAE organizational structure was published in the form of a Presidential Decree in 1993. At present, a new Presidential Decree on the internal organization of EEAE has been approved by the government and is in the final stage of issuance. Following IAEA IRRS, in 2012, mission findings, the new internal organization of EEAE provides for the operational separation between its regulatory functions and scientific and technical services. EEAE is governed by a seven-member Board. EEAE employs a sufficient number of about 75 qualified and competent staff to carry out its tasks. Most of EEAE personnel holds a degree of high level education and dispose specialized scientific expertise (M.Sc. and/or Ph.D.). Their continuous training, the participation in EEAE E&T activities and the participation in scientific networks and international fora and activities is encouraged in order to gain the knowledge and experience required for the fulfillment of their tasks. EEAE financial resources come from the public budget and from licensing fees and radiation protection services. The accounts and fiscal reports of the EEAE are subject to the control of the Audit Council. These data and fiscal reports are published on the EEAE website and submitted to the President of the Hellenic Parliament and the relevant Minister alongside the yearly report and the budget for the coming year. EEAE implements an integrated management system; in 2013 it was certified in accordance with the requirements of ISO 9001:2008 standard, which incorporates all functions and accreditations of EEAE. In December 2016, the IMS was updated, fulfilling the requirements of the revised ISO 9001:2015. Specific aspects were further identified to be embedded in the integrated management system to respond to the IRRS findings, in line with IAEA safety requirements. An IAEA IRRS mission was conducted in 2012 and follow-up mission in November 2017, where the majority of the recommendations and suggestions identified in 2012 were successfully considered and implemented by EEAE. EEAE succeeded in participating actively in EC-funded research projects, mainly through FP6 and FP7 (CONRAD, ORAMED, COCAE) Regarding radioactive waste (RW) management EEAE • is responsible for the enforcement and implementation of the "national framework" and recommends actions on improvement. • participates in the formulation and establishment of the "national policy" and ensures compliance and implementation • implements and maintains the system of authorization, inspections and enforcement for the spent fuel (SF) & RW management practices and facilities; it issues the inspection reports and grants the relevant license; • participates in the National Committee on Radioactive Waste Management (EEDRA) • cooperates with EEDRA for the review and updating of the "national program"; it has prepared the 1st "national program"; ensures its proper implementation of the national program.			

- maintains the National database for SF & RW, radioactive sources, radioactive materials or nuclear fuels and conducts annually the national inventory of SF & RW management and assess those that may occur in the future.
- approves proposed SF & RW management streams and technical solutions and SF & RW management practices.
- provides education and training in radiation protection to staff involved in the management of SF & RW.
- prepares and submit to the EC the national reports for SF & RW management

IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks

Task 2: EEAE's main interest on task 2 is to be informed about the best practices in Europe for waste characterization/classification. EEAE has already a limited experience on the subject due to its participation in the characterization of wastes produced by NORM industries during their operation phase, and during their decommissioning. It is also participate to the radiological characterization of wastes produced at a scrap metal recycling industry after the accidental melting of a radioactive source. EEAE also performs the determination of the specific clearance levels to assist these activities.

Task 3: EEAE's main interest on task 3 is to be informed about the best available radio-analytical techniques used for waste characterization and to contribute with its experience on these technique.

Task 5: EEAE will contribute to the analysis of national programmes of other countries with small inventories, in order to identify common aspects and points of interest of the existing and potential disposal options and RW streams. EEAE will contribute to the organization and participation to workshops.

Task 6: Following task 5, EEAE will contribute to the investigation on the common needs, views and attitudes of the EU countries regarding shared solutions of RW management. EEAE will contribute to the organization and participation to workshops.

a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities

Dr. Costas J. HOURDAKIS

Current position: Head of the Licensing and Inspection Department (LID/EEAE), Licensing and Inspection Division, Greek Atomic Energy Commission, EEAE. (16 persons). Acted as Head of the Ionizing Radiation Calibration Laboratory (SSDL) until 01.01.2016.

He studied Physics at the University of Athens, Greece (B.Sc. 1985). He awarded postgraduate M.Sc. in medical physics at the University of Surrey, UK (M.Sc. 1987); Ph.D. at the University of Athens, Greece (1995).

Since 2004 he has been an IAEA expert, participating in several IAEA expert missions He has coordinated and/or participated in several international scientific research and development projects regarding the ionizing radiation practices, radiation protection, clinical patient dosimetry and metrology of ionizing radiation, radiological preparedness and response. He is the Greek delegate in the Euratom Treaty Article 37 Group of Experts, in the Commission of Radiation Protection and Public Health (CRPPH) of the NEA/OCDE, in the European Metrology Committee (EURAMET), as well as the Greek (national) coordinator and national focal point at several EU and IAEA committees and working groups.

He is a lecturer in two Greek Medical Physics Post Graduate courses and an invited speaker in many seminars and courses organized by the Greek Atomic Energy Commission and other scientific organizations and committees

Main activities:

Coordinate the work of the LID/EEAE. Issue certificates of compliance with Ionizing Radiation Protection Regulations (IRPR) and operation licenses, transport licences and of radiation sources possession and use licenses.

Performing inspections of radioactive waste (RW) management facilities, as well as medical, research and industrial laboratories using ionizing sources

Organize and perform quality and dosimetry audits in radiotherapy, brachytherapy and diagnostic radiology.

Evaluation of hazard reports, perform of risk assessments and evaluation of doses to public, and radiation workers from ionizing radiation practices, including RW.
 Coordinate and assess the management of radioactive waste and disused radioactive sources.
 Participates in the committees and working groups for drafting of legislation and guidance on SF and RW management, radiation protection, medical application.
 Participate to EEAE's emergency team for radiological accidents and events.

Dr. Konstantinos POTIRIADIS,

Current position: Head of the Department of Environmental Radioactivity at the Greek Atomic Energy Commission. His main activities are:

- Environmental Radioactivity Monitoring: measurements of radioactivity in air, soil, water, foodstuff etc and compilation of data.
- Individual monitoring of exposed workers in the country: internal exposures
- NORMs: Inspection and licensing in facilities and workplaces with NORM activities
- Decommissioning of places with increased levels of naturally occurring radioactive materials.
- Emergency preparedness and response.
- Determination of clearance levels for different practices.
- Management of radioactive materials determined in scrap metal loads.
- Assessment of the environmental impact of NORM wastes to the environment.

He participates and coordinates several Research and Development Projects, as main researcher and he is (co)author of 40 publications in international scientific journals

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- [1] "Determining minimum alarm activities of orphan sources in scrap loads; Monte Carlo simulations, validated with measurements". Takoudis G, Xanthos S, Clouvas A, Potiriadis C
 Nuclear Instruments and Methods in Physics Research, Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 614 (1): 57-67 FEB 21 2010
- [2] "Decommissioning a phosphoric acid production plant: a radiological protection case study", Stamatis V, Seferlis S, Kamenopoulou V, Potiriadis C, Koukoulou V, Kehagia K, Dagli C, Georgiadis S, Camarinopoulos L, Journal of Environmental Radioactivity 101 (12): 1013-1023 DEC 2010
- [3] "Assessment of the occupational exposure at a fertilizer industry in the northern part of Greece". Potiriadis C, Koukoulou V, Seferlis S, Kehagia K Radiation Protection Dosimetry 144 (1-4): 668-671 MAR 2011
- [4] Greek "red mud" residue: A study of microwave reductive roasting followed by magnetic separation for a metallic iron recovery process, Samouhos, M; Taxiarchou, M; Tsakiridis, PE; Potiriadis, K, Journal of hazardous materials, Volume: 254, p. 193-205, JUN 15 2013.
- [5] "The COCAE Detector: An Instrument for Localization-Identification of Radioactive Sources".Lambropoulos CP, Aoki T, Crocco J, Dieguez E, Disch C, Fauler A, Fiederle M, Hatzistratis D, Gnatyuk VA, Karafasoulis K, Kosyachenko LA, Levytskyi SN, Loukas D, Maslyanchuk OL, Medvids A, Orphanoudakis T, Papadakis I, Papadimitriou A, Papakonstantinou K, Potiriadis C, Schulman T, Sklyarchuk VV, Spartiotis K, Theodoratos G, Vlasenko OI, Zachariadou K, Zervakis E, IEEE Transactions on Nuclear Science 58 (5): 2363-2370 Part 2, Oct 2011.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

- [1] "Identification, management and export for recycling of disused and orphan radioactive sources and materials" EEAE and Ministry of Development under EMII 20/6.12.2000 project of the Ministry of Environment; Budget: 1,367,000 Euros.
- [2] "Detection of radioactive scrap metal in the entrance of steel factories". (DG XI, European Commission)
- [3] "Cooperation across Europe for Cd(Zn)Te based Security Instruments" (FP7-SEC-2007-1).
- [4] "Decommissioning an abandoned phosphoric acid production plant"
- [5] "Strengthening the Capacity of the Radiation Protection and Nuclear Safety Regulatory Authority of Cyprus, Department of Labour Inspection of Cyprus. EC funding (Budget : 240,000 Euros)

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

EEAE is equipped with the following infrastructure which can be used in the framework of this proposal and especially in tasks 2 and 3:

1. Low background gamma spectrometry

EEAE is equipped with two low background gamma ray spectroscopic systems based on High Purity Germanium detectors (HPGe). The one is a p-type HPGe detector of relative efficiency 70% and the other a broad energy HPGe detector of relative efficiency 50%.

The measurements performed by EEAE with γ - spectrometry are accredited according to the requirements of the ELOT EN ISO/IEC 17025 standard.

2. Alpha spectrometry

Actinides (thorium, uranium, plutonium, americium and curium), as well as Polonium-210 and Radium-226, are isolated and measured by means of alpha spectrometry.

The measuring equipment used in EEAE's laboratory is a fully automated and integrated alpha spectroscopic system (Alpha Analyst, Canberra), consisting of 12 Passivated Implanted Planar Silicon (PIPS) detectors with 600 mm² active area.

EEAE with α - spectrometry in liquid samples are accredited according to the requirements of the ELOT EN ISO/IEC 17025 standard.

3. Liquid scintillation and gas flow detector to measure total α/β radiation

The total α/β measurements are performed by a gas flow proportional counter in anticoincidence quard G-M detection.

Low energy beta radionuclide emitters can be measured by a liquid scintillation counter of Quantulus type available in EEAE's laboratory.

This instrumentation could be used in the WP2 and WP3 of this proposal in complementarily with the previous ones.

4. In-situ measurements

In-situ measurements are usually included in the environmental radioactivity monitoring programme. In situ measurements are performed for the qualitative and the quantitative determination of a potential radiological contamination, the radiological inspection of scrap metals, the in-situ characterization of the materials and the characterization of places during decommissioning activities.

EEAE is equipped with four portable γ -ray spectroscopic systems based on germanium detectors of relative efficiency 10%, 20%, 35% and 35% and 5 NaI portable spectroscopic systems.

5. Secondary Standard Dosimetry laboratory (SSDL)

Maintaining the dosimetry standard for γ and X radiation and performing calibration of dosimetry equipment in the fields of radiation protection, radiotherapy and diagnostic radiology. Among others, the infrastructure includes Ge spectrometer for field measurements, characterization of radioactive material and material analysis.

6. In addition to the above methods, a pixelated CdTe detector is under development in the framework of a research project. This detector can provide information on the spatial distribution of the radioactive contamination.

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

N/A

	No	Name	Acronym
Participant	14	Empresa Nacional de Residuos Radiactivos S.A., S.M.E., M.P.	ENRESA
Description of the legal entity ENRESA is the Spanish radioactive waste management agency, with considerable experience in research and technological activities related to radioactive waste disposal and management of large industrial facilities and research programmes. ENRESA is a public company founded in 1985 by the Spanish Government for the management of radioactive wastes, including: • Design, construction and operation of facilities for the disposal of low-level waste (LLW), interim storage and final disposal of spent fuel, vitrified high-level waste and intermediate-level waste (SF/HLW/ILW). • Decommissioning of nuclear facilities, including nuclear power plants (NPP). • Drafting the R&D plans to cover the needs of the concepts and technical solutions for managing the radioactive wastes and SF in Spain. • Managing the Fund to cover the previous activities.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks WP DONUT: ENRESA, together with others WMO and one TSO, will prepare benchmarks from the point of view of the implementers and evaluators (task 5). These organisations and their partners participate in most of other work-packages, and the work will be carried out in close cooperation with the linked WPs and the RE involved in this task. The prepared benchmarks will help to quantify how numerical methods developed in DONUT are relevant regarding current used methods, and to compare tools in which these methods are implemented. In order to make the benchmarks relevant for a large community they will address coupled processes representative in different kind host rocks (e.g. clay, crystalline rocks, salt). WP Spent Fuel Evolution: ENRESA will participate in the definition and verification of procedures to determine the source terms of SNF assemblies with realistic confident limits (task 2.4) and in particular in subtask 2.4.2. that considers the use of “state-of-the-art” codes. ENRESA, through ENUSA will also participate in subtask 2.2.2 “Nuclide inventory by radiochemical analysis of a set of BWR SNF samples”. WP HITEC. ENRESA will participate in Tasks 1 (subtask 1.2. State-of-the-art) and 4 (Subtask 4.1 – Guidance for safety case development and repository optimization) of this WP. WP UMAN: ENRESA will participate in Subtask 3.2 “Uncertainties on waste inventory and on the impact of predisposal steps”, Subtask 4.3. “Preferences of the different actors on uncertainty management options”. Experience in developing design and performing safety assessment to obtain site, construction and operation licenses of near surface disposal facility currently in operation in Spain that include uncertainty management will contribute to the WP. KM WPs. ENRESA is not directly involved in these WPs, nevertheless ENRESA may contribute to their development.			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Mrs. Elena Vico (female) studied Physics of Materials (Universidad Complutense of Madrid) and a Master on Environmental Engineering and Management (Escuela de Organización Industrial (EOI), Madrid). She has over 20 years’ experience in radioactive waste management activities within ENRESA, working in several positions. She is currently responsible of the Safety and Licensing department, being in charge of the coordination and supervision of the licensing of the ENRESA’s radioactive waste management facilities and decommissioning projects.			

At the international level, she has been a member of different committees and working groups at the EC, the OECD/NEA and the IAEA. She also participated in the CASSIOPEE Consortium and in the Club of Agencies, composed by different European WMO. She is member of the WG2 of ENSREG (European Nuclear Regulatory Group). At EURATOM R&D Programmes, she was involved in CARBOWASTE project.

Mrs Elena Vico will be responsible for ENRESA participation in the DONUT WP.

Mr. Enrique García-García (male) is an Industrial Engineer (Universidad de Oviedo –UNIOVI) and is in process of getting the PhD (Universidad Nacional de Educación a Distancia -UNED-, Spain). He joined ENRESA in 2015 and is currently working at the Safety and Licensing dept., representing the department in the working group on the activities concerning the deep geological disposal project. He will participate in DONUT WP.

Mr. Francisco Javier Fernández-López, (male) is M.Sc. Industrial Engineering (Focused on Energy Techniques) at Polytechnical University (UPM) - Madrid (Spain) & M.Sc. Civil Engineering (Focused on Physics) at Free University - Brussels (Belgium) (Double Degree Program). At present is Head HLW Eng. and R&D Dpt. at ENRESA. Previous roles at ATC Eng. Dpt. as Responsible for the Electrical and Mechanical Discipline within the ATC Project and at HLW Eng. Dpt. at ENRESA as Responsible for SNF storage and transportation R&D Projects. Previous jobs at Belgonucleaire and ABB.

Mr. Fernández López will be responsible for ENRESA participation in the WP Spent Fuel Evolution.

Mr. José María Gómez (male) earned his degree in Industrial Engineering with a M.Sc. in Nuclear Engineering by the Polytechnical University of Madrid (UPM) in Spain and a Research Master (former Diploma) in Fluid Dynamics by the von Karman Institute for Fluid Dynamics in Belgium. He was part of the Spanish bid to host the European Spallation Source acting as a neutronic analyst. Later, he worked in nuclear fuel thermal-hydraulics at ENUSA. Currently, he is working for ENRESA in the HLW Eng. and R&D Dpt., collaborating in several spent nuclear fuel characterization and storage projects.

Mr. Gómez will be involved in WP Spent Fuel Evolution.

Mrs. Ana Muñoz (female) studied Industrial Engineering (specialized in Metallurgy) at the Polytechnical University of Madrid (UPM) in Spain, with extensive additional training related to the nuclear sector (as HRP School and WNU Summer Institute). She has over 15 years' experience in nuclear fuel working at ENUSA in the design and manufacturing areas as well as in R&D programs related to the fuel behavior, specially devoted in the last years to the spent fuel performance during storage and transportation. At the international level, she has participated in the SCIP projects of OECD/NEA focused on the damage mechanisms in the cladding. She is currently working for ENRESA in the HLW Eng. and R&D Dpt., collaborating in several spent nuclear fuel performance and storage projects.

Mrs. Muñoz will be involved in WP Spent Fuel Evolution.

Mr. Juan Carlos Mayor (male) is Mining Engineer (School of Mines of the Polytechnic University of Madrid) and holds a M. Sc. degree in Civil Engineering (Stanford University). He has over 25 years working experience in the field of radioactive waste management. He is presently Senior Project Manager in charge of the R&D programme of the Site Engineering Dept. of the Spanish Radioactive Waste Management Company (ENRESA) in the fields of Rock Mechanics and Hydrogeology. Previously, he has been staff project engineer at CGS and GYA, two private Spanish consultancy companies in mining, geotechnical engineering and hydrogeology.

At the international level Mr. Mayor has maintained strong cooperation with many of the WMOs, particularly through the EURATOM programme, by participating and coordinating different R&D projects in various URLs (Mont Terri, Grimsel, Hades, Asse mine), including the just finished projects PEBS and MODERN. He is a member of the Steering Committees of the IGD/Technology Platform, Mont Terri Project and Grimsel Test Site (Switzerland) and represents ENRESA at the NEA-IGSC working group on the Characterisation, the Understanding and the Performance of Argillaceous Rocks as Repository Host Formations. Mr. Mayor was member of the International Review Team involved in the NEA peer review of the post-closure radiological safety case produced by SKB (Sweden). He participated as well in various phases of the international DECOVALEX and INTRAVAL projects.

Mr. Mayor will be responsible for ENRESA participation in the WP HITEC.

Mrs. Inmaculada López (female) is M. Sc. Chemistry (Chemistry –Physics) (Autónoma University of Madrid) and holds Nuclear Engineering Master (Nuclear Energy Institute-CIEMAT). She has over 25 years working experience in the field of radioactive waste management. She is presently Head of LILW Engineered department of the Spanish Radioactive Waste Management Company (ENRESA). Formerly she was senior engineer in charge of the safety and licensing projects relating LILW and VLLW. Previously, she has been staff project engineer at Westinghouse, private Spanish engineering company. At the international level Mrs. Lopez has been a member of different IAEA Coordinated Research Projects and working groups at the IAEA. She also participates in the DISPONET IAEA Network, composed by different European WMO. She was a member of the ENRESA's expert group for the EC Twinning project "Radioactive waste management and reactor decommissioning". Mrs. López will be responsible for ENRESA participation in the WP UMAN.

Mrs. Sylvia De Gregorio (female) is M. Sc. Civil Engineer (Polytechnic University of Madrid). She has over sixteen years working experience in radioactive waste management. Now she is senior engineer at LILW engineering department at the Spanish Radioactive Waste company (ENRESA) being civil works responsible in the department since 2011 and Cabril's dam director since 2007 and working on the design, authorization and licensing of VLLW cells. In last years, she has worked on the design of the Centralised Interim Storage (ATC) installation for High Activity Radioactive waste. Previously she worked in two private engineering companies INIMA and INGEOTEC as engineer and as project coordinated or project manager. On an International level, she has worked on several radioactive waste installations design projects and collaborated with the IAEA in consultancies. She has also participated in international congresses organized by ENRESA.

Mr. Joaquín Farias Seifert, (male) is M.Sc. Mining Engineer (School of Mines of the Polytechnic University of Madrid). He has been working for SMM Peñarroya –España (1985-1989), Prephor & Cedesa (1989-1994), Geocontrol SA (1989, 1994-2005), AITEMIN (2005-2011) and ENRESA (2011-). He has been involved in ENRESA's R&D activities since 1994, being a member of the FEBEX (I & II) technical secretariat, and since 2004 he is involved in ENRESA's &D coordination, including the participation in EURATOM FW Programmes. He has been involved in several projects co-funded by the EC FEBEX I and II, NF PRO IP, ESDRED IP, PETRUS II, PETRUS III, etc. Mr. Farias has been the ENRESA's representative in the NEA initiative RK&M. Mr. Farias is responsible of R&D coordination in ENRESA. Mr. Farias will be involved in the WPs in which ENRESA is present, mainly in KM issues.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- SKI 2005. DECOVALEX III Project: Modelling of the FEBEX In-Situ Test. Task 1 Final report. SKI report 2005:20, 197 pp. ISSN 1104-1374.
- ENRESA 2006. FEBEX Project Updated Final report 1994-2004. Publicación Técnica ENRESA 05-0/2006. ENRESA, Madrid. 590 pp. ISSN 1134-380X.
- Mayor, J. C., García-Siñeriz, J. L., Alonso, E., Alheid, H.-J., Blümling, P. (2007a). Engineered barrier emplacement experiment in Opalinus Clay for the disposal of radioactive waste in underground repositories. – In: Bossart, P. & Nussbaum, C. (Eds.): Mont Terri Project – Heater Experiment, Engineered Barrier Experiment and Ventilation Experiment (p.115-179). – Rep. Swiss. Geol. Surv. 1.
- Mayor, J.C. and Velasco, M. (2014). EB dismantling synthesis report. Deliverable D2.1-8 of the PEBS Project.
- Zwicky, H.U. et al. (2010): Nuclide analysis in high burnup fuel samples irradiated in Vandellós 2. Journal of Nuclear Materials 402 (2010) 60-73.
- Lloret, M. et al. (2008): Results of thermal creep tests on highly irradiated Zirlo. Seoul 2008 Water Reactor Fuel Performance Meeting.
- Lloret, M. et al. (2012): Results of thermal creep tests on irradiated Zry2. Manchester 2012 TOP FUEL Meeting.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal • FEBEX I and II, which were projects with the aims of demonstrating the feasibility of manufacturing and assembling an engineered barrier system based on the Spanish SF disposal concept for a crystalline host rock and developing methodologies and models for assessment of the thermo-hydro-mechanical (THM) and thermo-hydro-geochemical (THG) behaviour of the engineered barrier system (near field). • NF-PRO (Understanding and Physical and Numerical Modelling of the Key Processes in the Near Field and their Coupling for Different Host Rocks and Repository Strategies, 6th FP), Components 1 to 5. • PAMINA (Performance Assessment Methodologies IN Application to Guide the Development of the Safety Case, 6th FP). The objective was to improve and harmonise methodologies and tools for demonstrating the safety of deep geological disposal of long-lived radioactive waste for different waste types, repository designs and geological environments. • MICADO (Model uncertainty for the mechanism of dissolution of spent fuel in a nuclear waste repository, 6th FP) focussed on assessing the uncertainties in models describing the dissolution mechanism of spent nuclear fuel in a repository for geological time periods. • The PEBS project (7th FP) aimed at evaluating the sealing and barrier performance of clay-based EBS over time, through development of a comprehensive approach involving experiments, model development and consideration of the potential impacts on long-term safety functions. • The CAST project (CARbon-14 Source Term) (7th FP): Their objective was to develop understanding of the generation and release of ¹⁴C from radioactive waste materials under conditions relevant to waste packaging and disposal to underground geological disposal facilities. The project will focus on releases from irradiated metals (steels, Zircalloys) and from ion-exchange materials as dissolved and gaseous species.
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task N/A

	No	Name	Acronym
Participant	15	Forschungszentrum Jülich	JUELICH
Description of the legal entity Forschungszentrum Jülich (JUELICH) makes a vital contribution to solving major challenges facing society in the fields of information, energy, and bioeconomy. It focuses on the future of information technologies and information processing, complex processes in the human brain, the transformation of the energy system, and a sustainable bioeconomy. Forschungszentrum Jülich develops simulation and data sciences as a key research method and makes use of large, often unique, scientific infrastructures. Its work spans a range of topics and disciplines and it exploits synergies between the research areas. With some 5,600 employees, Jülich – a member of the Helmholtz Association – is one of Europe's large research centres. The work program within EURAD will be performed in the Institute for Energy and Climate Research – Nuclear Waste Management and Reactor Safety (IEK-6), making use of the knowledge acquired during the last 50 years on safety issues regarding nuclear waste management and reactor safety.			
Institute for Energy and Climate Research – Nuclear Waste Management (IEK-6) contributes to the Helmholtz program NUSAFE and focuses on topics related to the safe management of nuclear waste and international safeguards as well as reactor safety. The safe management of radioactive waste and its final disposal in a deep geological repository is one of the grand challenges of our times and an integral part of the German “Energiewende”. The related research is multidisciplinary – while IEK-6 research mainly considers nuclear aspects, it addresses the behavior of radionuclides and the relevant waste form materials by combining radio-, geo- and materials chemistry aspects and by integrating experiment and simulation. Research covers the complete chain from waste generation to waste disposal including in particular: (1) Research in support of the long-term safety for deep geological disposal with a focus on repository near-field incl. waste forms, barrier materials and in particular secondary alteration phases (source term), (2) Research on unresolved issues prior to waste disposal e.g. pre-disposal: waste treatment, conditioning, decontamination/hydrometallurgical separation chemistry, with a strong emphasis on special radioactive wastes for which up to now no management solutions have been developed and (3) Research on international safeguards, incl. scientific coordination of the German IAEA Safeguards Support Program and qualification for IAEA Network of Analytical Laboratories. IEK-6 operates radiochemistry laboratories and is strongly linked to the Ernst Ruska-Centre, ER-C, to the Helmholtz Nanofacility with atom probe tomography, to the Jülich Supercomputer Centre, JSC, and the Central Institute for Engineering, Electronics and Analytics, ZEA. Future research will focus on reactive mass transport phenomena at chemically perturbed interfaces within a repository, the further development of solutions for radioactive special wastes and of analytical methods for nuclear safeguards and security applications.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks JUELICH (IEK-6) will contribute to EURAD on several levels. Within WP FUTURE, JUELICH-IEK-6 will serve as the WP Coordinator and also contribute to the technical RD&D. In WP ACED, JUELICH-IEK-6 will serve as co-task leader and perform RD&D. In WPs CORI and DONUT, JUELICH-IEK-6 will contribute to the RD&D program. Additional activities are related to the Strategic Study ROUTES. Given the high level of technical expertise at JUELICH-IEK-6 in all the fields relevant for the proposed work in EURAD, and the broad experience in coordinating national and international RD&D, JUELICH-IEK-6 is fully able to carry out the work proposed within EURAD.			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Prof. Dr. Dirk Bosbach (male) is an expert in radiochemistry and nuclear materials., with almost 20 years practical experience of R&D in the field. Prof. Bosbach joined JUELICH in 2009 and is director of the			

Institute of Energy and Climate Research, responsible for JUELICH'S R&D program on nuclear waste management. He has been involved in various national and international collaborative projects related to nuclear waste management and served as WP leader in the EC funded projects FUNMIG, SKIN and DISCO.

Dr. Guido Deissmann (male) is an expert in geochemistry/mineralogy with more than 20 years experience related to various aspects of radioactive waste management, such as waste form performance, radionuclide migration and reactive transport modelling, and safety assessments for nuclear waste disposal. Dr. Deissmann joined JUELICH in 2013 as senior scientist after 17 years of scientific consulting. He has been and is involved in various national and international collaborative R&D projects related to nuclear waste management and geological disposal such as the EC funded projects CEBAMA, DISCO and THERAMIN.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- Vinograd, V. L., Brandt, F., Rozov, K., Klinkenberg, M., Refson, K., Winkler, B., Bosbach, D. 2013. Solid–aqueous equilibrium in the BaSO₄–RaSO₄–H₂O system: First-principles calculations and a thermodynamic assessment. *Geochimica et Cosmochimica Acta* 122, 398-417.
- Guo, X., Szenknect, S., Mesbah, A., Labs, S., Clavier, N., Poinssot, C., Ushakov, S.V., Curtius, H., Bosbach, D., Ewing, R.C., Burns, P.C., Dacheux, N., Navrotsky, A. 2015. Thermodynamics of formation of coffinite, USiO₄. *Proceedings of the National Academy of Sciences of the United States of America* 112, 6551-6555.
- Poonosamy, J., Kosakowski, Van Loon, L.R., Mäder, U. 2015. Dissolution– precipitation processes in tank experiments for testing numerical models for reactive transport calculations: Experiments and modelling. *Journal of Contaminant Hydrology* 177/178, 1-17.
- Weber, J., Barthel, J., Brandt, F., Klinkenberg, M., Breuer, U., Kruth, M., Bosbach, D. 2016. Nano-structural features of barite crystals observed by electron microscopy and atom probe tomography. *Chemical Geology* 424, 51-59.
- Lange, S., Kowalski, P., Pšenička, M., Klinkenberg, M., Rohmen, S., Bosbach, D., Deissmann, G. 2018. Uptake of ²²⁶Ra in cementitious systems: A complementary solution chemistry and atomistic simulation study. *Applied Geochemistry* 96, 204-216.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

EC projects:

SKIN (FP7): Collaborative project on “Slow Processes in Close-to-Equilibrium Conditions for Radionuclides in Water/Solid Systems of Relevance to Nuclear Waste Management”. January 2011 – December 2013 (WP leader).

FIRST NUCLIDES (FP7): Collaborative project on “Fast / Instant Release of Safety Relevant Radionuclides from Spent Nuclear Fuel”. January 2012 – December 2015.

CEBAMA (Horizon 2020): Collaborative project on “Cement-based materials, properties, evolution, barrier functions”. June 2015 – May 2019.

DISCO (Horizon 2020): Collaborative project on “Modern Spent Fuel Dissolution and Chemistry in Failed Container Conditions”. June 2017 – May 2021(WP leader).

National (German) projects:

VESPA I & II (BMW): Collaborative project on “Behaviour of Long-Lived Fission and Activation Products in the Near-field of a Nuclear Waste Repository and the Possibilities of their Retention”. July 2010 – June 2013 & September 2017 – August 2020.

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

IEK-6 radiochemistry laboratories are fully licensed to handle radioactive materials and equipped with all necessary infrastructures to perform the proposed experimental work. This includes alpha glove boxes, inert gas alpha glove boxes and radionuclide laboratories. State-of-the-art analytical instruments and methods and advanced spectroscopic/diffraction tools exist for the sensitive detection and analysis of radionuclides and related materials. Trace element and isotope analysis is made by instrumental analytical techniques such as ICP-mass spectrometry. Nuclear chemical analyses via alpha-spectrometry, liquid scintillation and gamma-spectroscopy are available. Methods for characterisation of (radioactive) materials such as X-ray diffraction (XRD – powder and single crystal) and Rama-microscopy are installed. A modern environmental scanning electron microscope (ESEM) as well as a state-of-the-art FIB instrument for the preparation of radioactive sample for subsequent TEM and ATP analysis are available in the radiochemistry laboratories. JUELICH operates the Ernst Ruska Centre for Microscopy and Spectroscopy with Electrons, the Helmholtz Nanofacility, and the Central Laboratories for Engineering and Analytics providing dedicated cutting-edge analytical facilities in JUELICH. IEK-6 has established for many years a close collaboration within this framework. IEK-6 also uses different codes for multiphysics, geochemical and reactive transport modelling like iCP COMSOL-PHREEQC, openGeoSys/GEMS and PFLOTRAN amongst others, using the High Performance Computing facilities in JUELICH at the Jülich Supercomputing Centre. Furthermore, at IEK-6 atomistic simulation complements the experimental activities mainly using the DFT codes QUANTUM ESPRESSO and CASTEP, among others.

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task

All required operational capacity to carry out the work proposed by JUELICH within EURAD is fully available.

	No	Name	Acronym
Participant	16	Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH	GRS
Description of the legal entity The Gesellschaft für Anlagen- und Reaktorsicherheit (GRS gGmbH) is a non-profit organization which deals with technical-scientific research and provides expertise. The company administers interdisciplinary knowledge, progressive methods and qualified data. GRS was established as a business in January 1977. The headquarters are in Cologne, other locations include: Berlin, Braunschweig and Garching nearby Munich. Currently, there are approximately 450 employees at GRS, 350 of whom work in the technical-scientific sector. GRS is financed by contracts and the present annual volume of contracts is worth 53 million €. In the working field “Waste Management”, GRS is the only institution in Germany with comprehensive interdisciplinary expertise in this wide range of tasks. GRS has the relevant knowledge and experience in the field of disposal of radioactive and chemotoxic waste as well as in the assessment of safety-related questions. The instruments and methods necessary for a safety-analytical assessment have been developed and qualified within the framework of research activities over many years. The participation in committees and co-operation activities, as well as the presentation of the work in international scientific forums ensures the required state of the art in science and technology about expertise and development of procedures. In the Cologne division of GRS, the department of Waste Management Safety supports the authorities and ministry with expertise as Technical Support Organization (TSO). In the Braunschweig division of GRS, the Repository Safety Research department carries out research and develops methods that are essential to the verification of the long-term safety disposal of radioactive and toxic chemical wastes in geological formations. The division is divided into two departments: the Long-Term Safety Analysis department and the Process Analysis department, working in conjunction with an on premises geo-scientific lab. The competence fields “Waste Disposal”, “Assessment of Long-term Safety”, “Geochemical Research”, “Research in Underground Laboratories” and “Geochemical and Geotechnical Laboratory” are mainly oriented towards safety analyses and geosciences as a Research Entity (RE). Priority is given to the development of methods and instruments for the performance of safety analyses and experimental research on the examination of waste disposal concepts and the provision of data and models that are relevant regarding safety in the long term.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks GRS is participating in the work packages DONUT and ROUTES as TSO. GRS is also participating in the work packages DONUT, FUTURE, GAS and UMAN as RE. The general competencies of GRS are given in the description of the organisation.			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities			
BECKER, Dirk-Alexander (male) Studies: Physics Diploma and PhD in Physics Senior Expert and project leader at the Repository Safety Department of GRS gGmbH since 1995. Main topics of work: modelling of long term safety of repositories, uncertainty management and sensitivity analysis.			
BRACKE, Guido (male) Studies: Chemistry, Geochemistry, Mineralogy Diploma in Chemistry, PhD in Geochemistry and Mineralogy Senior Expert and project leader at the Department for Waste Management Safety of GRS gGmbH since 2007. Main topics of work: Radioactive waste management, Long term safety of repositories, Waste management regulatory framework.			
KAUFHOLZ, Peter (male)			

Studies: Chemistry, Nuclear Applications, Actinide partitioning
Bachelor's in chemistry, Master in Nuclear Applications, PhD in nuclear fuel chemistry
6 years of experience in the field of radioactive waste management and separation technology.
Main topics of work: Radioactive waste processing and chemistry, Spent fuel behavior in dry storage.

NOSECK, Ulrich (male)

Studies: Chemistry
Diploma in Chemistry, PhD in Physical Chemistry
Senior Expert and project leader at the Department for Site Selection of GRS gGmbH since 1995.
Main topics of work: Safety Case and long term safety assessment for repositories, Geochemical and transport modelling.

RÜBEL, André (male)

Diploma and PhD in Physics
Senior Expert and project leader at the Repository Safety Department of GRS gGmbH since 2001.
Main topics of work: Long term safety of repositories, transport modelling.

BRITZ, Susan (female)

Studies: Geoecology,
Diploma and PhD in Geoecology
Scientist at the Department for Site Selection of GRS gGmbH since 2012
Main topics of work: Experimental and numerical studies of geochemical and transport processes, long term safety assessments for repositories.

ZHANG, Chun-Liang (male)

Studies: Mining engineering (diploma). PhD in geotechnical engineering
Senior expert and project leader at the Repository Research Department of GRS gGmbH since 1995. Main topics of work: experimental and numerical analysis of thermo-hydraulic-mechanical coupling processes in different host rocks, buffer and backfill material

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- Bracke, G., Charlier, F., Liebscher, A., Schilling, F., Röckel, T.: Does Deep Borehole Disposal of HLRW has a Chance in Germany?, atw - Internationale Zeitschrift für Kernenergie, Bd. 62, Nr. 1, S. 46–53, 2017.
- Guido BRACKE, Fischer-Appelt K. (2015) Methodological Approach to a Safety Analysis of Radioactive Waste Disposal in Rock Salt: An Example, Progress in Nuclear Energy, 84, 79-88.
- DOPAS: Demonstration of Plugs and Seals EC-GA#323273 including four collaborative projects with BMWi /PTKA i. e. LAVA, LASA, THM and PASS, 1.9.2012 – 31.08.2016
- MOSEL: Investigation of Modern Methods of Probabilistic Sensitivity Analysis of Final Repository Performance Assessment Models (collaborative project, BMWi/PTKA, 01.05.2011-31.12.2016)
- WEIMAR: Further Development of the Smart-Kd-Concept for Long Term Safety analyses (collaborative project, BMWi/PTKA, 01.06.2017-28.02.2018)
-

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

- EU project MICADO : SUBATECH (Grambow B.), AMPHOS (Bruno J., Duro L., Merino J., Tamayo A.), ANDRA (Martin C., Pepin G., Schumacher S.), BELV (Smidt O.), CEA (Ferry C., Jegou C.), CIEMAT (Quinones J., Iglesias E., Rodriguez Villagra N., Nieto J. M.), ENRESA (Martínez-Esparza A.), FZK•INE (Loida A., Metz V., Kienzler B.), GRS (BRACKE G.), IRSN (Pellegrini D., Mathieu G.), JRC-ITU (Wegen D.), KTH (Jonsson M.), NAGRA (Johnson L.), SCK.CEN (Lemmens K.), SSM (Liu J.), STUDEVIK (Ekeröth E.), UPC (Casas I., de Pablo J.), Quintessa (Hodgkinson D.) (2010) FINAL Project Report: MICADO - Model uncertainty for the mechanism of dissolution of spent fuel in nuclear waste repository, European Commission, Sixth

Framework Programme Priority No. Nuwaste-2005/6-3.2.1.1-2. • EU project RECOSY: https://cordis.europa.eu/result/rcn/140458_en.html • VSG: Preliminary Safety Analysis of the Gorleben site (https://www.grs.de/vorlaeufige-sicherheitsanalyse-gorleben-vsg) • DOPAS: Demonstration of Plugs and Seals EC-GA#323273 including four collaborative projects with BMWi /PTKA i. e. LAVA, LASA, THM and PASS, 1.9.2012 – 31.08.2016 • MOSEL: Investigation of Modern Methods of Probabilistic Sensitivity Analysis of Final Repository Performance Assessment Models (collaborative project, BMWi/PTKA, 01.05.2011-31.12.2016) • WEIMAR: Further Development of the Smart-Kd-Concept for Long Term Safety analyses (collaborative project, BMWi/PTKA, 01.06.2017-28.02.2018)
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; geotechnical and geochemical laboratory
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task. N/A

		Name	Acronym
Participant	17	Ignalinos Atomine Elektrine	IAE
Description of the legal entity The state enterprise Ignalina Nuclear Power Plant - <i>Ignalinos Atomine Elektrine</i> (IAE) is carrying out the decommissioning of NPP, construction and operation of storage facilities and repositories for VLLW, LILW, SF (including DGR construction). It includes the operation of key systems that ensure nuclear, radiation and fire protection, as well as physical safety at the INPP, the unloading of spent nuclear fuel from power units and its transportation to the Interim Spent Fuel Storage Facility, equipment and building decontamination and dismantling, and radioactive waste treatment and storage. The INPP decommissioning is set to be completed by 2038.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks IAE is mainly involved in WP10-ROUTES and more specifically Task 2.1 and Task 4.1.			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Mr. Viktor Ognerubov NSR project manager. 13 year experience in the research activities related to Nuclear engineering safety at Kaunas university of technology, and Lithuanian Energy Institute on thermal-hydraulics and transient accidents, severe accident analysis. 5 years experience and Ignalina NPP as RAW management strategy development and project management of NSR and involvements of national RAW development program preparation, member of supervisory group of DGR project implementation. Experience in approval of NSR project by state institution, licensing process etc.			
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content Implemented and projects under implementation at Ignalina NPP. See list of : completed projects: https://www.iae.lt/en/activity/decommissioning-projects/completed-projects/ current projects: https://www.iae.lt/en/en/activity/decommissioning-projects/current-projects/			
a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal Dismantling of equipment in various buildings of INPP. Implementation of project related to SF and RAW storage facilities See list of : completed projects: https://www.iae.lt/en/activity/decommissioning-projects/completed-projects/ current projects: https://www.iae.lt/en/en/activity/decommissioning-projects/current-projects/			
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; See list of Ignalina NPP projects: completed projects: https://www.iae.lt/en/activity/decommissioning-projects/completed-projects/ current projects: https://www.iae.lt/en/en/activity/decommissioning-projects/current-projects/			
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task. See list of : completed projects: https://www.iae.lt/en/activity/decommissioning-projects/completed-projects/ current projects: https://www.iae.lt/en/en/activity/decommissioning-projects/current-projects/			

Participant	No	Name	Acronym
	18	Instytut Chemii i Techniki Jadrowej	INCT (ICHTJ)
Description of the legal entity The Institute of Nuclear Chemistry and Technology is the most recognised institution in Poland in the fields of nuclear chemistry, radiochemistry, radiation chemistry, nuclear chemical engineering and technology. The other fields of the INCT's expertise include application of nuclear methods in material engineering and process engineering, radioanalytical techniques, design and production of measurement instruments based on nuclear techniques, environmental research, radiobiology and radioprotection. The results of research performed at the INCT have already been implemented in various branches of the national economy, particularly in industry, medicine, environmental protection and agriculture. With nine electron accelerators in operation and with a staff experienced in the field of electron beam application, the INCT is one of the most advanced centres of science and technology in this domain. The Institute has four pilot plants equipped with six electron accelerators: for radiation sterilization of medical devices and tissue grafts; for radiation modification of polymers; for removal of SO₂ and NO_x from flue gases and for food hygienisation. The Institute trains international atomic energy agency's fellows and plays a leading role in agency regional projects. Because of its achievements, the INCT has been nominated "the IAEA's collaborating centre in radiation technology and industrial dosimetry". Its expertise and infrastructure was the basis for participation in several EURATOM, FP7 and Horizon2020 grants. The organization is preparing to play a role of TSO in the Polish nuclear energy programme, offering the expertise in: – Radioprotection and biological dosimetry; – Radioactive waste treatment and disposal; – Coolant and fuel chemistry; – Novel nuclear fuel cycles (including GENIV reactors) – front and back end; – Materials for present and novel reactor systems; – Environmental monitoring of nuclear facilities; – Measurement and control devices for NPPs and nuclear laboratories; – Education and training of the staff; – Public information; – Collaborative projects with stakeholders offering interaction between "the technical and the social" approaches. The INCT works in a consortium of Polish institutions developing the project of the selection of a site for a new near-surface repository for low and intermediate radioactive waste and on the scenario of closing up present repository in Rozan.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks As an organization with the mandate of the Ministry of Energy, the Institute of Nuclear Chemistry and Technology represents the Ministry and Polish stakeholders in the tasks of this proposal. The INCT will mainly work in Strategic Study WP "Waste management routes in Europe from cradle to grave (ROUTES)" providing all necessary information in the national context of radioactive waste management. The INCT will contribute to elaboration of this strategy collecting the existing state-of-the arts methods for characterization, treatment and disposal, especially for problematic waste and identifying future requirements of implemented technologies. As a mandated actor the INCT will disseminate the project results among stakeholders in Poland; evaluate the possibilities of implementation of the studied methods in the program of development of new RW repositories in Poland.			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities <i>Grazyna Zakrzewska-Koltuniewicz</i>, (F), DSc, PhD, Professor at the Institute of Nuclear Chemistry and Technology, a specialist in radiochemistry and nuclear chemistry. She supervised many national and international research projects concerning radioactive waste treatment, fuel cycle and separation of isotopes.			

Prof. Zakrzewska was a coordinator of Marie Curie ToK project in FP6 „Advanced Methods of Environment Research and Control” (AMERAC). She represented INCT as a partner, in several EURATOM projects, like IPPA, NEWLANCER, EAGLE, and CHANCE. She worked as an expert in projects related to siting the new repository for low and intermediate level radioactive waste and to the plan of closing up the old Rozan repository. She wrote over 139 scientific papers and was granted 10 patents. Prof. Zakrzewska is a representative of Poland in Radioactive Waste Management Committee of NEA and in Article 37 of EURATOM expert group. She also acts as elected President of Polish Nuclear Society.

Agnieszka Miskiewicz (F), PhD, chemist specialising in radioactive waste processing and separation methods for nuclear and environmental applications. She participated in several research projects concerning radioactive waste, among others EURATOM projects related to the public involvement in radioactive waste management decision-making processes, like IPPA and PLATENSO, and IAEA CRPs. She has also supervised the projects concerning radioactive waste management and nuclear methods application financed from the national funds.

Katarzyna Kiegiał (F), PhD in chemistry at University of Warsaw, The Faculty of Chemistry, (1998); scientific assistant at University of Warsaw, the Faculty of Chemistry (1998-2000); Postdoctoral position at University of Kentucky, Department of Molecular and Cellular Biochemistry, Lexington, KY USA (2000-2001). She has a position of senior specialist at the Institute of Nuclear Chemistry and Technology, Warsaw, since 2011. At present she works in the field of uranium chemistry and new extracting agents for actinides; she is a specialist in separation process like solvent extraction and solid-liquid extraction. She participated in research projects, financed from structural and EC funds, as well as EURATOM projects like NEWLANCER and ARCADIA.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

1. Grazyna Zakrzewska-Trznadel, Advances in membrane technologies for the treatment of liquid radioactive waste, Desalination, 321 (2013) 119-130.
2. Wioleta Olszewska, Agnieszka Miskiewicz, Grazyna Zakrzewska-Koltuniewicz, Leszek Lankof, Leszek Pajak, Multi-barrier system preventing migration of radionuclides from radioactive waste repository, Nukleonika 2015;60(3);557-563.
3. Grazyna Zakrzewska-Koltuniewicz, Advancement in Membrane Methods for Liquid Radioactive Waste Processing: Current Opportunities, Challenges, and the Global Scenario. In: Handbook of Membrane Separations, Chemical, Pharmaceutical, Food and Biotechnological Applications, Second Edition, ed. by A.K. Pabby, S. S.H. Rizvi, A.M. Sastre, CRC Press Taylor & Francis Group (2015), Pages 665-708.
4. Method of obtaining and separating valuable metallic elements, specifically from low-grade uranium ores and radioactive liquid wastes, (G. Zakrzewska-Trznadel, A. Jaworska-Sobczuk, A. Miskiewicz, W. Lada, E. Dluska, S. Wronski) EP2604713, 2015.
5. Claire Mays, Jaroslav Valuch, Chiara Condry, Agnieszka Miskiewicz, Grazyna Zakrzewska, Marin Constantin, Daniela Diaconu, Irena Daris, Metka Kralj, Nadja Železnik, Tanja Perko, Looking for citizen-centered communication: Dialogues between radiological protection or nuclear safety specialists and media professionals, J. Radiol. Prot. **36** (2016) S143–S159.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

1. 2012-2015 Strategic Research Project: Technologies supporting the development of safe nuclear energy, Research Task. No 4: Development of technologies supporting the management of spent fuel and radioactive waste, Hybrid processes in the treatment of radioactive wastewater, financed by the National Centre for Research and Development.
2. 2011-2013 Project FP7-269849 Euratom, Implementing Public Participation Approaches in Radioactive Waste Disposal (IPPA)
3. 2013-2016 Safety of Actinide Separation processes (SACSESS)
4. 2013-2017 Development of safety assessment methodology and selection of optimum location of shallow repository for low and medium radioactive waste, Project financed by the Ministry of Economy.
5. 2017-2021 Horizon 2020, Characterization of conditioned nuclear waste for its safe disposal in Europe (CHANCE)

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

The INCT possesses the infrastructure relevant to the performed R&D activities. The main infrastructure consists of 9 electron accelerators, radiochemistry laboratories equipped with hot cell and glove boxes, technological halls with pilot installations (research installations for nuclear materials and radioactive waste processing), high activity gamma sources, EPR spectrometers, dosimetry systems, pilot plant for flue gas treatment, Single crystal X-ray diffractometer, TGA-DTA analysers, TOC analysers, Isotope Ratio MS, ICP-MS ELAN DRC II, liquid chromatographs (HPLC PERKIN ELMER, HPLC, Shimadzu), gas chromatographs, ion chromatographs, atomic absorption spectrometers, spectrophotometers UV-Vis, liquid scintillation alpha and beta counters, HPGe detectors, gamma counters, Multi-channel gamma analysers, Thin layer chromatography analysers (TLC) with radiometric gamma detector, Electron microscopes, autoclaves, laminar chambers, etc.

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

N/A

	No	Name	Acronym
Participant	19	<i>Institut de Radioprotection et de Sûreté Nucléaire</i>	<i>IRSN</i>
Description of the legal entity			
The IRSN is a French public establishment of an industrial and commercial nature placed under the joint authority of the Ministries of the Environment, Health, Industry, Research and Defence. The IRSN's field of expertise covers all of the risks related to ionising rays used within industry or medicine, or even natural radiation rays. More precisely, the IRSN carries out missions relating to analysis and research in the following fields: the safety of nuclear installations, including those relating to defence; the safety of the transport of radioactive and fissile materials; the protection of man and the environment against ionising rays; the protection and control of nuclear materials and products likely to be used in the manufacture of weapons and the protection of installations and transport against acts of malevolence (theft or misappropriation of nuclear materials, or even sabotage). The research activities, most often carried out within the framework of international programmes, allows IRSN to maintain and develop its expertise. IRSN was involved in or coordinated several EC FP projects on waste safety (EVEREST, SPA, NFPRO, BENIPA, PAMINA, MICADO, FORGE, SITEX, JOPRAD).			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks			
- PMO WP: IRSN will participate in the PMO during the first 2,5 years (3 pm) - ACED WP: IRSN will participate (as task leader) in the task 2.			
The objective of the task 2 is to provide geochemical and coupled reactive transport models for assessing chemical evolution at steel/clay material and steel/cement material interfaces in terms of corrosion rates, geochemical alterations and physical alterations. These models will provide the bases of the up-scaling to waste package (Task 3) and near-field (Task 4) modelling. IRSN will work on a new in situ collaborative experiment (BACUCE) in the URL of Tournemire to study the interface between ambient temperature and 80°C between grout cement/CEM I and carbon steel cylinder until three years of interaction (with Mines Paris Tech, SUBATECH and ZAG). One of the focus points is on the influence of an imperfect contact.			
The BACUCE experiment started in 2017 to study the steel corrosion in contact with a cementitious environment (CEM I and grout cement) in a temperature range between 14°C and 80°C under the influence or no of bacterial activity and the influence of the interface quality. The first experiments were started in laboratory. New experiments will be start in in situ conditions in October 2018 at ambient temperature and 2019 at 80°C.			
The objectives of IRSN in ACED WP are: i/ to identify the corrosion speed of C-steel in alkaline and low alkaline environment and the influence of heterogeneities; ii/ to provide robust data for chemical model of the type of corrosion products and mineralogical evolution of cement materials with respect to temperature and spatial heterogeneity; iii/ to calibrate and refine the corrosion rates of steel under slightly alkaline conditions with respect to temperature and heterogeneities.			
- GAS WP: IRSN will participate in the work towards main objectives of this WP: ✓ <i>To improve the mechanistic understanding of gas transport processes in natural and engineered clay materials, their couplings with the mechanical behaviour and their impact on the properties of these materials;</i>			
IRSN will use its Lattice Boltzmann Model to study pore scale diffusion close to saturation with/without sorption to complete experimental results and deliver an interpretation basis with a strong link to the microstructure of materials. This work will also benefit from the previous work on development of 3D automatic segmentation mineral phases and pores in imaging data.			
The IRSN's Smoothed Particle Hydrodynamics code takes advantage of 3D images of material microstructure and is able to treat the mechanical deformation of the solid phase interacting with a two phase flow. It will serve to simulate small scale experiments conducted to better understand the relation between the microstructure and creation of dilatant pathways of gas in water saturated argillite.			

New gas injection in existing mock-up experiments will be performed on bentonite mixtures presenting an initial heterogeneous structural distribution, induced by the installation process, in order to investigate the effect of structural heterogeneities on gas transport processes. The samples will be subjected to hydraulic and gas loadings, both asymmetric to mimic real saturation scenario of shaft sealing systems: rapid increase of water pressure on top and independent control of lateral hydraulic boundary conditions and bottom gas pressure increase. In parallel a complementary cell in PMMA will be used to perform a microstructural analysis of the mixture at initial state and during gas /water injections by X-ray micro-tomography.

- ✓ *To evaluate the gas transport regimes that can be active at the scale of a geological disposal system and their potential impact on barrier integrity and repository performance.*

Based on previous experience in development of codes and simulations of gas migration within repository (participation in numerical benchmark in EC project FORGE), IRSN will construct, implement and use an extended 2-phase flow model for simulation of scenarios to be proposed within this project with the aim of increasing the predictivity of numerical simulations and reducing the gap between experimental data and ad-hoc parameters fits.

- DONUT WP: IRSN will participate in the task 2.

The goal of this task is to design and implement efficient numerical algorithms taking advantage of the latest research achievements for solving complex coupled problems. IRSN will participate to this task in developing numerical model aiming at improving physical representations of gas migration in porous media. This work will be focused on processes usually neglected in these models, such as hysteresis on relative permeability and retention curve, gas entry pressure in 2-phase-flow formula, hydro-mechanical behavior of interfaces at seals. The relevant processes among these will be implemented in THGas representations at large scales.

- UMAN WP: In the Task 2 related to Strategies, approaches and tools, IRSN will by notably share their experience with uncertainty and sensitivity analysis methods (subtask 2.3).

In the Task 3 of Characterization and significance of uncertainties for different categories of actors, IRSN will collect and synthesize relevant information on uncertainties associated with the site and geosphere. IRSN will notably have the ground to share the French experience related to the siting phase for geological and near-surface disposal projects (subtask 3.3).

For the Task 5 on Interactions between all categories of actors, in the subtask 5.1 of Preparation, support and reporting of pluralistic analyses, IRSN will be leader of Topic 2 related to Pluralistic analysis of uncertainty pictures. Thanks to the two hats profiles -both researcher and expert in safety assessments- of the IRSN participants as well as their experience in terms of dialog with Civil Society (through the French disposal project of Cigéo and through the SITEX European projects), IRSN will coordinate the development of materials to be discussed in two seminars and will lead the development of deliverable 5.2. IRSN will also take part to Topic 4 related to the Methods for a pluralistic assessment of uncertainties, contributing to the development of proposals of methods for a pluralistic assessment of uncertainties and to the development of deliverable 5.4.

- ROUTES WP:

IRSN will lead and coordinate the WP and will participate to the tasks 1, 2, 3, 4 and 6.

In this WP, IRSN will exchange on views, practices and radioactive waste management options available or not and bring the French experience. IRSN will share its feedback of safety relevant issues on waste management not only for disposal but also for pre-disposal including characterisation, treatment, conditioning and storage. Moreover, IRSN is involved in the assessment of the retrieval and conditioning processes for legacy waste which are of interest for a lot of countries involved in ROUTES WP.

a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities

Dr. **Delphine Pellegrini** holds a PhD in physico-chemistry from the University of Besançon, (France). In 1997, she joined IRSN as an engineer and was in charge of research and safety assessment related to

geochemical issues in the framework of geological disposal of radioactive waste. Then she was the technical lead of the review of the Dossier 2005 developed by the French waste management organisation for geological disposal of waste in clay. From 2007 to 2013, she was the manager of the Safety Assessment and Research Section for Radioactive Waste Disposal Facilities. She supervised in the last years several safety reviews and technical expertise for surface or geological disposal facilities. She was also deeply involved in EC-SITEX project (2012-2013) and was the coordinator of EC-SITEX II project (2015-2017). Before that, she took part in several EC projects (BENIPA, NF-PRO, PAMINA, MICADO) including as a WP Leader within the FORGE project (2009-2013) and contributed to AIEA consultancies related to waste disposal. She is currently the IRSN head of the Department for Radioactive Waste and Transfers in the Geosphere. She is also the president of the association called SITEX_Network in charge of enhancing and fostering cooperation at the international level in order to achieve a high quality expertise function in radioactive waste management.

Mrs. **Elisabeth Salat** has more than 20 years' experience in the field of radioactive waste management. She is a physic engineer who graduated from the University of Clermont Ferrand. She worked 5 years as safety engineer on near surface disposal at the French national agency for radioactive waste management (ANDRA). She then joined the CEA (French nuclear research organization) and participated as project manager in several RWM projects. She was also engaged in programming and managing the dismantling projects at CEA facilities. She is currently deputy head of department for radioactive waste and transfers in the geosphere, in IRSN. She is responsible for supervising IRSN safety assessments of radioactive waste disposal and of all types of activities in relation with waste management (treatment, containment...). She was involved in the EC project JOPRAD (2015-2017) in particular in the conditions for implementing a join programme. She will be involved in the PMO from Month 1 to Month 30.

Dr **Alexandre Dauzères** holds a PhD in Geoscience and Physico-Chemistry of Material from University of Poitiers and CEA. He joined IRSN in 2010 after his thesis to manage and develop the research activities on the material interactions (clay/concrete and clay/steel) with a multi-scale approach through in situ and lab exp. and reactive transport modelling. He managed 7 PhD students and 2 postdocs, especially in the concrete ageing research field. Since July 2017, he is Head of the Research Laboratory on Transfers and Interactions in Underground Environment (LETIS). The laboratory is in charge to conduct researches on the geological waste disposal to support the IRSN safety expertise. Alexandre currently evolves in the EC CEBAMA project.

Dr. **Muriel Rocher** holds a PhD in Tectonics from Paris VI University, Department Earth Science and Gaz de France. Since 2004 in IRSN as a nuclear safety engineer, she carries out both research projects and safety assessments related to geological and hydrogeological issues, including siting and seismic hazard, for low or high level–long lived waste disposal facilities (respectively shallow-surface and deep underground projects), and is involved in the development of the national guiding principles for siting of such waste disposal facilities. From 2009 to 2017, she was the main contact person for the on-site follow-up of the Andra's R&D in the Bure underground laboratory. She recently led the regulatory review of the Cigéo "Safety Option Dossier", submitted by Andra before the request for the construction license application and, in the same time, was involved in EC-SITEX projects.

Dr **Magdalena Dymitrowska** holds a master degree in physics and a PhD in physical chemistry from University of Orsay. In her previous experiences, she worked as a scientific and teaching collaborator for several academic institutions and specialized in modelling of physico-chemical phenomena at mesoscopic level (gas adsorption isotherms in nano-porous solids, elastic disorder in black rubber, localized corrosion). She joined IRSN in 2002 as a research engineer to develop radionuclide large scale transport models within Melodie software. Since 2006 she is in charge of defining and implementing of a scientific program focused on understanding and quantification of gas migration within HLW repositories. She was/is involved in EC projects of the 6th and 7th PCRD (PAMINA and FORGE) related to this subject, as well in several French projects (ANR HydroGeoDam, Needs-MiPor, MoMaS).

Dr **Zakaria Saadi** Holds a master degree in Physics (Fluid Mechanics), then a PhD in Fluid Mechanics with applications to surface and subsurface hydraulics and hydrology (co-tutored thesis: Ibn Tofaïl University, Kenitra-Morocco; Joseph Fourier University, ENSHMG-INPG-CNRS, Grenoble-France). An

accomplished professional with 20 years of experience in a solid analysis background. Possess thorough knowledge of specialised theories/principles in the fields of fluid mechanics, soil physics, agronomy, geosciences, watershed hydrology, physico-chemical and biological wastewater treatment technologies, formulations of mathematical problems of multiphase flow and contaminant transport processes and their applications. After 12-year experience as mathematical modeller in the above different disciplines during his PhD and three postdocs (IFP, INRA, CNRS) he joined IRSN in 2010 and assigned as lead for risk assessment, especially risks attributed to radon transport from the geosphere to indoor and outdoor environments (e.g., project JURAD-BAT). Now, works on gases transport emanating from radioactive waste disposal facilities and their potential impact on barrier integrity and repository performance, especially development of THM-Gas models at different scales. During his carrier, he developed and validated several codes of two-phase flow and transport in porous media: VZM, TNT2-INRA, POWER-CNRS, CAPSIS-INRA, TOUGH2/EOS7Rn, iT2Rn. He supervised 2 post-docs (radon transport from soils and karst systems to buildings), and 1 PhD student (uncertainties on gas transport near radioactive waste repositories due to negligible air entry pressure and hysteresis effects).

Dr **Virginie Wasselin-Trupin** holds a PhD in radiochemistry from Paris XI university-Orsay. After a post doc in the institute for the transuranium elements (ITU) from the EC-JRC, she joined IRSN in 2002 as engineer in charge of the assessment of the safety of nuclear waste packages and waste management. She is since 2012 the head of the Safety Assessment Section for radioactive waste management. She is also involved in research activities dealing with the management of radioactive waste (such as radiolysis phenomena) and European research project like MICADO or FORGE. V. Wasselin-Trupin participates to the French working group on the National Management Plan for Radioactive Materials and Waste (PNGMDR). She is involved in European contracts dealing with the management of waste (Bulgaria, Vietnam, Morocco, Ukraine, Indonesia, China, Georgia) and in many training courses. In IRSN, she performs also the technical supervision of review teams for the European Commission involving European TSOs and development of safety standards for IAEA as consultant in the waste management field.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- ✓ M. Dymitrowska, F. Smaï, F., A. Bourgeat. Thermodynamic modelling of hydrogen migration in argillite for a deep geological radioactive waste repository: IRSN contribution to FORGE, Geological Society Special Publication, 415 (1), pp. 167-188, 2015
- ✓ Dauzères, G. Achiedo, D. Nied, E. Bernard, S. Alahrache, B. Lothenbach, Magnesium perturbation in low-pH concretes placed in clayey environment - solid characterizations and modelling, Cement and Concrete Research: 79 (2016) 137 – 150.
- ✓ S. Grousset, M. Bayle, A. Dauzères, D. Crusset, C. Martin, V. Deydier, Y. Linard, P. Dillmann, F. Mercier-Bion, D. Neff, Study of irons sulfides in long-term iron corrosion processes: Characterizations of archeological artefacts, Corrosion Science, 112: (2016) 264-275.
- ✓ N. Seigneur, A. Dauzères, A. Dubus, P.E. Labeau, V. Detilleux, Numerical Elementary Representative Volume generation of a simplified cement paste and estimation of its diffusivity and comparison with dedicated experiments, Journal of Porous Media, 20, 1, (2017) 29 - 46.
- ✓ P. Lalan, A. Dauzères, L. De Windt, D. Bartier, J.-D. Barnichon, V. Detilleux, Impacts of 70°C temperature on an OPC paste in an in situ clayey environment: chemical and microstructural characterizations coupled with reactive transport modelling, Cement and Concrete Research, : 83 (2016) 164-178.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

- JOPRAD: the objectives of this project, in which IRSN was an active member, were to develop synergies and increase coordination at European level to go towards a joint programming on radioactive waste disposal. So the results of this project are the basis allowing building the EURAD EURAD.

- SITEX: IRSN coordinated the SITEX (EURATOM FP7, 2012–2013) and the SITEX-II (EURATOM Horizon2020 CSA, 2015-2017) projects. SITEX had the objective to build a sustainable network for independent technical expertise for radioactive waste disposal; the aim was to promote independent expertise

function and participation of the civil society within the expertise function. The association SITEX_Network embarks the major part of TSOs and civil society organisations involved in the EURAD.

- MODERN2020: The overall objective of the Modern2020 Project is to provide the means for developing and implementing an effective and efficient repository operational monitoring programme, that will be driven by safety case needs, and that will take into account the requirements of specific national contexts (including inventory, host rocks, repository concepts and regulations, all of which differ between Member States) and public stakeholder expectations (particularly those of local public stakeholders at (potential) disposal sites). The in situ experiments specifically developed by IRSN and partners in MODERN 2020 are linked to the research field of sealing using clay and concrete materials and will be certainly useful for the EURAD.

- CEBAMA: This project addresses key issues of relevance for long term safety and key scientific questions related to the use of cement-based materials in nuclear waste disposal applications. These materials are key components in the barrier system of repositories, independent on the actual host rocks. A wide part of the results of CEBAMA will be used in the EURAD, especially in the ACED WP. The results obtained by IRSN are concerned.

- FORGE: Objectives of the FORGE project were to study i/ the impact of gas migration on repository infrastructure and engineering performance, ii/ new models to describe the mechanisms and processes governing gas, water and radionuclide movement in repository components, iii/ new insights into the engineered barrier systems (EBS) properties, engineered disturbed zone (EDZ) behavior, far field interactions, gas generation and up-scaling. This project is clearly linked to the gas migration WP starting as part of the EURAD.

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

✓ The Tournemire URL:

Acquired by IRSN in 1992, the Tournemire Underground Research Laboratory, is now one of the four underground laboratories in Europe in which it is possible to carry out researches on disposal in clay formation.

The Tournemire URL is solely used for scientific and technical researches. Located in a former railway tunnel built over 120 years ago, this station provides access to a clay formation that has similar geological characteristics than the site chosen by Andra. The research carried out will enable IRSN to examine specific processes that play an especially important role in ensuring the long-term safety of a geological repository.

Various experimental studies are carried out by IRSN to analyze:

- The mechanisms responsible for the transfer of water and natural substances present in the clay formation;
- The effects of excavation and of using the underground engineering structures on the rock's containment properties;
- The effects related to interaction between the rock and the materials added, such as concrete and metal components;
- The performance of components essential to the long-term safety of a geological repository, such as seals.
- To test the monitoring

✓ The LUTECE Laboratory

This IRSN laboratory located in Fontenay aux Roses is dedicated to carry out experiments and analyses (solid and liquid analyses). This laboratory is equipped for example with SEM-EDS, 2 X-Ray microtomographs, a ionic polishing system, a BET, a laser granulometer and different devices for liquid analyses: ICPMS, ICAP, IC, Spectro UV-Visible....

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

N/A

	No	Name	Acronym
Participant	20	Instituto Superior Técnico – Laboratório de Proteção e Segurança Radiológica	IST-LPSR
Description of the legal entity			
Instituto Superior Técnico (IST) is the School of Engineering of the University of Lisboa and aims to contribute to the development of society, promoting and sharing excellence in higher education in the fields of Architecture, Engineering, Science and Technology. Técnico offers Bachelor, Master and PhD programmes, lifelong training and develops Research, Development and Innovation (RD&I) activities, which are essential to provide an education based on the top international standards. Until 2012, the former Instituto Tecnológico e Nuclear (ITN) was a State laboratory that operated the Portuguese Research Reactor, the RW storage facility, the Radiation Protection and Safety Laboratory and provided support to the Government in the fields of Radiation Protection including RW Management. In 2012, ITN was extinguished by Decree-Law n. 29/2012, of February 9th and incorporated into IST. IST assumed all the responsibilities in the field of Radiation Protection and Nuclear Safety once attributed to ITN, including all human resources and infrastructures. As such, IST operates at its <i>Campus Tecnológico e Nuclear</i> the Portuguese Research Reactor, the Radiation Protection and Safety Laboratory, and the only RW Management facility in Portugal, a surface type facility for storage of very low, low and intermediate level wastes (Decree-Law n. 156/2013, of November 5th). In summary, IST acts as WMO and TSO and RE, respectively, waste management organization, technical support organization and research entity. Moreover, the Radiation Protection and Safety Laboratory of IST (IST-LPSR) performs all the activities related to radiation protection and safety, namely, national metrology of ionizing radiation, individual monitoring, environmental monitoring including radioanalytical techniques for the measurement of natural and artificial radionuclides in environmental samples, foodstuff, feedstuff, construction materials, water for human consumption radon in water and in dwellings, safety assessment of radiological facilities, transport of radioactive material, RW management and storage facility, as well as providing education and training and emergency preparedness and response in the field.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks			
Portugal is a western European nation with 10.6 M inhabitants (approx.) facing the Atlantic Ocean with terrestrial borders with Spain only. Uranium ore extraction ceased in 2000 and all former U exploration sites have been or are presently being remediated, as there are no further plans to resume this activity. There are no nuclear power plants in the country although there is a 1 MW pool-type research reactor operated by IST, in transition to decommissioning since September 2017. In 2006 the research reactor was converted from high-enriched Uranium (HEU) to low-enriched Uranium (LEU) to improve proliferation resistance, in the framework of an agreement with the United States of America (USA) and the International Atomic Energy Agency (IAEA). All HEU was returned to the USA and at present there is no spent fuel (SF) at the reactor facility or anywhere else in the country. As a consequence, the radioactive waste (RW) generated in Portugal consists mainly of materials from past U and Ra mining and milling activities, spent and/or disused sealed sources, smoke detectors, lightning rods, contaminated scrap metal, depleted U from aircraft counterweights, materials contaminated with unsealed sources produced from the applications of ionizing radiation in the fields of Medicine, Industry and Research. The RW is of the very low, low and intermediate level waste types (VLLW, LLW and ILW) and is stored in a surface facility operated since the 1960s at IST's <i>Campus Tecnológico e Nuclear</i>. The first report of Portugal on the implementation of the Joint Convention of the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management was presented at the International Atomic Energy Agency (IAEA) in May 2012 and periodically updated since. Following the publication of Decree-Law n. 156/2013, of November 5th, that transposes Council Directive 2011/70/EURATOM into national law, IST prepares an inventory of the RW stored at its facility on an annual basis. RW records registered after the year 2000 are reliable but there is a strong uncertainty relative to the waste collected before, considered as legacy waste that requires characterization and classification. Prior to the publication of the Ministerial Ordinance 44/2015, of February 20th, adopting clearance and exclusion levels, all radioactive material with no further use, including materials that activated the radiation			

detection portals at the entrance of scrap metal yards, steel and iron melting facilities, landfills for dangerous materials, etc, were collected and brought to the RW storage facility at IST.

Very recently, the first National Programme for the Management of Spent Fuel and Radioactive Waste (2015-2019) was approved by the Government and published in the official journal on the 7th of September of 2017, following the strategic environmental assessment and public consultation.

The first National Program specifically considers the following activities (among other): the characterization and identification of legacy waste, eventual preparation of exclusion processes for waste that no longer require storage at such a facility, restoration of enough room for waste of concern, and the improvement of the overall inventory of radioactive waste.

Task nº2 - Identify challenging wastes to be collaboratively tackled within the Joint Programme - Mapping and shared understanding at EU level of practical issues on waste management routes

IST-LPSR will provide data on RW stored at the storage facility at IST, its classification, and on the identification of routes for disposal RW. Portugal is a country with a first programme on the Safe Management of RW (2015-2019) will benefit from the outcomes of the project.

Task nº3 - Description and comparison of radioactive waste characterisation approaches

IST-LPSR would like to benefit from the experience and knowledge on characterization of legacy RW with the aim to identify key radionuclides of concern and improve the inventory of its historic RW.

Task nº4 – Identification of WAC used in EU Member States for different disposal alternatives in order to inform development of WAC in countries without WAC/facilities

In Portugal there are no established WAC for the treatment and disposal of RW. IST-LPSR expects to improve its knowledge on this matter by sharing its limited experience on RW management balanced with the experience and the know-how from other advanced European member states.

Task nº5 - RWM solutions for small amounts of wastes

The RW generated in Portugal consists mainly of materials from produced from the applications of ionizing radiation in the fields of Medicine, Industry and Research, as there are no nuclear power plants in the country. On the other hand, Portugal is a country with its first programme on the Safe Management of RW (2015-2019). IST-LPSR will improve its knowledge on existing and potential disposal options and solutions for small amounts of radioactive waste.

Task nº6 – Shared solutions in European countries

IST-LPSR expects to learn from the possibilities for sharing technology and facilities available to European member states.

a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities

João Henrique Garcia Alves (male), born 10th of June of 1963, Portuguese, is the Head of the Radiation Protection and Safety Laboratory of Instituto Superior Técnico (IST-LPSR).

IST-LPSR performs all the activities related to radiation protection and safety, namely: metrology of ionizing radiation, individual monitoring, environmental monitoring including radioanalytical techniques for the measurement of natural and artificial radionuclides in environmental samples, as well as foodstuff, feedstuff, construction materials, water for human consumption radon in water and in dwellings, safety assessment of radiological facilities, transport of radioactive material, radioactive waste management, radioactive waste storage facility, education and training and emergency preparedness and response.

João Alves holds a PhD in Physics (Biophysics) by the Faculdade de Ciências e Tecnologia of Universidade Nova de Lisboa (2000); a MSc in Applied Nuclear Physics by the Faculdade de Ciências (FC) of Universidade de Lisboa (UL) (1992); and Graduation in Physics (Microphysics) by FC-UL (1987).

Started working in Radiation Protection and Dosimetry matters in 1988 at the former Instituto Tecnológico e Nuclear and presently Instituto Superior Técnico (IST). Since 2000, is a researcher of (IST) at the Department of Nuclear Sciences and Engineering (DECN); Since 2013, is Deputy Director of the Radiation Protection and Safety Laboratory of IST (IST-LPSR). Since 2007 is a Council Member of the European Radiation Dosimetry association (EURADOS).

Has worked as Coordinator of IST teams and IST team member in 7 projects funded by international institutions; Coordinator of IST teams and IST team member in 2 projects funded by the national research foundation (FCT).

Reviewer of articles submitted to scientific journals for publication like Radiation Measurements and Radiation Protection Dosimetry, upon the request of the respective editorial board.

Is a member of the scientific committee and co-organizer of 3 international conferences, of 6 international short-term Training Courses on Individual Monitoring, Metrology of Ionizing Radiation and Radiation Protection, and of 5 Radiation Protection training actions at IST-LPSR.

Is an author and/or co-author of 40 original publications in international peer-reviewed journals and 7 national journals (approx.); Co-author of the EU *Technical Recommendations for Monitoring Individuals Occupationally Exposed to External Radiation*. Radiation Protection n. 160 (2009); Co-author of 18 technical reports (approx.). Author and/or co-author of 53 communications (oral and poster) presented at international conferences and symposia and 25 communications at national events. Is also a member of the teams awarded with 3 prizes at national events

Is also a member of the IST teams for the preparation of national legislation for the transposition of EU Directives, preparation Ordinances, and Technical Recommendations, etc on the Basic Safety Standards, Radioactive Waste management, National Programme for the Safe Management of Radioactive Waste and Spent Fuel, Assessment of radiological parameters in Water for Human Consumption, Metrological evaluation of ionizing radiation measurement devices;

Has collaborated with the International Atomic Energy Agency on the revision of Technical Documents, Technical Meetings (on the revision of IAEA Safety Guide n.º TS-G-1.2, 2002); and Training Actions (on *Emergency Preparedness and Response for Port and Maritime Emergencies*, Vienna, May 2018).

Has also collaborated with national institutions in several matters related to Radiation Protection issues, such as, the Ministry of Foreign Affairs, Directorate-General for Health, Portuguese Institute for Accreditation, National Commission for the Safety of Nuclear Facilities, Portuguese Environment Agency, National Authority on Civil Protection, NRBQ units of the Armed Forces.

Alfredo José Martins Nogueira Baptista (male), born 23rd of May of 1974, Portuguese, is the responsible for the Operational Radiation Protection nucleus at the Radiation Protection and Safety Laboratory (LPSR) of Instituto Superior Técnico (IST).

Alfredo Baptista holds degree in Physics Engineering by the Faculdade de Ciências e Tecnologia of Universidade Nova de Lisboa (2000).

His main tasks are the safety assessment of radiological facilities, transport of radioactive material, radioactive waste management at the storage facility, and emergency preparedness and response.

Started working in Radiation Protection matters in 2006 at the former Instituto Tecnológico e Nuclear and presently Instituto Superior Técnico (IST). Since 2015, is a technical officer at the Radiation Protection and Safety Laboratory of IST (IST-LPSR) and responsible for the Operational Radiation Protection nucleus.

Has worked as IST team member in projects funded by international and national institutions.

Is an author and/or co-author of 10 original publications in international and national peer-reviewed journals (approx.); Co-author of several technical reports. Author and/or co-author of 20 communications (oral and poster) presented at national conferences and symposia.

Has collaborated in the preparation of national legislation for the transposition of EU Directives, preparation Ordinances, and Technical Recommendations, etc on Radioactive Waste management, National Programme for the Safe Management of Radioactive Waste and Spent Fuel.

Has also collaborated with national institutions in education and training events and drills and exercises related to Radiation Protection and Emergency Preparedness and Response, such as, the Ministry of Foreign Affairs, Directorate-General for Health, National Commission for the Safety of Nuclear Facilities, Portuguese Environment Agency, National Authority on Civil Protection, NRBQ units of the Armed Forces.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

W. Rühm, E. Fantuzzi, R. Harrison, H. Schuhmacher, F. Vanhavere, J. Alves, J. F. Bottollier Depois, P. Fattibene, Ž. Knežević, M. A. Lopez, S. Mayer, S. Miljanić, S. Neumaier, P. Olko, H. Stadtmann, R. Tanner, C. Woda. *EURADOS Strategic Research Agenda: Vision for Dosimetry of Ionizing Radiation*. Radiat. Prot. Dosim. **168** (2): 223-234 (2016). doi: [10.1093/rpd/ncv018](https://doi.org/10.1093/rpd/ncv018). WOS: 000371607500010.

J. Cardoso, J. Santos, L. Santos, J.G. Alves, C. Oliveira. *Characterization of an active dosimeter according to IEC 61526:2010*. Radiat. Prot. Dosim. **170** (1-4), 127-131, (2016). doi: [10.1093/rpd/ncw090](https://doi.org/10.1093/rpd/ncw090). WOS: 000384713300030.

M.F. Pereira, J. Pereira, S. Rangel, M. Saraiva, J.G. Alves. *Environmental monitoring with passive detectors at CTN in Portugal*. Radiat. Prot. Dosim. **170** (1-4), 342-345 (2016) doi: [10.1093/rpd/ncv479](https://doi.org/10.1093/rpd/ncv479). WOS:000384713300077.

M.J. Fartaria, C. Reis, J. Pereira, M.F. Pereira, J.V. Cardoso, L.M. Santos, C. Oliveira, V. Holovey, A. Pascoal, J.G. Alves. *Assessment of the Mean Glandular Dose using LiF:Mg,Ti, LiF:Mg,Cu,P, Li₂B₄O₇:Mn and Li₂B₄O₇:Cu TL Detectors in Mammography Radiation Fields*. Phys. Med. Biol. **61**, 6384-6399 (2016). doi: [10.1088/0031-9155/61/17/6384](https://doi.org/10.1088/0031-9155/61/17/6384). WOS: 000384209800012.

S. Sarmiento, J.S. Pereira, M.J. Sousa, L. Cunha, A.G. Dias, M.F. Pereira, A.D. Oliveira, J. Cardoso, L.M. Santos, J.A.M. Santos, J.G. Alves. *The use of needle holders in CTF-guided biopsies as a dose reduction tool*. J Appl Clin Med Phys, **19** (1), 250-258 (2018) doi: 10.1002/acm2.12234. WOS: 000427481300028.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

R. Trindade, I. Paiva, A. Batista, L. Portugal, J. Venâncio. *Radioactive Scrap Metal in Portugal: an overview*. Communication presented at the *International Conference on Control and Management of Inadvertent Radioactive Material in Scrap Metal*, Tarragona (Spain), February 2009.

R. Trindade, I. Paiva, P. Duarte, F. Gomes, L. Portugal, A. Batista. *Exposição do Público Resultante das descargas de Efluentes Líquidos Radioativos na Rede Pública*. Communication presented at the XII Congresso Nacional de Medicina Nuclear, Coimbra (Portugal), November 2009.

J.G. Alves. *Interim Storage, Regulation and Practical Aspects (the case of Portugal)*. Communication presented at the *NEA-Nuclear Energy Agency Workshop on the Management of Non-Nuclear Radioactive Waste*, Legnaro, Padova (Italy), May 2017.

Collaboration with national Regulatory Commission for the Safety of Nuclear Facilities (Comissão Reguladora para a Segurança de Instalações Nucleares, COMRSIN) for the preparation of the following documents:

Guidelines for the Safe Management of Radioactive Waste for Storage at a Surface Facility (2015) and *National Programme for the Safe Management of Radioactive Waste and Spent Fuel* (2015-2019) foreseen in Decree-Law n.º 156/2013, of the 5th of November. Preparation of the document, public discussion, published as Resolution of the Council of Ministers of the 7th of September.

Draft Safety Guide (DS469) Preparedness and Response for an Emergency during the Transport of Radioactive Material. Revision of the document *Planning and Preparing for Emergency Response to Transport Accidents involving Radioactive material*, IAEA Safety Standards Series, *Safety Guide* n.º TS-G-1.2, (2002) (this work is on-going).

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

IST-LPSR has laboratories to perform the following activities: laboratory of metrology of ionizing radiation, laboratory of individual monitoring, laboratory of environmental radioactivity for the measurement of natural and artificial radionuclides in environmental samples (foodstuff, feedstuff, construction materials, water, etc).

At the RW management facility and related activities have access to the laboratories with the following techniques: high-resolution gamma spectrometry, insitu gamma spectrometry (NaI and HPGe), several portable dose rate meters and contamination monitors, activity concentration measurement device for large samples.

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

N/A

No	Name	Acronym
Participant	Associação do Instituto Superior técnico para a Investigação e Desenvolvimento	IST-ID
Description of the legal entity		
Associação do Instituto Superior técnico para a Investigação e Desenvolvimento (IST-ID)		
IST-ID, the Association of Instituto Superior Técnico for R&D (http://www.ist-id.pt) is a private not-for-profit institution for which Instituto Superior Técnico (IST) is one of the founding associates. IST is part of the Universidade de Lisboa, and it is the largest and most reputed school of engineering, Science and Technology (S&T) in Portugal. Its mission is to provide top quality higher education in the areas of Engineering, S&T and Architecture, as well as developing RD&I activities that meet the highest international standards. IST-ID is the host institution of Centro de Ciências e Tecnologias Nucleares (C²TN) where the proposed R&D activity will be carried out. Under agreements between IST and IST-ID, IST makes available the majority of facilities, infrastructures and services, where IST-ID R&D activities are carried out. Researchers from the Radiological Protection and Safety Group (GPSR) of C²TN, mainly, will be involved in the project but collaborations with other C²TN research groups are envisaged. They are members of the EU Research Platforms MELODI, EURADOS, Alliance, NERIS, IGD-TP and EURAMET and are involved in IAEA and NEA within radioactive waste management activities.		
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks		
Portugal produces radioactive wastes from UMM, health and industry sectors, research, training and education, and from the operation, since 1961, of the Portuguese 1 MGW swimming pool research reactor (RPI) located at CTN, Campus of Loures of the Instituto Superior Técnico. Main categories of wastes produced are NORM, VLLW, LLW and ILW. Radwaste R&D activities in the Campus, started in the 90's, with: Radium and uranium industry tailings remediation; liquid effluents treatment from the chemical process with traditional and innovative methodologies (ion-exchange, filtration, co-precipitation, membranes and electrochemical processes, production and test of new molecules to encapsulate radwastes for safer disposal, etc.); characterization and evaluation of treatment methodologies for wastes from nuclear medicine and research; and implementation of safes methodologies to handle, dismantling and conditioning of sealed sources for long-term storage and disposal. Also R&D has been implemented to developing a specific Portuguese methodology for suitable places to host a near-surface repository with the identification of specific geomaterials with adequate properties to be used as engineering barriers. IST-ID has also participated in R&D projects focusing models application to waste management, actinide science, and studies contributing to the development, public acceptance and implementation of geological repositories. IST-ID has also been involved in specific E&T projects/activities to ensure knowledge is passed to future generations and a new pool of highly trained researches and technical personnel will be available in the futre. All these activities have been carried within the objectives of the EU concerning safe and reliable solutions for radwaste management and the objectives of IGD-TP and the IAEA related to safe and reliable solutions for radioactive waste today and in the future energy market. The work is in tune with the National Framework Programme on Radioactive Waste, Decree-Law n. 156/2013, of November 5th, (Council Directive 2011/70/EURATOM), IAEA Joint Convention Articles and NEA research recommendations. IST-ID is firmly engaged in pursuing the R&D efforts need to fulfil the vision, agenda and objectives of EURAD. IST-ID will be actively involved in WP9-ROUTES: • Task nº2 - Identify challenging wastes to be collaboratively tackled within the Joint Programme - Mapping and shared understanding at EU level of practical issues on waste management routes (subtask 2.2)		

IST-ID will identify R&D needs in Portugal and will collaborate with other partners needs as well in providing data on RW treatment technologies used, will identify disposal routes and how to achieve them, will contribute to reports content and questionnaires and will present work in the progress meetings, workshops and conferences.

- **Task n°3 - Description and comparison of radioactive waste characterisation approaches**
IST-ID will contribute with information and share experiences and R&D data on collection and treatment of data related to key radionuclides (^3H ; ^{14}C ; $^{99\text{m}}\text{Tc}$, iodine isotopes, etc.); Characterization and segregation of legacy waste from the different radioactive waste streams (from medical, research and industrial facilities as well as NORM. IST-ID will contribute to reports, questionnaires and will present work in progress meetings, workshops and conferences (subtask 3.1 & 3.2).
- **Task n°5 - RWM solutions for small amounts of wastes**
IST-ID will support JSI with conceptual model developed for long-term interim storage for decay at surface in terms of radwaste small inventories, contributing to reports, questionnaires and presenting work in progress meetings, workshops and conferences (subtask 5.1).
- **Task n°6 – Shared solutions in European countries**
IST-ID will contribute to the identification of gaps, needs and opportunities in R&D towards shared radwaste approaches and solutions by contributing to reports, questionnaires and presenting work in progress meetings, workshops and conferences (subtask 6.3).

IST-ID will also contribute to the continuation of:

- E&T of students in radwaste treatment technologies and management strategies through the implementation of the national and international Master's programmes (MPSR/IST and PETRUS/ENEN) and to increase competence maintenance, education and training (CMET)
- Promoting **application of Learning Outcomes (knowledge, skills and competencies) to ensure a future radioactive waste management work force highly knowledgeable and prepared for the new challenges**
- Production of written materials such as books, papers, oral presentations, posters and other divulgation materials for schools, experts and public towards a better comprehension of safe solutions for radwaste such as GD.
- Better interaction with public and other stakeholders, in matters of common European solutions for radwaste management, mainly, GD.

a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities

Maria Isabel Flausino de Paiva (Female) is a researcher of IST and was co-coordinator the GRRR (Radioprotection and Radioactive Waste Group) (2011-2012) of Nuclear and Technological Institute (ITN)). With the transition to the Lisbon University, she became a member of Department of Nuclear Sciences and Engineering (DECN), a researcher at Centre for Nuclear Sciences and Technologies (C²TN), a member of the Environmental Radioactivity Unit of LPSR and adviser for questions related to the Portuguese radioactive waste management facility.

She holds a Degree in Chemistry/Biochemistry (Lisbon University, 1987), a PhD in Chemical Engineering (Loughborough University of Technology, UK and Harwell Labs, 1992-1996) and a Post-Doc in Radiochemistry (Florida State University, 1999-2000), in radioactive waste treatment technologies.

Main areas of research are:

- Radioactive waste management and treatment technologies for interim storage and disposal
- Radiological protection and environmental radioactivity
- Radiological and nuclear emergencies
- Education and training throughout life, students and communication with public on radwaste

She is:

- Author/co-author of more than 30 works between original publications in Refereed Journals, proceedings, oral presentations and communications in national and international scientific events

related to radioactive waste management and radiological protection.

- Responsible and professor for the curricular unit Radioactive Waste in the IST' Master on Radiological Protection and Safety (MPSR).

Other activities:

Participation and coordination, for PT, of several national and international Research Projects, financed by FP EURATOM/FISSION, Radiological Protection and E&T (FP4,6 and 7), FCT, ERAMIN and IAEA:

- CONFIDENCE - "Coping with uNcertainties For Improved modelling and DEcision making in Nuclear emergenCiEs" (EURAD-CONCERT Call 2016, Radiation Protection Research in Europe) (2017- 2020).
- ENVIREE – ENVIronmentally friendly and efficient methods for extraction of Rare Earth Elements from secondary sources, (FCT/ERA-MIN). (2015-2019).
- IAEA & EC Project C.3, Contract Agreement 2013/313-757, Strengthening of an effective compliance regime in transport of radioactive material in the European Southern neighbourhood region (Mediaterranean Sea) and associated shipping States (2013-2016).
- IAEA Project RER/09/080 - Strengthening National Capabilities in Radiation, Waste and Transport Safety in the Mediterranean Region. (2014-2017).
- CMET - Competence Maintenance, Education and Training – Concerted Action within Project SecIGD2, IGD-TP. (2013-2016).
- MetroNORM - Metrology for Processing Materials with High Natural Radioactivity. EMRP Project: JRP- IND57. (2013- 2016).
- ARIAS - Application of Ionizing Radiation for a Sustainable Environment, FCT-2012 RECI/AAG-TEC/O400/2012. (2013-2016).
- MetroMETAL – Ionizing Radiation Metrology for the Metallurgical Industry. EMRP Project: JRP-IND04. (2013-2014).
- PREPARE – Innovative integrative tools and platforms to be prepared for radiological emergencies and post-accident response in Europe. (EURATOM/FP7-Fission/NERIS-TP. (2013-2016).
- PETRUS III – Implementing Sustainable E&T Programmes in the Field of Radioactive Waste Disposal (FP7/Euratom for Nuclear Research and Training). (2013-2016).
- EAGLE Stakeholders Group - Enhancing education, training and communication processes for informed behaviors and decision-making related to ionizing radiation risks IST representative at stakeholders group. (EURATOM/FP7). (2012-2014
- PETRUS II – Towards an European training market and professional qualification in Geological Disposal. Post-Graduation development of the PD and Pilot PD programmes. (FP7/Euratom for Nuclear Research and Training). (2009-2012).
- ACSEPT-ReCycling by SEParation and Transmutation (FP7/Fission,Radwaste). (2007-2012).
- KADRWaste – Study of the Adsorption Mechanisms and Kinetics in Geomaterials and Their Structural Characterization: Implications for Processes of Natural Attenuation of Heavy Metal Contamination and Radioactive Wastes Confinement (FCT 2008), (2006-2010).
- PT Directorate for Health Project n°6/01, DGIES - A Study of radioactive liquid discharges from national medical establishments, ITN/DPRSN/DGIES. (2000-2004).
- Project FP4/EURATOM/Fission1990 - Advanced processes for the treatment of low level radioactive liquid wastes at a pilot plant scale (Contrato DGXII F12-CT90-0057) (1990-1995). CEC DGXII Grantee).
- Post-Doc DOE project - Study of the actinide polyoxometalate systems, mainly the study of the interaction of the lacunary form P2W17 with the actinide DI-Oxo cation uranyl UO22+, DOE/USA, Dpt. Química, Florida State University, USA (1999-2000).

Collaboration with:

- GEOSAF – International Intercomparison and Harmonization Projecto in Demonstrating the Safety of Geological Disposal IAEA. (208-2010).
- Project IAEA RER/9/107 - Policy Formulation and Strategy Options for Radioactive Waste Management. (2011-2012).
- Project IAEA RER/0/031 - Strengthening Sustainability of Nuclear Research and Development Institutes in the Modern Science and Technology Environment. (2011-2012).

- Project RER/9/101, “Building Competence through Education and Training in Support of Radiation Protection Infrastructures”.
- Project IAEA RER/9/103, “Identifying and Managing Uncertainty for Post-Closure Safety Assessments in Support of Repository Development Programmes”.
- Project FP4/EURATOM/Fission1990, "Environmental impact assessments and geological repositories" (B4-070/97/000821/MAR/C3) (1997-1999).
- Project FP4/EURATOM/Fission1990, "Management and disposal of disused sealed radioactive sources in the EU" (B4-3070/96/000781/MAR/C3) (1997-1999).

She has been IST/PT representative in:

- IGD-TP platform (Implementing Geological Disposal) (
- MedNET Network on Transports of Radioactive Materials.
- EURATOM Treaty Art.º 37’ experts.
- OSPAR Convention, RSC.
- NCP for the Joint Convention on safety of spent fuel and safety of management of radioactive waste – The Joint Convention), Vienna, 2011-2012. Elaboration and presentation of the first national report at the Fourth Review Meeting of the Contracting Parties pursuant to Article 3, Vienna, May 14-23, 2012.
- NCP for the database NEWMDB (Enable Waste Management Database), IAEA, 2006-2008.
- ITN/PT representative in the AQG (scientific and technical support to REPER), Brussels, 2004-2008. Collaboration with the Council and EC in support of various technical and legislative proposals, mainly, Council Directive 2011/70/Euratom 19 July 2011, contributing with analysis and texts.
- PT representative in the Ad-hoc WG on Nuclear Safety, WPNS, Brussels, 2004-2008.
- PT representative in the CCE_Fission/ WG-Radioactive Waste, 2004-2006. Participation in the elaboration of a proposal for supporting and financing R&D in the area of radioactive wastes to be presented to the European Parliament.
- PT representative in the WASSC committee, Vienna, 2004 – 2011.
- Collaboration with the PT representative in the ACPM (Advisory Committee for Programme Management of Community Plan of Action in the Field of Radioactive Waste), by evaluating progress reports of the projects under the EURATOM framework program (FP5 e FP6), Luxemburg, 1998-2003.

Mário João Capucho dos Reis (Male) is a researcher of the IST since December 2002. He holds a Degree in Environmental Engineering, New University of Lisbon, Faculty of Sciences and Technology, Portugal (1987) and a PhD in Physics, Évora University, Portugal (2002).

He is responsible for the Environmental Radioactivity Nucleus (NRA) of the Radiological Protection and Safety Laboratory (LPSR) since November 2016.

He is also responsible and professor for the curricular units Environmental Radioactivity and Metrology of Radiation in the IST’ Master on radiological Protection and Safety (MPSR).

Main Scientific Areas of Research are:

- Environmental Radioactivity
- Radioactivity Measurements
- Radiation Protection

He has participated in Scientific Training Programmes:

- International Atomic Energy Agency Fellowship Programme, completed at the Gesellschaft fuer Strahlen – Umweltforschung GMBH Muenchen, Institut fuer Strahlenschutz, Neuherberg, Germany, on the field of Radiation Protection (3 months, from April to July 1991).
- International Atomic Energy Agency Fellowship Programme, completed at the Laboratoire de Mesure de la Radioactivité de l’ Environnement (LMRE), Institut de Radioprotection et Sûreté Nucléaire (IRSN), Orsay, France, on the field of γ -ray spectrometry measuring techniques of low-level environmental samples, including both natural and anthropogenic nuclides (1 month, September 2003) and has Been counterpart of

IAEA research projects. He is representative of IST in the NERIS platform.

Scientific Works:

- Participation in several national and international Research Projects, financed by FCT, PT2020, EMRP and 7th Framework Programme;
- Author/co-author of more than 20 original publications in Refereed Journals;
- Author/co-author of more than 40 oral presentations and communications in national and international scientific events.

Pedro Vaz (Male) Coordinator Researcher of IST with Habilitation. President of Centro de Ciências e Tecnologias Nucleares (C²TN) and Coordinator of the Radiological Protection and Safety Group (GPSR) of C²TN.

Ph.D in Physics. Co-author of more than 300 peer-reviewed articles. Has participated in several EU EURATOM funded research projects as well as in CERN experiments related to the measurements of the cross-sections for neutron-induced reactions.

Portuguese delegate and representative to several international Committees and Groups under the EU, IAEA, OECD/NEA and EU platforms.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- Paiva, R. Trindade, M. Gonçalves and A. Mateus, “Development of a specific methodology to assess suitable sites to receive a repository for L/ILW in the Portuguese territory” in ASME/ICEM Books of 15th International Conference on Environmental Remediation and Radioactive Waste Management, Bruxelas 8-12 Setembro. ISBN: 978-0-7918- 5601-7; WOS: 000337804600026 (2013)
- Paiva, R. Trindade. “The impact of council directive 2011/70/Euratom and IAEA Joint Convention on the ongoing establishment of the Portuguese regulatory framework and the future national radioactive waste national plan” in ASME/ICEM Books of 15th International Conference on Environmental Remediation and Radioactive Waste Management, Bruxelas, Setembro 8-12. ISBN: 978-07918-5601-7; WOS: 000337804600027 (2013)
- Reis, M., Freitas, M.C., Dung, H.M., Mateus, A., Paiva, I., Madruga, M.J., Gonçalves, M.A., Silva, L., Dionísio, I. “Characterization of geomaterials from NE Portugal using k (0)-based instrumental neutron activation analysis (k (0)-INAA) and gamma spectrometry methods”. Journal of Radioanalytical and Nuclear Chemistry, 294(3), 363-369. ISSN: 0236-5731; doi: 10.1007/s10967-012-1613-5; WOS: 000310995000006 (2012) (IF 1.467)
- Duarte, P., Mateus, A., Paiva, I., Trindade, R., Santos, P. “Usefulness of systematic in situ gamma-ray surveys in the radiometric characterization of natural systems with poorly-contrasting geological features (examples from NE of Portugal)”, Applied- Radiation and Isotopes, 69: 463-474. ISSN: 0969-8043; doi:10.1016/j.apradiso.2010.10.002; WOS: 000287063700031 (2011) (IF 1.179)
- E. Andrade, M.J.Madruga, I.Bobos, I. Paiva, F. Maia, A. Mateus, R. Trindade, M.C. Freitas, M.A. Gonçalves, "Characterization of Portuguese geomaterials, the clay component of rañas, as potential liners for low and intermediate radioactive disposal sites, J. Radioanalytical & Nuclear Chemistry, 286:777-783. ISSN: 0236-5731; doi: 10.1007/s10967-010-0715-1; WOS: 000285099700030 (2010) (IF 0.777)
- Paiva, C. Oliveira, L. Portugal, R. Trindade, Interim storage of spent and disused sealed source: optimization of external dose distribution in waste grids, using MCNPX code, ICRS10 /RPS2004; Funchal, 9-14 May 2004, Radiation Protection Dosimetry, Vol. 116, Edição 1-4, Part.2, 417-422. ISBN: 019-856886-X; ISSN: 0144-8420; doi: 10.1093/rpd/nci246; WOS: 000234784800088 (2005) (IF 0.58)
- Duarte, P., Silva, I., Mateus, A. Araújo, M.F. Reis, M., Trindade, R., Paiva, I., Radiological and geochemical characteristics of an ultramafic massif (NE Portugal) and their significance in the assessment of the site aptness to host a near surface repository for low and intermediate level radwaste”, Environmental Earth Sciences, Vol. 68, Issue 2, Pages 547-557, DOI:10.1007/s12665-012-1758-0,Jan,(2013)

- A.R. Gomes, J. Abrantes, A. Libânio, M.J. Madruga, M. Reis, (2017). Determination of tritium in water using electrolytic enrichment: methodology improvements, J Radioanal Nucl Chem, 314, 669-674. doi: 10.1007/s10967-017-5456-y
- Vaz, P., Paiva, I., & Portugal, L., "Status of the safety and security of radioactive sources in Portugal in: Proceedings of the International Conference on Safety and Security of Radioactive Sources: Maintaining Continuous Global Control of Sources throughout Their Life Cycle", Abu Dhabi, United Arab Emirates, Outubro 27-31 (2013), in IAEA Proceedings Series (ISSN: 0074-1884), STI/PUB/1667, pp. 493-498, ISBN: 978-92-0-105214-8 (2015)
- M. Palmu, M. Cantone, M.-C., Paiva, I., and Vivalda, C. , "The CMET working group actions within IGD-TP. Feasibility of voluntary accreditation in geological disposal using ECVET approach" in Proceedings of the Nuclear Education and Training International Conference, NESTet, Madrid, Novembro 17-21 (2013)
- N. Soares, I. Paiva e Leonor M. Monteiro, "Radionuclides in Waste Discharges from Health Establishments". Conference "Proteção Radiológica na Saúde 2017 (PRS 2017)", IST, Lisboa, Portugal, Setembro 27-29 (2017).
- Paiva, O. Monteiro Gil, M. Baptista, M. Reis, P. Vaz. An innovative vision on education and training programs in radiological protection, nuclear and radiation safety. Proceedings Conferência internacional RICOMET 2016, Bucareste, Junho 1-3. Book of Abstracts, pp 52, SCK CEN-BA_0076 publication (2016)
- S. Vogiatzi, A. Lagumdzija, J. Cremona, H. Bsai, S. Zeroual, I. Paiva. "Mediterranean Network (MedNet) - Overview of the regulatory infrastructure for the safe transport of radioactive material" in Proceedings of the 18th International Symposium on the Packaging and Transportation of Radioactive Materials, PATRAM 2016, Kobe, Setembro 18-23 (2016)

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

Research projects:

- IAEA Project RER/09/080 - Strengthening National Capabilities in Radiation, Waste and Transport Safety in the Mediterranean Region. (2014-2017)
- PETRUS III – Implementing Sustainable E&T Programmes in the Field of Radioactive Waste Disposal (FP7/Euratom for Nuclear Research and Training). (2013-2016).
- PETRUS II – Towards an European training market and professional qualification in Geological Disposal. Post-Graduation development of the PD and Pilot PD programmes. (FP7/Euratom for Nuclear Research and Training). (2009-2012).
- ACSEPT-ReCycling by SEparation and Transmutation (FP7/Fission,Radwaste). (2007-2012).
- KADRWaste – Study of the Adsorption Mechanisms and Kinetics in Geomaterials and Their Structural Characterization: Implications for Processes of Natural Attenuation of Heavy Metal Contamination and Radioactive Wastes Confinement (FCT 2008), (2006-2010).
- PT Directorate for Health Project n°6/01, DGIES - A Study of radioactive liquid discharges from national medical establishments, ITN/DPRSN/DGIES. (2000-2004).
- Project FP4/EURATOM/Fission1990 - Advanced processes for the treatment of low level radioactive liquid wastes at a pilot plant scale (Contrato DGXII F12-CT90-0057) (1990-1995). CEC DGXII Grantee).
- GEOSAF – International Intercomparison and Harmonization Projecto in Demonstrating the Safety of Geological Disposal IAEA. (208-2010).
- Project IAEA RER/9/107 - Policy Formulation and Strategy Options for Radioactive Waste Management. (2011-2012).
- Project IAEA RER/9/103, "Identifying and Managing Uncertainty for Post-Closure Safety Assessments in Support of Repository Development Programmes".
- Project FP4/EURATOM/Fission1990,"Environmental impact assessments and geological repositories" (B4-070/97/000821/MAR/C3) (1997-1999).
- Project FP4/EURATOM/Fission1990, "Management and disposal of disused sealed radioactive sources in the EU" (B4-3070/96/000781/MAR/C3) (1997-1999).

PT representative in: - IGD-TP platform (Implementing Geological Disposal) - MedNET Network on Transports of Radioactive Materials. - EURATOM Treaty Art.º 37' experts. - OSPAR Convention, RSC. -
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; IST-ID has access, among others, to the following facilities and equipment's: - High resolution gamma spectrometry (NaI, HPGe and Si(Li)) - Gas flow proportional counter - Liquid scintillation counting - Low resolution gamma spectrometry - Alpha spectrometry - Portable radiation detectors - IRMS, HPLC/ICPMS - Electron microscopy - Acelerator Van de Graaff de 2,5 MV, Microsonda nuclear, Acelerator Tandem de 3 MV, Hotbird - Particle Induced X-ray Emission (PIXE), X-ray diffraction (XRD), XRF and Mössbauer spectroscopy - Chemistry of f-elements - Low Temperature and High Magnetic Field Laboratory (LTHMFL) - Low and high activity samples measurement labs - ⁶⁰Co irradiator Simulation tools: -COMSOL (in collaboration with Sweden) -Monte Carlo
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task. N/A

		Name	Acronym
Participant	22	Jožef Stefan Institute	JSI
Description of the legal entity Jožef Stefan Institute (www.ijs.si) is the leading Slovenian scientific research institute, covering a broad spectrum of basic and applied research. The staff of more than 900 specializes in natural sciences, life sciences, and engineering. The main areas include production and control technologies, information, communication and knowledge technologies, biotechnologies, new materials, environmental technologies, nanotechnologies, and nuclear engineering. JSI accumulates and disseminates knowledge through the pursuit of research, development, and education at the highest international level of excellence. This project will be supported by the Reactor Engineering Division (http://r4.ijs.si), Reactor Physics Division (http://f8.ijs.si) and Department of environmental sciences (www.environment.si). JSI also acts as a Technical and scientific support organization (TSO) to the Slovenian nuclear regulatory authority.			
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks JSI is involved in 6 work packages of the Joint Programme, with all of the falling into the scope of its regular research and TSO activities. ACED: in-situ monitoring of corrosion of steels in the ongoing experiments and potentially in the new experiments proposed by IRSN (NE2-2/1) to assist at the identification of corrosion type, rate and corrosion products. The test fields at three hydroelectric dams on Drava River in order to get reliable samples of concrete in different locations of saturated zone of the dams. Laboratory investigation of samples in terms of microstructure characteristics Support by linked third party ZAG is foreseen. CORI: JSI will study degradation products of organic compounds after irradiation in research reactor by gamma radiation for different times and fluxes. In addition, sorption and diffusion of organic compounds in cementitious environment will be studied. SFC: Contribute to the theoretical study of SNF source terms and to definition and verification procedures to determine the source terms of SNF assemblies with realistic confidence limits. ROUTES: technical data on different radioactive waste types will be provided for Slovenia and all input information of different waste management routes will be collected and analysed. involved in the interaction with civil society is planned. Support by linked third party EIMV is foreseen. UMAR: contribution to common understanding among the different categories of actors on uncertainty management for RWM and contribution to analyses and mitigation procedures on activities related to risk & safety. Support by linked third party EIMV is foreseen. KM: Contributions to State of knowledge and guidance, with emphasis on early-stage of RWM programmes. Support by linked third party EIMV is foreseen			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Prof. Dr. Leon Cizelj (male) , scientific councilor and head of Reactor Engineering Division of the Jožef Stefan Institute. Full professor of Nuclear Engineering, Faculty of mathematics and physics, University of Ljubljana. Ph.D. physics, University of Ljubljana, 1993. Research interest in safety and reliability of complex technologies; integrity and ageing of safety related components of nuclear power plants; computational solid, fluid and fracture mechanics, multiscale and multiphysics computations. President of			

the Management board of the Slovenian radwaste agency ARAO (2013-2016). Member of the Scientific Council for Technology at the Slovenian Research Agency ARRS, 2006-2011; member of the Governing Board of SNETP, 2013-2015; President of the Board of Directors of European nuclear Education Network, 2016-2018.

Assist. prof. Marjan Kromar, PhD (male) is a leader of the nuclear power reactor group within the Reactor physics division of JSI. He received a PhD degree in nuclear engineering from the University of Maribor in 1992. He conducts researches for 35 years on the development of the nuclear design tools, methods, codes and their applications to the design PWR calculations. He is specialized on the nuclear fuel behaviour especially criticality safety, decay heat and shielding aspects of the spent fuel storage.

Assist. prof. Luka Snoj, PhD (male) received the Diploma and PhD thesis in Physics from the Faculty of Mathematics and Physics, University of Ljubljana, Slovenia in 2005 and 2009, respectively. In 2010, he was on 6 months postdoctoral position at Culham centre for Fusion Energy, where he was in charge of neutron transport calculations to support JET neutron yield calibration. In 2010 he has been appointed head of TRIGA reactor at the Jozef Stefan Institute (JSI). Since 2014 he has been head of reactor physics division at the Jozef Stefan Institute. He is very active in teaching; reactor and radiation physics, experimental reactor physics at the Faculty of mathematics and physics where in 2014 he was elected assistant professor. He has been advisor to 12 master theses and is advisor to 6 PhD students. His research interest is mainly theoretical reactor physics related to practical applications in power and research reactors, in particular: Monte Carlo transport of neutrons and photons in fission and fusion nuclear reactors, integral reactor experiments, criticality experiments and calculations. He regularly performs evaluations and evaluation reviews of critical and reactor physics experiments for International Criticality Safety Benchmark Evaluation Project (ICSBEP) and International Reactor Physics Experiment Evaluation (IRPhE) Project working groups under OECD/NEA.

Klemen Ambrožič, MSNE (male) received his Diploma in Physics in 2013 and a Master Degree in Nuclear Engineering in 2015 from and is currently enrolled into PhD Nuclear Engineering programme at Faculty of Mathematics and Physics, University of Ljubljana. In year 2017 he performed part of his studies at CEA Cadarache, DEN, DER, SPEX, EPL laboratory for 2 months, where he was developing methods for experimental determination of delayed gamma fraction in fission nuclear reactors, and at CEA Saclay, DEN/DM2S/SERMA/LTSD laboratory, developing a detailed simulation model of the JSI TRIGA reactor for TRIPOLI 4 Monte-Carlo code, and studied computational methods for delayed particle transport. His research interest is mainly theoretical reactor physics and computational code development and reactor experimentation for code validation and radiation hardness testing.

Dr. Marko Štok (male), research associate is Head of Radiochemistry laboratory at the Department of Environmental Sciences, JSI. 10 years of experience in analytical radiochemistry, mass spectrometry, migration of radionuclides, radioecology. His research interests are in migration of radionuclides in different environmental compartments, determination of radionuclides in different samples, application of isotope ratios in geochemistry.

Dr. Ester Heath (female), senior research associate is Head of Organic analyses group at the Department of Environmental Sciences, JSI. 20 years of experience in the field of organic analytical chemistry, particularly in environmental and biomedical research. Research topics: identification of pharmaceutical transformation products with GC-MS, determination of trace-level organic compounds in environmental or biological samples, water treatment technologies.

Dr. Vladimir Radulović (male), research associate is researcher at the Reactor Physics Department, JSI. 10 years of experience in the field of reactor physics. Research topics: development of new methods for the analysis of research and power reactors, neutron transport calculations, nuclear data, validation of nuclear data and sensitivity analysis, experimental reactor physics.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software),

or other achievements relevant to the call content Smodiš, B., Štrok, M. Partitioning of natural radionuclides in sediments around a former uranium mine and mill. Journal of Radioanalytical and Nuclear Chemistry, 2013, 297, 201-207. Kotnik, K., Kosjek, T., Krajnc, U., Heath, E. Trace analysis of benzophenone-derived compounds in surface waters and sediments using solid-phase extraction and microwave-assisted extraction followed by gas chromatography-mass spectrometry. Analytical and bioanalytical chemistry, 2014, 406, 3179-3190. Radulović, V., Fourmentel, D., Barbot, L., Villard, J.F., Goričanec, T., Žerovnik, G., Snoj, L. Measurements of miniature ionization chamber currents in the JSI TRIGA Mark II reactor demonstrate the importance of the delayed contribution to the photon field in nuclear reactors. Nuclear instruments and methods in physics research. Section A, Accelerators, spectrometers, detectors and associated equipment, 2015, 804, 149-154. M. Kromar, B. Kurinčič, "Determination of the NPP Krško spent fuel decay heat", V: AIP conference proceedings : Thermophysics 2017, 22nd International Meeting of Thermophysics 2017, Terchova, 12-14 September 2017, (AIP conference proceedings, 1866), Anton Trník, ur., Jurij Avsec, ur., Igor Medved, ur., Terchova, American Institute of Physics, 2017, p. 050005-1. HURE, Jeremy, EL SHAWISH, Samir, CIZELJ, Leon, TANGUY, Benoit. Intergranular stress distributions in polycrystalline aggregates of irradiated stainless steel. Journal of nuclear materials, 2016, vol. 476, pp 231-242, doi: 10.1016/j.jnucmat.2016.04.017
a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal - MASSTWIN Spreading Excellence and Widening Participation in Support of Mass Spectrometry and related techniques in Health, the Environment, and Food Analysis (H2020) - Epithermal neutron flux determination and validation of nuclear cross-sections and through activation measurements employing neutron spectrum filters (JSI-CEA collaboration project) - JOPRAD- Towards a Joint Programming on radioactive waste disposal (H2020 EURATOM) - NEWLANCER New Member States Linking for an Advanced Cohesion in Euratom Research (FP7 EURATOM) - "Characterization of the NPP Krško spent fuel for the purpose of storage in dry containers", project financed by Slovenian Nuclear Safety Administration (URSJV).
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; - Research reactor TRIGA MARK II - Hot cells facilities - Fully equipped radiochemical laboratories - Instrumentation for radiometric detection (gamma spectrometry, alpha spectrometry, liquid scintillation counters, proportional counters) - Instrumentation for mass spectrometry (MC-ICP-MS, laser ablation, quadrupole ICP-MS (ICP-QQQ, conventional ICP-MS), IRMS, QTRAP, MALDI MS)
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

No	Name	Acronym
Participant 23	European Commission, DG Joint Research Centre	JRC

Description of the legal entity

The Directorate General-Joint Research Centre is the European Commission's science and knowledge service. Its mission is to support EU policies with independent evidence throughout the whole policy cycle. Its work has a direct impact on the lives of citizens by contributing with its research outcomes to a healthy and safe environment, secure energy supplies, sustainable mobility and consumer health and safety. The JRC hosts specialist laboratories and unique research facilities and is home to thousands of scientists working to support EU policy. The JRC has ten Directorates and is located across five EU Member States (Belgium, Germany, Italy, the Netherlands and Spain).

The Directorate involved in this project is Directorate G – Nuclear Safety and Security within which the JRC's nuclear work programme, funded by the EURATOM Research and Training Programme, is carried out. It contributes to the scientific foundation for the protection of the European citizen against risks associated with the handling and storage of highly radioactive material, and scientific and technical support for the conception, development, implementation and monitoring of community policies related to nuclear energy. Research and policy support activities of Directorate G contribute towards achieving effective safety and safeguards systems for the nuclear fuel cycle, to enhance nuclear security then contributing to achieving the goal of low carbon energy production.

The research programmes are carried out at the JRC sites in Germany (Karlsruhe), Belgium (Geel), The Netherlands (Petten) and Italy (Ispira) and consist of research, knowledge management and training activities on nuclear safety and security. They are performed in collaboration and/or in support to the EU Member States and relevant international organizations. Today the Directorate G is one of the leading nuclear research establishments for nuclear science and technology and a unique provider of nuclear data measurements. Typical research and policy support activities are experimental and modelling studies covering nuclear reactor and fuel cycle safety, including current and innovative nuclear energy systems. Fundamental properties, irradiation effects and behaviour under normal and accident conditions of nuclear fuels and structural materials are studied. The activities cover also studies of structural integrity and functioning of nuclear components, emergency preparedness and radioactivity environmental monitoring, nuclear waste management and decommissioning, as well as the study of non-energy technological and medical applications of radionuclides. A dedicated functional entity is devoted to the management and dissemination of knowledge and to facilitate open access to JRC nuclear facilities including training and education.

Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks

1. The work to be performed by JRC is divided into three parts. The first part deals with the quantification of radionuclide inventory, the second part with spent fuel rod stability under predisposal conditions and the last part with knowledge management.
2. JRC-Geel will act as the co-ordinator of the task 2: Fuel properties characterisation and related uncertainty analysis. The main contribution is on the development of innovative non-destructive analysis (NDA) methods and the improvement of existing ones to characterise SNF. JRC-Geel, in collaboration with JRC-Ispira, will develop a detection system to determine the neutron output of a SNF pellet; design and construct a system to define the nuclide inventory of a SNF pellet by NDA applying Neutron Resonance Transmission Analysis (NRTA) and investigate the potential of new radiation resistant neutron detectors. They will also produce a report describing the performance of existing and innovative NDA systems for SNF characterisation, which is the main deliverable of subtask 2.2. JRC-Geel/Ispira will also assist in defining correlation schemes between experimental observables from NDA measurements and contribute to the definition of recommended state-of-the-art procedures to determine the main source terms (decay heat, neutron and gamma-ray emission rate, reactivity) of a SNF assembly.

Within subtask 3.1 "Thermo-mechanical-chemical properties of the SNF rods and cladding", JRC-Karlsruhe (JRC-Karlsruhe) will concentrate its experimental work on quantifying the effects of hydrogen load, hydride distribution and re-orientation as well as mechanical loading to create a knowledge base to evaluate the integrity of spent nuclear fuel rods affected by thermo-mechanical conditions as well as fuel/cladding chemical interaction after discharge from reactor but before final disposal. Additionally, the modification of

the fuels mechanical and elastic properties due to alpha-damage formation and associated radiogenic helium production will impact the ensemble cladding/fuel and also determine the magnitude of the fuel fragmentation during impact tests.

In respect to the objectives in subtask 3.1 JRC-Karlsruhe will perform two bending and one impact tests on pre-treated and non-treated spent UO_2 and MOX fuels. Five ring compression tests will be performed after different treatments followed by characterisation of the compressed irradiated cladding. In respect to the alpha-damage studies ^{238}Pu -doped UO_2 samples will be conditioned and thereafter followed by post-characterisation of the alpha-damaged ^{238}Pu - UO_2 samples by regular XRD and Vicker's hardness measurements complemented by TEM analyses.

The JRC-Karlsruhe experimental programme fits the task 3.1 objectives as it is the only part where real irradiated spent fuel rods are tested and the outcome used to benchmark the non-irradiated rod experiments in this task.

The JRC is has a leading role in the knowledge management programme, providing the knowledge management (KM) programme coordinator in the overall EURAD Programme Management Office (PMO), but also contributing to the organization of work within the three KM workpackages. The role of the KM programme coordinator in the PMO includes ensuring that the KM programme is evolving in line with the overall agreed upon objectives and workplan; communicating the progress of the individual KM workpackages to the PMO; keeping the KM workpackages informed about the overall EURAD coordination work and decisions; managing the fund with financial resources used for meetings, workshops, training events, training motilities, external experts in addition to the in-kind contributions within the EURAD and the development and maintenance the knowledge platform, etc. The contributions within the individual KM workpackages includes development of initial proposal and follow-up of the knowledge platform population strategy and time schedule, managing and reviewing the knowledge platform population process, managing the process for up-dating the PLANDIS Guide and development of the subsequent detailed guidance, contributing to the management of training events, establishment of on-line training material, and the training mobility programme.

a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities

Dr. Peter Schillebeeckx (M) will coordinate Task 2 and is responsible for the activities related to NDA of SNF. He has been responsible for several other tasks (workpackages) of projects in FP6 and FP7. He has more than 30 year experience in the field of NDA of nuclear material (calorimetry, neutron and gamma-ray detection), production of nuclear data, sensitivity analysis and uncertainty evaluation. He is one of the main actors behind the development of the use of Neutron Resonance Analysis for the characterisation of materials and objects.

Dr. Gašper Žerovnik (M) worked since 2007 in the fields of nuclear data and reactor physics. He has experience with fuel depletion calculations, since he was the main contributor to two projects for the Slovenian Agency for Radwaste Management, i.e. "Calculation of isotopic composition and decay heat from spent nuclear fuel from NPP Krško" (No. 03-00-014-004-2, 2008) and "Code for optimization of spent nuclear fuel filling into canisters for terminal disposal regarding constraints on decay heat" (No. 08-1-03-00-014-003-1, 2009). Additionally, he has experience in uncertainty analysis of nuclear data, where he contributed to the Work Package 10 ("Development of nuclear data for Myrrha reactor safety analyses") of the EU CHANDA project. For the applied project, his role would be to perform fuel depletion calculations, and to estimate and propagate the uncertainties originating from nuclear data.

Dr. Bent Pedersen (M) has worked more than 20 years with non-destructive assay methods and instrumentation for applications in nuclear safeguards, security and waste characterisation. He specialises in passive and active neutron detection systems for the characterisation of fissile materials mainly for safeguards purposes and for waste characterisation. He also operates a pulsed neutron interrogation facility for R&D in active neutron methods on fissile materials. He contributed to the Euramet funded Metrodecom project that concluded in 2017, and he is currently work package leader in the MetroDECOM II follow-up project. This work concerns validation of a measurement facility for characterisation of low and intermediate level nuclear waste.

Dr. Dimitrios Papaioannou (M) is in charge of the non-destructive and destructive examinations of spent nuclear fuel rods, including expertise in handling and preparation of fuel samples (AREVA, BNFL, METAPHIX, NFIR, DECOSTOS, SPERUS and DISCO). His role would be to coordinate handling, characterisation and sample distribution of spent fuel rods/samples.

Dr. Gunnar Buckau (M), having being involved in the EURATOM indirect action programme since the early eighties (Project “Migration of radionuclides in the geosphere” (MIRAGE)), in particular coordinator of the Integrated Project Fundamental Radionuclide Migration Processes (IP FUNMIG) (FP 6) but also coordinating HUMICS (FP4), HUPA (FP5), and ReCosy (FP7) before leaving to the JRC in 2011. The contribution to the present EURAD is based less on the scientific background, but rather the administrative and policy development, the key tasks at the IAEA (1994 – 1996) and at the JRC. In the more recent years, responsibility at the JRC has shifted from being the coordinator of the JRC RWM R&D project to becoming the head of the project on KM in RWM and Decommissioning. It is in this role that he represents the JRC in coordination of the EURAD KM programme as member of the PMO, and participates in the three different KM WPs.

Dr. Thierry Wiss (M) is involved in radiation damage studies and in microstructural analyses of nuclear materials (mainly using electron microscopy). His activities are also related to the ageing of spent nuclear fuel and of waste matrices and more particularly on the effects of rare gas formation and defect interaction in nuclear materials. He has been previously involved in the EU projects NF-PRO, SFS, RECOSY, FIRST-Nuclides. He will perform the SEM-EDX investigations and make interpretations of the SEM-EDX analyses of the corroded spent fuel surfaces.

Dr. Paul Carbol (M) during the last 15 years has worked in the field of spent fuel corrosion under reducing conditions. He has been a key contributor to several programmes devoted to the investigation of the corrosion mechanisms and expected environment in a deep underground repository (EC 5th FP SFS, 7th CP ReCosy, input to FP 7th MICADO and FIRST-Nuclides, JOPRAD and DISCO). His role would be to coordinate the work progress within the JRC.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

P. Schillebeeckx, B. Becker, H. Harada and S. Kopecky, "Neutron resonance spectroscopy for the characterisation of materials and objects", JRC Science and Policy Report, Report EUR 26848 EN.

Gašper Žerovnik, Luka Snoj, and Matjaž Ravnik, "Optimization of Spent Nuclear Fuel Filling in Canisters for Deep Repository", Nucl. Sci. Eng. 163 (2009) 183-190.

R. Nasyrow, D. Papaioannou, V. V Rondinella, E. Vlassopoulos, K. Linnemann, V. Ballheimer, J. Sterthaus, A. Rolle, F. Wille, S. Caruso, Bending test device for mechanical integrity studies of spent nuclear fuel rods, in: 18th International Symposium on the Packaging and Transportation of Radioactive Materials, PATRAM 2016, Institute of Nuclear Materials Management, Kobe, Japan, 2016.

E. Vlassopoulos, R. Nasyrow, D. Papaioannou, V.V. Rondinella, S. Caruso, A. Pautz, Destructive tests for determining mechanical integrity of spent nuclear fuel rods, in: ANS IHLRWM 2017 - 16th International High-Level Radioactive Waste Management Conference: Creating a Safe and Secure Energy Future for Generations to Come - Driving Toward Long-Term Storage and Disposal, 2017: pp. 726–733.

V.V. Rondinella, R. Nasyrow, D. Papaioannou, E. Vlassopoulos, F. Cappia, O. Dieste-Blanco, T.A.G. Wiss, Mechanical integrity studies on spent nuclear fuel rods, in: ANS IHLRWM 2017 - 16th International High-Level Radioactive Waste Management Conference: Creating a Safe and Secure Energy Future for Generations to Come - Driving Toward Long-Term Storage and Disposal, 2017: pp. 734–740.

Wiss, T., Hiernaut, J.-P., Roudil, D., Colle, J.-Y., Maugeri, E., Talip, Z., Janssen, A., Rondinella, V., Konings, R., Matzke, H., Weber, W., 2014, Evolution of spent nuclear fuel in dry storage conditions for millennia and beyond, 2014, J. Nucl. Mater., 451, pp. 198-206.

Wiss, T., Thiele, H., Janssen, A., Papaioannou, D., Rondinella, V.V., Konings, R.J.M., Recent Results of Microstructural Characterization of Irradiated Light Water Reactor Fuels using Scanning and Transmission Electron Microscopy, JOM, 2012, vol. 64, pp. 1390-1395.

G. Buckau, A. van Kalleveen, V. Matuzas, "Horizontal Activities, Working Document for development of Integrated Knowledge Management System on Radioactive Waste Management at European Level", Deliverable 3.6, EURATOM Coordination and Support Action "Towards a Joint Programming on Radioactive Waste Disposal" (JOPRAD), (to be published July 2018).

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

JRC-Directorate G (former Institute for Transuranium Elements, ITU) and Institute for Reference Materials and Measurements (IRMM) has been involved in several international programs on nuclear waste characterisation, storage and disposal issues, and collaborates with research centres and agencies worldwide. JRC-Karlsruhe has participated in the Source Term Assessment project SFS in FP5. In FP6 and FP7 ITU contributed to the projects NF-Pro, MICADO, ReCosy, FIRST-Nuclides and DISCO, where it also has had workpackage leadership.

JRC-Karlsruhe has participated to the project SFTEST where two devices for mechanical testing on fuelled, pressurized spent nuclear fuel rod segments have been developed for gravitational impact and 3-point bending tests. Before installation in the hot cells, the equipment has been tested and optimized by performing a campaign of "cold" tests. Additional project in SPEND (WP SPERUS) which included experimental hot cell studies in conjunction with single effect investigation to extend and deepen the characterization of the spent fuel rod integrity and response to mechanical loading under accidental handling or transportation. The tests are performed on spent fuel using our home-developed 3-point bending and impact test equipment.

JRC (ITU/IRMM) contributed to the EURAMET funded Metrodecom project that concluded in 2017, and contributes in the MetroDECOM II follow-up project. JRC-IRMM participated in the EURAMET funded MetroRWM project and in the H2020 Insider project. JRC-IRMM was also responsible for a workpackage within the FP7 CHANDA project related to sensitivity analysis and uncertainty evaluation.

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

The JRC Directorate Nuclear Safety & Security site in Karlsruhe has 24 concrete and lead hot cells with a capacity of up to 10^6 Ci along with a full range of shielded facilities in gloveboxes (optical microscope, SEM-EDX, EPMA, Knudsen cell, γ -spectrometers, gas-mass spectrometer for fission gas determinations etc.) for the handling, sample preparation, examination, and analysis of highly irradiated materials, including facilities to study electrochemical spent fuel corrosion using specific leaching and electrochemical techniques. The hot cells are configured to accept full-length fuel rods. Structural, micro-structural, micro-analytical, mechanical, thermo-physical, thermodynamic and chemical studies are performed on a wide array of irradiated fuels and materials.

A total of more than 300 gloveboxes in 30 laboratories equipped with instruments relevant for transuranium element investigations are available. The surface investigations are performed by electron-optical investigations made by SEM-EDX and TEM. The chemical analyses of highly radioactive aqueous solutions are performed in the chemical hot cells by ICP-MS, ICP-OES and γ -spectrometry.

In preparation for developing a KM platform, JRC at its "Science Hub" has established the web site "Managing decommissioning & radioactive waste management knowledge". At this site, aspects relevant for the forthcoming RWM-EURAD-1 Knowledge Platform are developed and tested. As a test case for using multilinked web format, the state-of-knowledge for the three topical areas are developed for the project "Improved nuclear site characterization for waste minimization in decommissioning operations under constrained environment" (INSIDER). The process of coupling the SoK with training material and documenting and developing this in a web-based format is foreseen to be further implemented in the field of decommissioning, and may be directly used for the RWM-EURAD-1 or used as experience feedback and input for establishing the knowledge platform at another host.

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.N/A

	No	Name	Acronym
Participant	24	Karlsruhe Institute of Technology	KIT
Description of the legal entity Karlsruhe Institute of Technology (KIT) is one of the biggest science and engineering research institutions in Europe and funded jointly by the Federal Republic of Germany and the State of Baden-Wuerttemberg. Its research and development program is embedded in the superordinate program structure of the Helmholtz Association of National Research Centers. KIT was established by the merger of the Forschungszentrum Karlsruhe GmbH and the Universität Karlsruhe (TH) on October 01, 2009. KIT combines the tasks of a university of the state of Baden-Württemberg with those of a research center of the Helmholtz Association in the areas of research, teaching, and innovation. In research and education, KIT assumes responsibility for contributing to the sustainable solution of the grand challenges that face the society, industry, and the environment. Project Management Agency Karlsruhe (KIT-PTKA): Since 1971 the project management agency KIT-PTKA is a service provider, partner, and codesigner of various customers of public organisations with a view to promote scientific research, technical development, and dissemination of research results in the field of nuclear waste management, environment and energy, water technology, production and services. Approximately 2000 projects/a are supervised by KIT-PTKA with a total volume of 135 Mio. EUR/a. In the competence area of nuclear waste management, KIT-PTKA is an agency of the Federal Ministry of Economics and Energy (BMWi) and supervises technical and administrative R&D projects in the fields of "Disposal of highly radioactive waste" and "Nuclear Safety Research". In 2017 ~ 50 Mio. EUR were invested by the BMWi to carry out R&D work in ~ 75 projects. Institute of Nuclear Waste Disposal (KIT-INE): The Institute for Nuclear Waste Disposal (INE) at KIT is strongly focusing on safety research for radioactive waste disposal by investigation of geochemical processes relevant for assessing long-term behavior of waste forms and (geo-)technical and natural barriers. The research contributes to the demonstration of safety within the disposal Safety Case for all types of host rock under consideration. Since several years, INE is one of the driving organizations developing of scientific knowledge which feeds the geochemically based long-term safety assessment for radioactive waste disposal. The competence of INE covers, amongst others, interactions of waste forms and barrier materials in disposal systems, basic radionuclide thermodynamics, the behavior of long-lived radionuclides in the geosphere, radionuclide transport properties in all host rocks considered in Europe, isotope-geochemistry and hydrology. In the area of the nuclear waste disposal Safety Case, it provides support in various national advisory bodies and interacts within several international collaborations.			
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks Project Management Agency Karlsruhe (KIT-PTKA): In its role as a management agency, PTKA will not participate in individual work packages in the form of scientific activities. Rather, PTKA has the task of integrating relevant LTPs into the development of scientific content and implementing the corresponding legal link. Furthermore, PTKA will ensure that all administrative requirements in connection with the implementation of joint programming at national level are met at organisational level. Institute of Nuclear Waste Disposal (KIT-INE): KIT-INE will contribute to EURAD on several levels. Within CORI, KIT-INE will serve as the WP Coordinator and also contribute to the technical RD&D. In SFC, KIT-INE will serve as co-task leader and perform RD&D. In FUTURE, KIT-INE will contribute to the RD&D program. Additional activities of KIT-INE within EURAD are related to the Strategic Study UMAN and contributing to the Knowledge Management program. Given the high level of technical expertise at KIT-INE in all the fields relevant for the proposed work in EURAD, and the broad experience in coordinating national and international RD&D, KIT-INE is fully able			

to carry out the work proposed within EURAD.

a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities

Project Management Agency Karlsruhe (KIT-PTKA):

Since May 2010 Dr. Silvia Stumpf is working at the Project Management Agency Karlsruhe (KIT-PTKA) in the "Disposal" department, where she is responsible for "Nuclear Safety Research - Disposal Research" as project manager. Furthermore, S. Stumpf is in charge of all international tasks such as representing the national contact point for nuclear waste disposal, managing international relations and supervising international projects. In addition to the work as project manager, S. Stumpf was involved from 2010 to 2016 in the closure process of the German repository Asse as a member of the "Working Group on Closure Options" (AGO). For the period 2015-2016 she had the lead of the AGO office. In all mentioned functions, S. Stumpf assumes responsibility as a service provider for the federal ministries BMWi, BMBF and BMUB.

Institute of Nuclear Waste Disposal (KIT-INE):

Dr. Marcus Altmaier (male) is expert on aquatic chemistry and thermodynamics of actinides and long lived fission products. Dr. Altmaier joined KIT-INE in 2000, since 2012 he is head of the Radiochemistry Division at KIT-INE. In 2017 he was appointed deputy director of KIT-INE. Experimental research activities focus on radionuclide chemistry in aqueous media. Dr. Altmaier has a strong interest in radioanalytical techniques, actinide and fission product chemistry and the study of radionuclide solubility phenomena in dilute to concentrated systems. Dr. Altmaier has been involved in several national and international projects, ranging from fundamental scientific research on actinide chemistry to applied work related to the final disposal of nuclear waste in deep underground facilities. Dr. Altmaier served as Coordinator for the EC funded projects RECOSY (2010-2013) and CEBAMA (2015-2019), and is currently developing the WP CORI within EURAD.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- [1] Altmaier, M.; Gaona, X.; Fanghänel, Th., Recent Advances in Aqueous Actinide Chemistry and Thermodynamics, Chemical Reviews (2013), 113, 901–943.
- [2] Altmaier, M. (Hrsg.), Montoya, V., Duro, L., Valls, A., Proceedings of the First Annual Workshop of the HORIZON 2020 CEBAMA Project; KIT Scientific Publishing, Karlsruhe, (2017). <http://dx.doi.org/10.5445/KSP/1000068889>.
- [3] Duro, L., Bruno, J., Grivé, M., Montoya, V., Kienzler, B., Altmaier, M., Buckau, G.; Redox processes in the safety case of deep geological repositories of radioactive wastes. Contribution of the European RECOSY Collaborative Project, Applied Geochemistry, Vol. 49, 206-217, 2014.
- [4] Geckeis, H., Lützenkirchen, J., Polly, R., Rabung, Th., Schmidt, M., Mineral–Water Interface Reactions of Actinides, Chemical Reviews (2013), 113, 1016–1062.
- [5] Kienzler, B., Duro, L., Lemmens, K., Metz, V., De Pablo, J., Valls, A., Wegen, D., Johnson, L., Spahiu, K., Summary of the Euratom collaborative project FIRST-nuclides and conclusions for the safety case, Nuclear Technology 198(3), pp. 260-276, 2017.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

EC projects:

- CEBAMA (Horizon 2020): Collaborative project on “Cement-based materials, properties, evolution, barrier functions”. June 2015 – May 2019. (Coord. KIT-INE).
- FIRST NUCLIDES (FP7): Collaborative project on “Fast / Instant Release of Safety Relevant Radionuclides from Spent Nuclear Fuel”. January 2012 – December 2015. (Coord. KIT-INE).
- RECOSY (FP7): Collaborative project on “Redox Phenomena Controlling Systems”. April 2008 - March 2012. (Coord. KIT-INE).

German projects:

- GRaZ (BMW/PTKA): Collaborative project on “Geochemical retention of radio nuclides on cement alteration phases”. September 2015 – August 2018.
- ENTRIA (BMBF/PTKA): Collaborative project on “Disposal Options for Radioactive Residues:

Interdisciplinary Analyses and Development of Evaluation Principles". 2013 - 2017
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; <i>Project Management Agency Karlsruhe (KIT-PTKA):</i> More than 100 employees at two locations at the main office in Karlsruhe and the branch office in Dresden use the excellent infrastructure of and vicinity to research at the Karlsruhe Institute of Technology. <i>Institute of Nuclear Waste Disposal (KIT-INE):</i> INE laboratories are fully licensed and equipped with all necessary infrastructures to perform research with radionuclides in the context of Safety Research for Nuclear Waste Disposal. This is including hot cells, alpha glove boxes, inert gas alpha glove boxes and radionuclide laboratories. State-of-the-art analytical instruments and methods and advanced spectroscopic tools exist for the sensitive detection and analysis of radionuclides. Trace element and isotope analysis is made by instrumental analytical techniques such as X-ray fluorescence spectroscopy (XRF), atomic absorption spectroscopy (AAS), ICP-atomic emission spectroscopy (ICP-AES) and ICP-mass spectrometry (Quadrupole-ICP-MS and high resolution ICP-MS). Methods available for surface sensitive analysis and characterization of solid samples include X-ray diffraction (XRD) and atomic force microscopy. A modern X-ray photoelectron spectrometer (XPS) and an environmental scanning electron microscope (ESEM) are installed. INE has direct access to a TEM instrument. A wide variety of Laser spectroscopic techniques are developed and are available including laser fluorescence spectroscopy (TRLFS), or laser-induced breakdown detection (LIBD). NMR analysis of radioactive samples is possible. INE operates the INE-Beamline at the Karlsruhe synchrotron source KARA (formerly ANKA) where extended X-ray absorption fine structure (EXAFS) spectroscopy and other techniques are available for investigations of radioactive samples. INE also uses different codes for modeling, multiphysics/geochemical codes like iCP COMSOL-PHREEQC amongst others.
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task. All required operational capacity to carry out the work proposed by KIT-PTKA as well as KIT-INE within EURAD is fully available.

	No	Name	Acronym
Participant	25	Lietuvos Energetikos Institutas	LEI
Description of the legal entity			
Lithuanian Energy Institute (LEI) is a state scientific research organization with about 250 employees. LEI carries out fundamental and applied research in various fields related to radioactive waste and spent nuclear fuel (SNF) management, heat transfer, hydro and gas dynamics, alternative energy sources, materials science. LEI laboratories are participating in broad of international projects (COST, EUREKA, FP5, FP6, FP7, H2020, IAEA, Phare, etc.). Since 1994 the LEI Nuclear Engineering Laboratory (NEL) has been actively involved in the analysis of the radioactive waste management problems at Ignalina NPP covering planning and decommissioning of nuclear power plant, designing storage, treatment and disposal facilities, evaluating environmental impact of nuclear facilities and post closure safety of repositories. Implementing the research on SNF and long-lived intermediate level waste disposal in Lithuania, the researchers of LEI NEL with the assistance of experts from Sweden and other countries proposed the concept of deep geological repository in crystalline and clay rocks in Lithuania, and generic repository safety assessment was initiated. The concept on disposal and the safety assessment are constantly being updated taking into account international experience and thermal, groundwater flow, mechanical and chemical properties of a possible repository site.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks			
LEI will contribute to five RD&D (“Mechanistic understanding of gas transport in clay materials”, “Influence of temperature on clay-based material behaviour”, “Assessment of chemical evolution of ILW and HLW disposal cells”, “Spent fuel characterisation and evolution until disposal”, “Development and improvement of numerical methods and tools for modelling coupled processes”), two Strategic Studies (“Waste Management routes in Europe from cradle to grave”, “Understanding of uncertainty, risk and safety”) and Knowledge Management Work Packages.			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities			
Prof. Povilas Poskas is the head of Nuclear Engineering Laboratory with large and over 20 years experience in the field of radioactive waste and SNF management. He will be responsible for coordination of LEI contributions, development of methodologies/models and analysis of the results. Dr. Dalia Grigaliuniene is a senior researcher with experience in numerical modelling of radionuclide transport and chemical processes interaction under different scenarios. She will be responsible for LEI activities in WP “Assessment of chemical evolution of ILW and HLW disposal cells”. Dr. Darius Justinavicius is a researcher with experience in numerical modelling of gas transport and modelling of coupled thermo-hydro-mechanical processes. He will be responsible for LEI activities in WP “Mechanistic understanding of gas transport in clay materials”. Dr. Ernestas Narkunas is a senior researcher with experience in numerical modelling of radiation transport, neutron activation, shielding and spent fuel characterization. He will be responsible for coordination of LEI activities in Knowledge Management WP. Dr. Asta Narkuniene is a senior researcher with experience in numerical modelling of radionuclide transport from the repository under different evolution scenario, modelling of coupled processes and uncertainty/sensitivity analysis. She will be responsible for LEI activities in WP “Development and improvement of numerical methods and tools for modelling coupled processes”.			

Dr. Gintautas Poskas is a researcher with experience in uncertainty, sensitivity and multi-criteria decision analysis. He will be responsible for LEI activities in Strategic Study “Understanding of uncertainty, risk and safety”. Dr. Robertas Poskas is a senior researcher with experience in the field of radioactive waste and SNF management and investigations of the thermal processes. He will be responsible for LEI activities in WP “Influence of temperature on clay-based material behaviour”. Dr. Arturas Smaizys is a senior researcher with experience in numerical modelling of activation processes and spent fuel characterization. He will be responsible for LEI activities in WP “Spent fuel characterisation and evolution until disposal”. Dr. Audrius Simonis is a researcher with experience in management and characterization of institutional and decommissioning radioactive waste. He will be responsible for LEI activities in Strategic Study “Waste Management routes in Europe from cradle to grave”.
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content Justinavicius D., Poskas P., Narkuniene A. Gas migration modelling in geological repository module in clay formation and sensitivity analysis. Engineering geology. 2016. Vol. 213, p. 158-168. Narkunas E., Smaizys A., Poskas P., Ragaisis V. Modelling of RBMK-1500 SNF storage casks activation during very long term storage. Applied radiation and isotopes. 2016. Vol. 115. p. 100–108. Poskas P., Grigaliuniene D., Narkuniene A., Kilda R., Justinavicius D. Modelling of irradiated graphite ¹⁴C transfer through engineered barriers of a generic geological repository in crystalline rocks. Science of the Total Environment. 2016. Vol. 569–570, p. 1126–1135. Narkuniene A., Poskas P., Kilda R., Bartkus G. Uncertainty and sensitivity analysis of radionuclide migration through the engineered barriers of deep geological repository: Case of RBMK-1500 SNF. Reliability Engineering & System Safety. 2015. Vol. 136, p. 8–16. Justinavicius D., Sirvydas A., Poskas P. Thermal analysis of reference repository for RBMK-1500 spent nuclear fuel in crystalline rocks. Journal of Thermal Analysis and Calorimetry. 2014. Vol. 118(2), p. 767–773.
a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal H2020 research projects: BEACON (2017-2021), THERAMIN (2017-2020); FP7 research projects: CAST (2013-2018), FORGE (2009-2013), CARBOWASTE (2008-2012); IAEA Coordinated Research Project: “The use of numerical models in support of site characterization and performance assessment studies for geological repositories” (2005-2010).
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; LEI researches in the consortium will be focused on modelling activities (model development, validation and application). Range of modelling tools COMSOL, CODE-BRIGHT, COMPASS, GOLDSIM, MCNP, SCALE, PETRASIM, PHAST, PHREEQC and supercomputer available at LEI NEL will be used.
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

N/A

No	Name	Acronym
Participant 26	Centre for Energy Research, Hungarian Academy of Sciences	MTA EK
Description of the legal entity Hungarian Academy of Sciences Centre for Energy Research was established in 2012 by a merger of two Institutes: KFKI Atomic Energy Research Institute and MTA Isotope Institute. MTA EK is mainly active in the field of basic and applied research related to nuclear energy. The activities of the Centre started in the 1950's. The main research areas of MTA EK are reactor physics, thermal hydraulics, fuel behaviour studies, and material sciences, health physics, environmental physics, nuclear electronics and chemistry. MTA EK is the chief technical consultant of NPP Paks and key player in the power-upgrade, safety, life extension and maintenance activity of the utility. At the same time MTA EK also serves as a technical support organisation (TSO) to the nuclear safety authority in Hungary. The Centre operates the 10 MW Budapest Research Reactor, providing the scientific community of Europe (see Budapest Neutron Centre for details) with research possibility for neutron physics and applications. The Centre has acquired important experience with VVER-type reactors, both in experimental and in analytical fields. MTA EK has been contributing to many EURATOM research programs and member of several expert associations. The Centre is the co-founder of V4G4 Centre for Excellence which organizes the research for the next generation gas cooled fast reactor. MTA EK is the coordinator of the National Nuclear Research Program focusing on radiation ageing of reactor structural materials, spent fuels and radioactive waste management and advanced modelling and simulation of nuclear reactor physics.		
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks The work programme within EURAD-1 will be performed under Radioactive Waste and Decommissioning platform of MTA EK involving Fuel and Reactor Materials, Nuclear Security and Environmental Physics Departments and as LTP the Social Organization for Radioecological Cleanliness. RD&D is focused on spent fuels, RN mobility in clay, conditioning and deep geological disposal of radioactive waste. Environmental Physics and Nuclear Security Departments are interested in FUTURE and ACED WP's: - in FUTuRE Subtask 2.1-Mobility of radionuclides in compacted clay with following plan: MTA EK will carry out diffusion experiments on host rock samples with radiotracers (Eu, U, Ra, Se) assuming different perturbation effects and microscopic investigations of the diffusion front (inactive Se) and in FUTuRE Subtask 2.3- Reversibility of sorption; with plan: MTA EK will carry out test uptake experiments (Ni) involving thin sections for transferability of sorption phenomena, TEM identification of irreversibly formed phases on micro/nanoscale in natural rock sample, study of sorption reversibility using isotope exchange experiments (Ni, Ra) and modelling, experiments and modelling of competition of metal sorption in clay systems. In ACED Subtask 2.1-Steel/clay material interface reactivity; MTA will set up new experiment with KO-033 steel – plate and/or cylinder placed in contact with the Boda claystone formation between ambient temperature and 80°C. In ACED Subtask 2.2-Steel/cement material interface reactivity; MTA will set up new experiments with steel (KO33) – plate and/or cylinder emplaced with Portland concrete or other cementitious mixture from ambient temperature to 80°C. In ACED Subtask 3.1 – <i>Experimental analysis</i>; MTA EK will carry out different experiments in order to study the chemical evolution of a system borosilicate glass/steel/Boda-claystone formation (BCF). They focus on the understanding of the secondary phase formation (SEM, TEM, XRD, XPS methods). In ACED Subtask 3.2- Modelling of chemical evolution of HLW waste package scale; Using previous datasets, and the results from the planned experiments in subtask 3.1, MTA EK use GEMs, an advance sorption model (2SPNE CE/SC) and the GoldSim 8.02 software, which is suitable to model a complex system taking into account various conditions and mechanisms.		

Fuel and Reactor Materials Department is interested in SFC WP, in Subtask 3.1-Thermo-mechanical-chemical properties of the SNF rods and cladding; Creep tests will be performed with pre-hydrided and pre-treated at high temperatures Zr1%Nb samples. Hydride reorientation will be studied with pre-hydrided samples in mechanical tests at different temperatures and with different mechanical loads. Post-test investigation of the samples will be carried out with optical and scanning electron microscopy.

in Subtask 3.3- Pellet-cladding interaction under conditions of extended storage, transport and handling of SNF rods;

Cladding samples will be pre-treated in order to simulate the typical conditions for dry storage. Several samples will be charged with hydrogen, other samples will be treated in high temperature inert gas. Mandrel tests will be carried out to simulate crack propagation in cladding.

Through our LTP (Social Organization for Radioecological Cleanliness (SORC)) we are interested in DONUT WP.

In Task 2.- Numerical methods for high performance computing of coupled processes;

SORC will develop modules with numerical algorithms adapted to the resolution of multiphysic coupled problem on GPU-CPU Server platforms.

The lists of projects and publications indicate the experiences of MTA EK in spent fuel studies, the radionuclides transport in clay-rich rock systems and the conditioning of HLW. Our staff and equipment is suitable to serve the initiated program of EURAD-1.

a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities

CV of Zoltán Hózer who is responsible for SFC WP

Graduated as nuclear engineer from the Moscow Power Engineering Institute in 1984. Dr. Univ diploma for two-phase flow modelling at Budapest Technical University in 1988. PhD diploma for leaking fuel modelling at Budapest University of Technology and Economics in 2003. DSc diploma for experimental investigation of fuel integrity at the Hungarian Academy of Sciences in 2016.

Working at Centre for Energy Research, Hungarian Academy of Sciences (MTA EK) and at the KFKI Atomic Energy Research Institute (AEKI) since 1984. Head of the Fuel and Reactor Materials Department for more than twenty years. Leader of experimental programmes with VVER fuel components focusing on the behaviour of Zr claddings in normal operation, accident and storage conditions.

Member of programme review groups of international fuel projects (OECD Halden Reactor Project, SCIP III, Sandia Fuel Project, RASPLAV, MASCA). Co-ordinator of the OECD-IAEA Paks Fuel Project. Participant of several EU projects (OPSA, COLOSS, SARNET, ENTHALPY, COVERS, FIRST-Nuclides, ESNII Plus). Chairperson of the OECD Working Group on Fuel Safety.

Lecturer at the Budapest University of Technology and Economics. Former president of the Hungarian Nuclear Society.

Complete list of publications at https://www.kfki.hu/~hozer/Hozer_Zoltan_en.htm

CV of János Osán, who is responsible for FUTuRE WP

János Osán graduated in 1992 as a physicist at the Eötvös Loránd University in Budapest, Hungary. He received a Ph.D. degree in environmental physics and biophysics at the Semmelweis University, Budapest, Hungary, in 1997. He spent postdoctoral fellowship at the Department of Chemistry, University of Antwerp on methodological development and application of electron probe X-ray microanalysis of individual environmental particles, until 1999.

Since then, he has been working as a research scientist at the Environmental Physics Department of the Hungarian Academy of Sciences Centre for Energy Research. He has been involved in methodological development and application of modern X-ray microanalytical methods in environmental analysis, microscopic X-ray fluorescence and absorption spectrometry. His main research fields are microscale characterization of radionuclide uptake of the host rock of high-level radioactive waste repository, environmental evaluation of fossil, nuclear and renewable energy generation technologies, measurements and dispersion modelling of atmospheric aerosol particles.

In 2003, he received Young Scientist Award of the Hungarian Academy of Sciences based on his outstanding scientific achievement in environmental physics. In 2005, he received Certificate of Merit by the Hungarian Academy of Sciences, Advisory Board of the János Bolyai Research Fellowship, for outstanding research work between 2001 and 2004.

He is member of the Hungarian Synchrotron Board, Hungarian Aerosol Society within Hungarian Chemical Society and the European X-ray Spectrometry Association. He was asked as invited speaker at various European scientific conferences and selected as a member of Editorial Board of journal Spectrochimica Acta Part B.

He was principal investigator of several national, bilateral and European projects, acted as coordinator of the Swiss-Hungarian Cooperation project "Development of a macro- and microscopic approach to investigate the geochemistry of radioactive waste disposal systems" between 2012 and 2015.

He spent two years (2016-2017) in the Nuclear Science of Instrumentation Laboratory of the International Atomic Energy Agency (IAEA), worked as consultant on development and environmental applications of X-ray fluorescence and absorption spectrometry.

He is co-author of 5 book chapters and 73 scientific papers for which he received 890 independent citations.

CV of Margit Fábíán, who is responsible for ACED WP

Margit Fábíán received her MSc degree from Babes Bolyai University of Cluj-Napoca, Romania and PhD degree in Theoretical and physical chemistry, materials science program at Eötvös Loránd University of Budapest in 2010. Between 2003 and 2011 she worked at the Wigner Research Centre for Physics, since 2012 she's research fellow at Centre for Energy Research in Department of Environmental Physics. Her research activity is focused on the development and study of amorphous and crystalline systems. She performed comprehensive work in the field of storage and management of radioactive waste, focused the preparation and characterization of special matrix systems for storage of high-level radioactive waste. She has extensive experience in the field of microstructural characterization (neutron and X-ray methods) and computer modelling of atomic structure. She develops a special sample environment - with High Temperature and Pressure Cell - at PSD neutron diffractometer where she is instrument scientist. She established a radiochemistry laboratory for preparation of glassy materials, installed special instruments and equipment's.

She was principal investigator of several national and international-projects, acted as leader of the OTKA-PD 'Preparation, structural studies and optimization of borosilicate glasses for HLW storage applications' (2014-2016), 'Novel oxy-halide superionic glasses for safe rechargeable solid state batteries' (2018-2021) supported by the National Research, Development and Innovation Office, industrial R&D project 'Investigation of basaltic magmatic matrices' (2016-2017) etc.

She is Secretary of Hungarian Nuclear Society and president of Diffraction Committee of the Roland Eötvös Society of Physics. She is member of Solid State Physical Science Committee of Hungarian Academy of Sciences, member of the ASTM International Committee C26 on Nuclear Fuel Cycle and board member of the Budapest Neutron Centre.

Detailed List of Publications in MTMT database, with ID: 10013934 or in:

<https://vm.mtmt.hu/search/slist.php?lang=0&AuthorID=10013934>

CV of Tibor Kovács who is responsible for DONUT WP as LTP of MTA EK

Graduated as chemical engineer from the University of Veszprem in 1994. PhD in Biological effects of ionizing radiation at Semmelweis University in 2005.

Working at University of Pannonia since 1999. Head of the Institute of Radiochemistry and Radioecology.

The main research topics are measurements of alpha emitted radioisotopes, investigation of the resources of radon, parameters influencing its moving in buildings and in underground area, investigation of radon, thoron and daughter elements equilibrium, the sorption of daughter elements, their admission to the human body, investigation of radionuclide uptake of vegetable samples. Evaluation of dose contributions by radionuclide, study of natural originating alpha-emitter radionuclides by alpha spectrometry, development of new sample preparation methods, radiological assessment of drinking-, mineral-, and spring-water.

Member of the editor board in two scientific paper: Nature and Journal of Nuclear Chemistry. President of Social Organization for Radioecological Cleanliness. Lecturer at the Chemical and Environmental Sciences Doctoral School.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

1. Márton Király, Dániel Mihály Antók, Lászlóné Horváth, Zoltán Hózer: Evaluation of axial and tangential ultimate tensile strength of zirconium cladding tubes, Nuclear Engineering and Technology, 50,3 (2018) 425-431, DOI: [10.1016/j.net.2018.01.002](https://doi.org/10.1016/j.net.2018.01.002)

2. H. Hózer, Cs. Győri, L. Matus, M. Horváth: Ductile-to-brittle transition of oxidized Zircaloy-4 and E110 claddings, Journal of Nuclear Materials, 373 (2008) 415-423, DOI: [10.1016/j.jnucmat.2007.07.002](https://doi.org/10.1016/j.jnucmat.2007.07.002)
3. J. Osán, A. Kéri, B. Breitner, M. Fábián, R. Dähn, R. Simon, S. Török: Microscale analysis of metal uptake by argillaceous rocks using positive matrix factorization of microscopic X-ray fluorescence elemental maps, Spectrochimica Acta Part B 91 (2014) 12-23; DOI: [10.1016/j.sab.2013.11.002](https://doi.org/10.1016/j.sab.2013.11.002)
4. D. Breitner, J. Osán, M. Fábián, P. Zagyvai, C. Szabó, R. Dähn, M. Marques Fernandes, I. Sajó, Z. Máthé, S. Török: Characteristics of uranium uptake of Boda Claystone Formation as the candidate host rock of high level radioactive waste repository in Hungary, Environmental Earth Sciences 73 (2015) 209-219, DOI: [10.1007/s12665-014-3413-4](https://doi.org/10.1007/s12665-014-3413-4)
5. M. Fábián, E. Sváb, M.V. Zimmermann, Structure study of new uranium loaded borosilicate glasses, Journal of Non-Crystalline Solids 380 (2013) 71-77, DOI: [10.1016/j.jnoncrysol.2013.09.004](https://doi.org/10.1016/j.jnoncrysol.2013.09.004)

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

1. Zirconium Materials Science Studies, 2017-2019, supported by the National Research, Development and Innovation Fund of Hungary (contract number: NVKP_16-1-2016-0014)
2. Hungarian Nuclear Research Platform, 2015-2018, supported by the National Research, Development and Innovation Fund (contract number: VKSZ_14-1-2015-0021)
3. Development of a macro and microscopic approach to investigate the geochemistry of radioactive waste disposal systems, 2010-2015, supported by the Swiss-Hungarian Cooperation Programme (contract number: SH/7/2/11)
4. Preparation, structural studies and optimisation of borosilicate glasses for HLW storage applications, 2014-2016, supported by the National Research, Development and Innovation Fund (contract number: OTKA-PD 109384)
5. OECD-IAEA Paks Fuel Project, 2005-2007, <https://www.oecd-neo.org/nsd/docs/2008/csni-r2008-2.pdf>

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

Our Institute is one of the most equipped knowledge base in Hungary in the Academic sector.

- Isotope laboratory (Grade C) available with equipment necessary for wet chemistry experiments, diffusion cells
- Gamma spectrometers, Liquid scintillation counters
- ICP-MS instrument
- Unique XRF, XRD equipment are in regular use for elemental mapping and bulk measurements
- MTA EK hosts the Budapest Neutron Centre where different beamlines are provided (Neutron Diffraction, Neutron Tomography etc.)
- Transmission electron microscopes with ion milling sample preparation
- Scanning electron microscopes
- Mössbauer spectroscopy

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

N/A

Participant	No	Name	Acronym
	27	National Cooperative for the Disposal of Radioactive Waste in Switzerland	Nagra
Description of the legal entity Nagra (the Swiss national cooperative for the disposal of radioactive waste) is responsible for the safe management of all types of radioactive waste arising in Switzerland. Since it was founded by the Swiss electricity utilities and the government in 1972, Nagra has developed into an internationally recognised know-how centre in the field of nuclear waste management. Nagra's activities span the areas of development of disposal concepts, regional studies, field investigations and site characterisation, performance assessment, design of deep geological repositories as well as design, construction and operation of underground research facilities. Through operation of the Grimsel test site (GTS) and participation in the Mont Terri URL, Nagra's scientists have been and are involved in the planning, implementation and interpretation of research, development & demonstration programmes during the past 20 years addressing all major aspects of underground disposal of radioactive waste. Nagra's work is supported by an effective quality management system that is certified in accordance with ISO 9001.			
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks <u>WP HITEC</u> Coordination of the Subtask 4.1: Guidance for safety case development and repository optimization, contribution to the SOTA, coordination of the THM URL FE experiment modelling benchmark. As an implementor and owner of the FE experiment Nagra is well placed to perform these tasks. <u>WP Gas</u> Technical coordination of Task 2 "Barrier integrity", including the elaboration of a detailed scope of work, FEP-screening, elaboration of a state-of-the-art report. Technical coordination of sub-task 2.1 ("Gas-induced impacts on barrier integrity"), emphasising an integrated laboratory programme for investigating the evolution of damage of clay-rich geomaterials when subjected to excessive water/gas pressures. <u>WP Uncertainty Management multi-Actor Network (UMAN)</u> Nagra will lead Subtask 4.2 "Compilation and review of [...] information on [...] management options" and actively provide input from the Swiss program to other tasks. Nagra has been dealing with uncertainty management through its safety analysis for several decades. <u>WP SFC</u> Since a large part of the Swiss HLW inventory to be disposed of consists of spent nuclear fuel (SNF, also high burn-up), Nagra has developed significant expertise in this domain in the last decades to ensure the optimization of the loading of disposal canisters and plan for the final disposal including the operational and post-closure safety assessment. As a consequence Nagra will coordinate the following subtasks: • 1.2 – State-of-the-art and Gap analysis • 4.1 – Accident scenario for fuel under dry interim storage conditions Moreover, Nagra will contribute to the following subtasks with activities and know-how: 1. 1.3 – Training materials 2. 2.1 – Theoretical study of SNF source terms 3. 2.3 – Determine the inventory of activation and fission products in cladding material 4. 3.1 – Thermo-mechanical-chemical properties of the SNF rods and cladding 5. 4.2 – Consequence analysis of postulated accidents			
A curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities <i>Irina Gaus</i> (female) is currently head of research and development at Nagra and during 2017 also ad interim manager for the safety based comparison of the siting regions for the future repositories in Switzerland. Before joining Nagra in 2007 she worked for the French Geological Survey (BRGM) and the			

British Geological Survey. She obtained her PhD in hydrogeology at the University of Ghent (Belgium) in 1998 where she also graduated as a geologist. Her technical expertise covers environmental applications of the shallow and deep subsurface (radioactive waste disposal, thermo-hydro-mechanical-chemical impacts, carbon storage, groundwater management).

Paul Marschall (male) coordinates Nagra's geoscientific modelling activities with special focus on phenomenological analyses of repository induced effects. This includes the simulation of thermo-hydro-mechanical and -chemical (THM-C) coupled processes in the engineered barrier system (EBS) and the host rock, respectively, but also model-based assessments of the overall performance of a geological repository in response to repository induced perturbations (heat and gas emission of the wastes, perturbations of the initial stress and pore pressure conditions, hydro-chemical interactions of the EBS materials with the host rock). Paul's scientific interests are related to pore water flow and gas transport processes in low-permeability rock formations and to the geomechanical characteristics of indurated clays (claystones, shales), which exhibit transitional deformation behavior between hard soils and weak rocks.

Thomas Kämpfer (male) graduated as mathematics engineer in 1998 from Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland. After his diploma, Mr. Kaempfer continued on with a Ph.D. in Computational Materials Science in the Faculty of Engineering at EPFL. From the completion of his Ph.D. until 2009, Mr. Kaempfer studied transport processes in geophysical materials with a focus on snow. Mr. Kaempfer joined AF-Consult (formerly AF-Colenco) in 2009 and has led the Department for Groundwater Protection and Waste Disposal from 2013 to 2017. Besides his management tasks he has participated in long-term safety analyses for the comparison and in sensitivity analyses of repository systems, as well as in software development projects. He focused on project acquisition and management but contributed actively to all phases of the projects. Since November 2017, Mr. Kaempfer is working at Nagra on the safety case for the Swiss radioactive waste repository program and since July 2018 is leading the safety analysis group. He and his group are providing the safety related argumentation for the site selection for Switzerland's deep geological repositories and are responsible for the safety case that will be a key document of the general license application. In his role, Mr. Kaempfer is actively involved in uncertainty management activities at Nagra.

Berrak Firat Lüthi (female) studied Geological Engineering at Middle East Technical University, Turkey, between the years 2007-2012. Upon completion of her Bachelor she started working at borehole exploration sites as a site engineer for 6-month. In 2013, she has started her Master's Degree program in the Department of Engineering Geology at ETH Zurich and finished her studies in October 2015. Since 15.08.2016 Mrs. Firat Lüthi has been working at the Swiss National Cooperative for the Disposal of Radioactive Waste (Nagra).

Throughout her Master studies, she has had 4-month of industrial internship at Nagra. She has had the opportunity to work for the FE Project in the Mont Terri Underground Rock Laboratory in St. Ursanne during the instrumentation and the backfilling of the FE-Tunnel. After her graduation, she had the chance to start another internship, where she was responsible of preparing, conducting and analyzing the experiments with fiber optic cables by using active distributed temperature sensing method (active DTS) in bentonite to determine the thermal conductivity under varying density and water contents. Currently, Mrs. Firat Lüthi is working as a Scientific Assistant for the FE experiment, and is responsible of the data management, field measurements, reporting.

Stefano Caruso (male) have been working at Nagra for seven years as project manager, (from 2017 as principal project manager of the Inventory and Logistics unit), in the Radioactive Materials division. He is chief scientific investigator for the Nagra in the EURATOM/DoE I-NERI, and IAEA SPARV IV, as well as Swiss representative at the OECD/NEA WPNCs. Main responsibilities are in the area of spent fuel and high-level waste: spent fuel integrity for operational safety and long-term safety aspects in relation to geological disposability and criticality safety assessment. He got his M.Sc. in Nuclear Engineering at the University of Rome "La Sapienza" and obtained his PhD in reactor physics at the EPFL in 2007. He worked in complex multidisciplinary projects, engaged in a large variety of organisations including industrial companies as well as research institutions (e.g. five years as reactor engineer at the nuclear power plant Beznau for core surveillance). His technical expertise covers experimental as well as numerical/modelling studies in the following core competences: nuclear science, nuclear power plant,

engineering, reactor physics, information technology, nuclear safety, radiation detection.

Olivier Leupin (male) has a background in mineralogy /petrology and a specialisation in aquatic geochemistry. At Nagra he is deputy to the head of Research and Development and advisor in scientific strategic planning. He coordinates and manages Nagra's RD&D activities in the underground rock laboratory of Mont Terri (Switzerland). Olivier Leupin is responsible for Nagra's main project on repository induced effects and responsible for their integration into safety assessment.

Ingo Blechschmidt (male) is the Head of the Grimsel Test Site (GTS) Section. He completed a bachelor in Geosciences in 1994 and a master in Geology (Dipl. Geol.) in 1998, at the Friedrich Schiller University Jena, Germany. In 2002, he obtained a PhD at the Institute of Geology at the University of Bern. Following his engagement as a leading field geologist in various projects in the Middle East, he joined Nagra in 2004 as a Project Manager, responsible for specific tasks in various experiments conducted at the GTS underground rock laboratory (URL), then became involved in the general operation and management of the GTS, first as a Scientific Coordinator and later as a Manager. Since 2007 he is Head of the Section as well as Deputy Division Head of Nagra's International Services and Projects Division. In addition to his responsibilities for the Grimsel Test Site, its staff, its budget, the strategic planning and the coordination of RD&D activities in compliance with Nagra's RD&D programme and the goals pursued by international research partners, Ingo has been involved with and/or leading pioneering experiments - planning, implementation, interpretation - conducted at GTS. Ingo Blechschmidt represents Nagra in international organisations such as the IAEA/URL Network of Centers of Excellence, IGDTP and CRC (Crystalline Club), and he actively supports Nagra's public relations activities.

A list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- Diomidis, N., Cloet, V., Leupin, O.X., Marschall, P., Poller, A., Stein, M. (2016): Production, consumption and transport of gases in deep geological repositories according to the Swiss disposal concept. Nagra Technical Report NTB 16-03.
- Senger, R., Romero, E., Marschall, P. (2018): Modeling of Gas Migration Through Low-Permeability Clay Rock Using Information on Pressure and Deformation from Fast Air Injection Tests. Transp Porous Med., July 2018, Volume 123, Issue 3, pp 563–579
- Caruso, S. (2018): From a conservative approach to a BEPU implementation for spent nuclear fuel characterisation and safety assessment from the perspective of geological disposal, Key-note invited lecturer, ANS Best Estimate Plus Uncertainty Conference (BEPU 2018), Real Collegio Lucca, Italy, May 13-19 2018.
- Vlassopoulos, E., Nasyrow, R., Papaioannou, D., Rondinella, V., Caruso, S. & Pautz, A. (2017): Destructive tests for determining mechanical integrity of spent nuclear fuel rods, International High-Level Radioactive Waste Management Conference, April 9-13, 2017, Charlotte, NC, Westin.
- Blechschmidt, I. & Vomvoris, S. (2017): 5 - Relevance of underground rock laboratories for deep geological repository programs. - Geological repository systems for safe disposal of spent nuclear fuels and radioactive waste, Ahn J.; Apted M.J. (eds.), Woodhead Publishing Series in Energy: Number 9, Woodhead Publishing Limited, Oxford, 2017, S. 113-142

A list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

- *FE experiment at the Mont Terri URL*: large scale 1:1 heater test to demonstrate the feasibility of the Nagra concept and assess the THM impact on the engineered barriers and Opalinus Clay
- *Grimsel Test Site – International GMT Project*: In-situ experiment on gas transport in sand/bentonite; *GAST experiment*: in-situ demonstration experiment on gas transport in S/B seal sections.
- *International Mont Terri Research Programme: HG-A* - In-situ experiment on gas transport along the EDZ of a sealed tunnel section; *HG-D* - Gas transport in fractures
- Several PhD Theses at EPFL (Lausanne) and UPC (Barcelona) related to two-phase flow properties of claystones, bentonites and sand/bentonite mixtures
- Several Nagra managed and financed projects on: Behaviour of spent nuclear fuel under conditions relevant for interim dry storage, handling and transportation; Criticality safety assessment; spent fuel

characterisation; Core Surveillance and Safety Assessment (NPP Beznau); Characterisation of high-burnup LWR fuel rods through gamma tomography (PSI)

A description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work

Databases, samples, laboratory programmes (examples)

- Data bases from the on-going GAST experiment at the Grimsel test site and the FE experiment at the Mont Terri URL will be provided.
- Advanced laboratory programmes have been sponsored by Nagra, aimed at investigating gas transport processes in claystones, bentonite and bentonite sand/mixtures. The experiments were carried out at EPFL and UPC. The experimental data bases will be made available to the participating modelling teams.
- Rock samples for laboratory experiments will be provided, which have been recovered in the framework of Nagra's recent site investigation programme (Opalinus Clay and other indurated claystone formations)
- Advanced laboratory programmes have been sponsored by Nagra (PSI, JRC Karlsruhe), aimed at spent fuel investigations for safety relevant aspects.

Grimsel Test Site (GTS - Nagra)

The GTS is a well-established underground research facility which contributes to the development and confirmation of safe geological disposal concepts and to the characterisation of suitable host rock formations. It is used by a wide range of research organisations and universities on a national and international level. The international community of organizations responsible for radioactive waste management and contributing researchers have always looked to the GTS with great interest. The facility lends itself to a large spectrum of geoscientific and engineering experimental concepts. A special feature is its radiation-controlled zone (IAEA Level B/C) which allows work to be carried out with radioactive tracers in the geosphere under close-to-realistic boundary conditions. Nagra has used the GTS to provide scientific answers and technical experience for the Swiss national disposal program. However, the GTS is also an essential tool for public outreach which helps to improve understanding of the disposal program by the general public and provides answers to questions people may have.

International cooperation with other national waste management organizations and research institutes has been an important component of the research program since day one. As some geoscientific results and practical experience gained from experiments conducted at the GTS may be transferred to other repository concepts it is conducive to share the costs and knowledge invested, and profit from the added value gained from the synergy effects during analysis and interpretation. In the more than thirty years of operation the GTS has hosted partnerships between Nagra and more than two dozen organizations and research institutes from twelve countries and the European Union.

Another aspect of international cooperation exercised at the GTS is that of knowledge transfer through training. The GTS offers its infrastructure and databases for educational purposes. Nagra staff and experts from the International Atomic Energy Agency (IAEA) and other organizations use the underground facilities as a practice base to teach the next generation of scientists and engineers and to facilitate specific workshops for experienced specialists for support interdisciplinary knowledge transfer.

If operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

Operational capacity can be demonstrated

	No	Name	Acronym
Participant	28	National Centre for Scientific Research « Demokritos »	NCSR
Description of the legal entity The National Centre for Scientific Research “Demokritos” (NCSR) was founded in July 1961 as a Research Centre for Nuclear Research, Demokritos. Today it is the largest multidisciplinary Research Centre of Greece with approximately 180 Researchers in tenured and tenure-track positions and over 500 Research Personnel working in projects funded mainly by grants from State Funds, the European Union and Private Industries. It is governed by the Board of Directors and is supervised by the General Secretariat of Research and Technology, which is in the Ministry of Education, Research and Religious Affairs of Greece. The Centre consists of five independent Institutes focusing on different scientific fields: 1) Institute of Nuclear & Radiological Sciences and Technology, Energy & Safety (INRASTES); 2) Institute of Nuclear and Particle Physics (INPP); 3) Institute of Nanoscience and Nanotechnology (INN); 4) Institute of Biosciences & Applications (IBA); 5) Institute of Informatics & Telecommunications (IIT). The NCSR is a mandated RE in EURAD-RWMD. The INRASTES operates: 1) the Greek research reactor (GRR-1) by the Research Reactor Laboratory; 2) the centralized facility in Greece for interim storage of radioactive waste and sources by the Radioactive Waste & Material Laboratory (RWML). Furthermore, INRASTES possesses Laboratories who performing research and technological development in 1) sorption, multiphase flow, heat & mass transfer in porous materials; 2) reliability and safety of complex technological systems; 3) radioecology and radiation protection; 4) materials characterization by X-ray scattering, X-ray fluorescence spectroscopy, Positron Annihilation Lifetime Spectroscopy, Scanning and Transmission Electron microscopy in collaboration with the INN, mechanical testing, optical and thermal properties measurement in collaboration with the INN; 5) nuclear and radiation techniques (prompt gamma neutron activation analysis, gamma spectrometry, RBS, NRA, NAA in collaboration with the TANDEM accelerator laboratory/ INPP). The RWML research and development activities are related to radioactive waste and materials management as well as to the decommissioning of nuclear facilities. The main activity is the development of techniques as well as the elaboration and performance of studies for radiological characterization of waste (including historical waste) and facilities by destructive and non-destructive techniques. Furthermore, RWML elaborates studies for the safe storage of radioactive waste at the NCSR and provides services to the laboratories of the Centre as well as to hospitals, the Industry, companies and individuals.			
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks The NCSR is a multidisciplinary Research Centre of Greece with infrastructure and technical equipment relevant to the proposed work. Furthermore, it is the main producer of radioactive waste in Greece and operates the centralized facility in the country for interim storage of radioactive waste and sources. Greece is a small inventory member state (SIMS) without NPP but possesses a research reactor and other applications of radioactive isotopes. The radioactive waste is producing in the same way, but in much smaller amounts. Furthermore, the disposal solutions have not been determined yet. The profile of the NCSR matches the tasks of the proposal in the following way: Task n°2 - Identify challenging wastes to be collaboratively tackled within the Joint Programme - Mapping and shared understanding at EU level of practical issues on waste management routes The NCSR will provide data about radioactive waste and sources kept at the centralized storage facility of the centre as well as about the waste that will arise from the future dismantling of facilities. NCSR will contribute in the analysis of the challenges encountered with small programmes including practical issues on waste management routes for challenging wastes. DMT (TLP) will support the NCSR as well as the other SIMS and collect the information from Task2 for the work in Task5. Task n°3 - Description and comparison of radwaste characterisation approaches			

The NCSR D will provide experience and knowledge on characterisation of radioactive waste from the Greek Research reactor and the other research facilities of the Centre. Furthermore, key radionuclides of concern and inventories in selected radioactive waste will be provided. DMT (LTP) will present the techniques and procedures used for characterisation of raw legacy/ historical wastes in SIMS including the case of NCSR D.

Task n°4 – Identification of WAC used in EU Member States for different disposal alternatives in order to inform development of WAC in countries without WAC/facilities

Since Greece is a country without WAC for treatment and disposal of radioactive waste, the NCSR D will be observer in the workshops of the Subtask 4.2 – Sharing experience on waste management with/without WAC available and Subtask 4.3 – R&D needs and opportunities of collaboration, in order to gain knowledge from the experience and the knowhow of other countries in Europe and understand the future needs for R&D as well as the possibility of collaboration.

Task n°5 - RWM solutions for small amounts of wastes

NCSR D will summarize the knowledge for existing and potential disposal options for small amounts of radioactive waste in a report (deliverable 5.1) where further needs of R&D on this issue will also be listed. Furthermore, NCSR D will support the preparation of the second report (deliverable 5.2) where the suitable predisposal routes for small amounts of waste will be determined, even without WAC for disposal. NCSR D will organize the first workshop of this task. DMT (LTP) will take over the management of the Task and give information about disposal options appropriate for SIMS like the use of old mines, tunnels, bunkers, caverns, deep shafts and boreholes (some 100 m). Furthermore, DMT will collect the necessary information for the work in Task5 from the other Tasks of the WP.

Task n°6 – Shared solutions in European countries

DMT (LTP) will participate in this Task instead of NCSR D and contribute by describing examples of sharing facilities in Germany as well as by providing feedback. DMT will share the information from the work in this Task with NCSR D.

a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities

Dr Anastasia Savidou (female), date of birth 8 December 1960, nationality Greek, will be the primary responsible from the NCSR D.

Dr Savidou has been working at the NCSR D since 1986. She is a Senior Researcher and since 2013 Head of the Radioactive Waste & Materials Lab (RWML) of the Institute INRASTES with main task the upgrading of the radioactive waste and sources facility at the Centre. Dr Savidou is a member of the National Radioactive Waste Management Committee and participates in the four-member technical group of this Committee. Also, she is the representative of the NCSR D at the EURAD-RWMD. Dr Savidou received her Bachelor degree in Physics from the National & Kapodistrian University of Athens (1978-1983) and her PhD in nuclear application techniques from the National Technical University of Athens (1986-1992). In 1997 she was trained on treatment and disposal of radioactive waste at the Institute for Energy Technology, Kjeller, Norway with IAEA fellowship. Dr Savidou was group leader for radiological characterization and drawing up of the GRR-1 decommissioning plan at the Research Reactor Lab from 2007 to 2013, group leader for radioactive waste management from 1997 to 2006, Post Doctor at the Environmental Radioactivity Lab from 1992-1996 and PhD student at the TANDEM accelerator Lab from 1986-1991. She has experience in a wide range of analytical techniques and applications. She have large experience in gamma spectrometry, non-destructive techniques by MCNP simulations, radiochemical methods in combination with alpha spectrometry and liquid scintillation counting as well as in radon measurement methods including radon exhalation techniques. Dr Savidou coordinated R&D projects which concerned: 1) radiological characterization of waste and facilities; 2) development of clearance techniques for radioactive materials; 3) study of natural radioactivity and development of techniques for determination of radon exhalation. She dealt

also with other R&D activities: 1) study of leaching mechanisms of ions; 2) development of Proton Induced Gamma-ray Emission (PIGE) techniques. She has over than 50 publications in scientific journals and conferences proceeding with more than 210 citations by others and over than 30 reports and scientific studies. Dr Savidou supervises a number of undergraduate student for the development of bachelor thesis as well as PhD students.

Dr Jörg Feinhals (male), date of birth 22 June 1955, nationality German.

Dr Feinhals obtained his Diploma in Physics (1976-1982) and his PhD (Dr. rer. nat.) (1982-1988) from the University of Hanover. He has been working at DMT GmbH & Co. KG, Hamburg as Senior Expert and Head of Project Group Radiation Protection and RadWaste Management since 2011. He was Member of the Directorate of the German Swiss Association for Radiation Protection and is Secretary of Working Group Disposal. From 1988 to 2011 Dr Feinhals was Senior Expert and Head of Group RadWaste Management and Decommissioning, Radiation Protection Commissioner and Project Manager Repositories at TÜV NORD SysTec GmbH & Co. KG, Hamburg. He was Member of the German Commission on Radiation Protection for Evaluation of State Licenses by order of the Federal Ministry of Environment and Reactor Safety from 1999 to 2009. Dr Feinhals was German Representative at IAEA, Hamburg/ Vienna, for the International Decommissioning Network, PRISM Project, GEOSAF II from 2007 to 2015. From 1986 to 1988 he was scientific assistant at the Institute of Radioecology of Lower Saxony, Hanover and dealt with the transfer of tritium from atmosphere to soil. Dr Feinhals has wide experience in safety assessment in the field of: 1) disposal of radioactive waste (conditioning and interim storage); 2) design of disposal facilities; 3) radwaste management, clearance of radioactive materials; 4) decommissioning of nuclear installations (NPP Greifswald, Rheinsberg, Stade). Furthermore, he has large experience in: 1) radiation protection, training of health physicists; 2) quality assurance; 3) project management; 4) consulting nuclear authorities and operators for licensing; 5) organizing international conferences. Dr Feinhals worked outside of Germany as Senior Expert of: 1) the TACIS Project “Evaluation and Development of the technical Basis for Ensuring the safe Decommissioning of Nuclear Facilities” (Russian Federation, 1998 – 2000); 2) the TACIS Bistro Project “Development of the requirements to the content of the basic documents for obtaining NPP unit decommissioning license of Gosatomnadzor of Russia by operating organization” (Russian Federation, 2001-2002); 3) Senior expert for the IAEA in three expert missions: Assistance of the Nuclear Regulatory Body of Romania to Improve Regulatory Skills (related to near surface disposal facility at Savigny) (Romania 2007-2008, 2011).

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

List 5 Relevant Publications:

- 1) Tzika F., **Savidou A.** and Stamatelatos I.E., [*Non Destructive Characterization of Radioactive Waste Drums by Gamma Spectrometry: A Monte Carlo Technique for Efficiency Calibration*](#), Heath Physics Journal, 93(5) suppl 3:S174-S179, (2007)
- 2) Papadokostaki K. G., **A. Savidou**, [*Study of Leaching Mechanisms of Caesium Ions Incorporated in Ordinary Portland Cement*](#), Journal of Hazardous Materials, 171, pp. 1024–1031 (2009)
- 3) **Savidou A.**, I.E. Stamatelatos, [*Non Destructive Technique to Verify Clearance of Pipes*](#). Journal of Nuclear Technology Radiation Protection, Vol. 25, No. 2, pp. 133-137 (2010)
- 4) **Savidou A.**, S. T. Valakis, [*Management of Materials that will Arise from the Dismantling of the Primary Cooling System of the GRR-1*](#), Fresenius Environmental Bulletin, Vol. 22, No. 7a, pp. 2027-2034 (2013)
- 5) Feinhals J., Kemp D., **Savidou A.**, [*No Nuclear Plans–No Disposal Facility?*](#), GeoResources Journal 2 Mining, pp. 16-24, (2017)

Additional relevant publications

J. Feinhals, A. Savidou, D. Kemp, Disposal Facilities for Countries without a Nuclear Power Programme, RRFM2016/IGORR 13-17 March 2016 Berlin, Germany

J. Feinhals, H. Völkle et al., Results of the Workshop on Radiation Protection Culture in Waste Management, Swiss-German Association for Radiation Protection, 31 Aug – 02 Sep 2015 Schloss Böttstein, Switzerland

J. Feinhals , Disposal Strategies for Low Amounts of Radioactive Waste , IAEA TC-Project RER/3/009 Annual Meeting Athens, 1-3 Dec. 2009 J. Feinhals, General International Concepts on Waste Disposal of VLLW and Clearance – Today and in the Future (IAEA, OECD, EC), FS,SFRP, ÖVS Workshop on Clearance, Strasbourg, May 2009 J. Feinhals, J. Krause, D. Richter, S. Schappert, Evaluation of Disposal Strategies for Storages containing old Stock of Nuclear Waste in Nuclear Power Plants, Report to KONTEC 1999, Hamburg
a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal List 5 Relevant Previous Projects or Activities: 1) 1997-2003: Coordination of the internal project that concerned the clearance of historical radioactive waste (mentioned in a Joint Convention National Report) 2) 2004-2006: Coordination of the internal project that concerned the characterization of the drums containing ion exchange resin waste from the research reactor 3) 2007- 2011: Participation in the national project that concerns the refurbishment of the Greek Research Reactor 4) 2013- : Coordination of the internal project that concerned the upgrading of the radioactive waste management in the NCSR “Demokritos” 5) 2017-2021: Coordination of the project “Development of a Time and Cost Effective Technology for Radiological Characterization/ Segregation of Radioactive & NORM Waste” funded by POLYECO S.A. and the STAVROS NIARCHOS FOUNDATION
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; RWML infrastructure for radiological characterization • High-resolution gamma spectrometry system • Low background total-beta/ total alpha counting system • In-situ gamma spectrometry systems (HPGe, LaBr, NaI) • a number of dose rate meters and contamination monitors • The MCNPX code • Fume hood and glove box
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task. N/A

Participant	No	Name	Acronym
	29	Nuclear Engineering Seibersdorf GmbH	NES
Description of the legal entity			
Radioactive waste management organization of Austria			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks			
- Identify challenging wastes to be collaboratively tackled within the Joint Programme - Mapping and shared understanding at EU level of practical issues on waste management routes (Strategic WP ROUTES Task 2) - Collection and analysis of existing work on categorization and classification of radioactive waste regarding disposal options, identification of waste for which there is not yet a complete management plan in each Member State, identification of waste management routes for pre-disposal steps → provide national relevant input data; analyze the challenges encountered with small waste programs (Strategic WP ROUTES Task 2.1) - Understanding at EU level of the practical issues on waste management routes for challenging waste→ Establish and share synthesis on practical issues on waste management routes for challenging wastes (Strategic WP ROUTES Task 2.2) - RWM solutions for small amount of wastes (Strategic WP ROUTES Task 5) - Collecting and analyzing actual existing knowledge about disposal options for SIMS→ NES is contributing the subtask regarding long-term interim storage on surface for decay, participating in two workshops (Strategic WP ROUTES Task 5.1) - Describe the necessary predisposal routes for the disposal options of subtask 5.1→ NES will organize the workshop and write the report with partners (Strategic WP ROUTES Task 5.2) - Shared solutions in European countries (Strategic WP ROUTES Task 6) - State of the art on shared development and use of technologies and facilities→ State of the art on shared development and use of technologies and facilities (Strategic WP ROUTES Task 6.1) - Case studies on shared development and use of technologies and facilities →Provide input and participate in workshop (Strategic WP ROUTES Task 6.2) - Assess the feasibility of developing further European shared solutions for waste management from cradle to grave→Provide input and participate in workshop (Strategic WP ROUTES Task 6.3)			
Nuclear Engineering Seibersdorf GmbH is the only WMO in Austria. NES has a profound knowledge of radioactive waste management, and can carry out all necessary predisposal steps on its premises.			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities			
Eileen Langegger, f, born 1986 in Graz. Graduated 2011 with a Master of Science in Technical Physics from the Universities of Technology Graz and Vienna. Work experience: Consultancy at IAEA (2011-2012); scientific staff at Technical University Vienna (2012-2013), since 2013 at Nuclear Engineering Seibersdorf GmbH, since 2014 Head of Interim Storage. She started teaching at the Montanuniversity Leoben in 2015, since 2017 she gives courses at the Technical University Vienna, since 2018 at the University of Technology Vienna. Roman Beyer knecht, m, born in 1966, graduated in 1994 with a Master of Science in Technical Physics from the Technical University Vienna. Work experience: 1995 – 1999 Product Manager at Voith Sulzer AG; 1999 – 2007 Expert for Radiation Protection and Nuclear Topics for the Government of District Lower Austria, since 2007 at Nuclear Engineering Seibersdorf GmbH, 2007 – 2012 Head of Business Unit Radioactive Waste Management, since 2012 CEO of Nuclear Engineering Seibersdorf GmbH.			
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content			
W.Neckel, Freimessung von Abfällen, RADOS Freimessanlagen Forum Hamburg, Germany, 2011 B. Wellens, Unsicherheitsbetrachtungen bei heterogenen Aktivitätsverteilungen, ÖVS Jahrestagung, 2013 E.Radde (Langegger), Reduction of Radioactive Waste by improvement of Conditioning facilities, Nuclear Espana No. 354, Spain, 2014			

R. Beyerknecht, State of the Art Management of LILW in a Small Non-Nuclear Country – The Austrian Case; Waste Management Symposia, Phoenix, Arizona, March 2015 R. Beyerknecht, Integrated Waste Stream Management in a Small Non-Nuclear Country; Annual Meeting of the International Radioactive Waste Technical Committee, IAEA Vienna, April 2016
a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal • Reconditioning of stored waste: Older radioactive waste packages stored at Nuclear Engineering Seibersdorf GmbH will be reconditioned, in order to ensure the state of the art conditioning of all the waste. This includes for example new packaging for high force compacted and for homogeneously cemented waste, if possible clearance of already decayed (mainly homogeneously cemented) waste and state of the art treatment of inhomogeneous cemented waste. • Modernization of conditioning facilities – building of a New Handling Centre (NHC) for the treatment of non-burnable waste: optimization of workflow, logistics and working safety. Renewal of conditioning facilities such as 2 manipulation boxes, high force compactor, drum drying system, hot cell with underground storage, cementation and mixing equipment, decontamination chamber • Ultra- filtration Facility(UFA): This plant, in operation since 2009, is used to clean contaminated water from the premises of the research campus. Decontamination is achieved without chemical pre-treatment. The water is later on released. • Soil Measurement and Sorting Device: Processes soil, gravel, ballast crushed concrete and the like with a sieve curve less than 32 mm. β- and γ- detectors enable the separation of contaminated from clean material.
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; • Water treatment facility: - o UFA – see above - o Filtrox – older facility, which is capable of radioactive water treatment towards release • Incineration Plant – all burnable radioactive waste is burned in the incineration facility • New Handling Center includes the following radioactive waste treatment facilities: - o High Force Compactor: a 1500 t compactor for solid non- burnable wastes to achieve a maximum compaction. Rests of contained liquids are held back within the system and collected for further treatment - o Drum Drying Systems – 32 drums can be dried in the system at max. 140°C. This guarantees a possible storage of the drums afterwards with physical and chemical stable material, without moisture. - o Sorting and Manipulation Boxes- the so called “Caissons” are used for the handling of raw waste and for the reconditioning of old waste. In these 2 stainless steel boxes work with contaminated or alpha active waste is possible. There is also the possibility of handling of larger items. - o Decontamination Chamber – a facility that enables the easy and safe decontamination of larger items. - o Source Treatment – Sealed radioactive sources are identified and sorted and placed in the corresponding containers. A special lead castle was built to enable safe working conditions. - o Hot Cell – High active sources can be brought into the Hot cell, identified and stored in the underground storage containers. - o Cementation Facilities • Soil Sorting Facility – for automatic measuring and sorting material like contaminated soil and building rubble • Various plants and facilities for treatment, conditioning and interim storage of radioactive waste like take over building, buffer storages, interim storage buildings, radiochemistry laboratories, radiation protection equipment, ...
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task. N/A

	No	Name	Acronym
Participant	30	Národný jadrový fond	NJF
Description of the legal entity National nuclear fund (NJF) was established in 2006 as a state fund for accumulation and management of resources for back end of nuclear facilities life cycle (which replaced the State Fund for the Decommissioning of Nuclear Energy Facilities and the Treatment of Spent Nuclear Fuel and Radioactive Waste existing from 1995). Its role is to ensure sufficient acquisition sources for decommissioning of nuclear installations and for construction of deep geological repository in Slovak Republic and supervise accounting of decommissioning and waste management projects and their consistence with National Policy and Program. Board of supervisors of the Nuclear Fund except of account control insure the evaluation, updating and continuous performance of tasks resulting from the National Policy and Program for the Management of Spent Nuclear Fuel and Radioactive Waste in cooperation with other central state administration bodies, license holders and other stakeholders.			
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks NJF will take part of the task No. 6 Shared solutions in European countries providing input, feedback and participate in workshop. NJF is responsible for evaluation and updating of National Policy and Program for the Management of Spent Nuclear Fuel and Radioactive Waste, where one of the considered alternative along with national deep geological disposal is international repository. In near future, NJF will reassess recent national policy of SNF management according current national and international experiences in sharing of waste management solutions.			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Adela Mršková (F) graduated in 1995 at Slovak University of Technology. She has technical expertise in radioactive waste management and disposal, decommissioning of nuclear power plants, nuclear emergency preparedness and response, accident management modelling and safety assessment, radiation protection, national energy policy and strategy evaluation, public information and involvement. She has been involved in EURATOM projects, particularly those combining technical and societal knowledge in the area of waste disposal (IPPA, SITEX).			
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content Salzer P., Přítrský J., Mršková A., Richardson Ph.: The Status of Multinational Waste Management Solutions, EC IPPA project deliverable 3.3, Jan. 2012 Mršková, A. et al: Commonalities and differences in public participation between national and multinational options and Recommendations with regard to national and regional public involvement programmes, EC IPPA project deliverable 3.4, Dec. 2013 Vojtěchová H., Mršková A.: Strategy of public engagement for DGR development in Slovakia and analyzes of options of economic and non economic incentives supporting DGR project, study, ÚJP Praha, Deep geological repository - site selection 1. Stage, October 2015			
a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal Contractor of SITEX II project Member of JOPRAD TSO working group			
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work -			
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task -			

	No	Name	Acronym
Participant	31	Nuclear Research and Consultancy Group	NRG
Description of the legal entity NRG has been the lead organisation for research in nuclear technology and in geological disposal in the Netherlands for over 30 years. NRG operates the HFR research reactor, a Hot Cell Laboratory, a Waste Storage Facility and various other nuclear facilities. NRG has almost 500, employees, more than about 100 employees work The Research, Consultancy and Services departments of NRG NRG has been studying disposal options since the 1970's. NRG had a key role in the recently completed research program into disposal in Boom clay in The Netherlands, (https://covra.nl/en/downloads/opera-info) and provides the Dutch authorities with advice on various topics concerning radioactive waste disposal and radiation protection in general.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks NRG contributes to the Workpackages ACED, DONUT, ROUTES and UMAN. As a TSO, NRG main activities are in the field of safety cases, safety studies and (total system) performance assessments IUMAN). This requires to be a knowledgeable and active user of the models developed and laboratory tests results in the research work packages (such as ACED), and to be able to understand and link the models to system performance models (DONUT)			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Key experts of the NRG contributing team are: <i>Mr. Hans Meeussen</i> (PhD in Soil Chemistry and MSc in Environmental Science and Software Engineering) joined NRG in 2010. His main area of expertise is the chemical and migration behaviour of contaminants in soils, waste forms, and cement barriers. He has (co-)authored over 40 scientific papers in this area and is developer of the <i>ORCHESTRA</i> reactive transport modelling software (www.meeussen.nl/orchestra). This open source software framework is widely used to implement detailed chemical speciation and reactive transport models, but it is also suited to embed detailed migration models within PA code. Hans Meeussen is NRG partner in the US DOE funded Cement Barriers Partnership (cementbarriers.org), a consortium that aims to develop next generation simulation tools for the evaluation of performance and degradation of cement barriers and materials used in nuclear applications. <i>Mr. Jacques Grupa</i> (NRG), MSc Technical Physics, has more than 15 years of experience in the fields of risk assessments for nuclear power plants as well as performance assessments for geological radioactive waste repositories. His relevant expertise regarding the latter is a thorough understanding of the complex in-situ behaviour of the waste, package, backfill and sealing materials in both normal and deviating conditions, in-depth understanding of performance analyses and its role in the Safety Case for a repository. Mr. Grupa acted as coordinator of EC Concerted Action on the retrievability of long lived radioactive waste disposed in deep underground repositories and was component leader in the EU 6th framework project PAMINA. Furthermore, he was project manager of several recent Dutch performance assessments studies for waste disposal in rock salt and clay formations. <i>Mr. Jaap Hart</i> (NRG) holds a PhD in chemical engineering and has more than 20 years of experience in the fields of risk assessments of nuclear reactors and safety assessments for radioactive waste facilities. In 2001, Jaap Hart joined the Department of Radiation and Environment of NRG and since then has been involved in a variety of national and international projects related to radioactive waste management, amongst others several Framework projects of the European Commission, and the international working groups ASAM (Application of Safety Assessment Methodologies for Near Surface Disposal Facilities) and PRISM (Practical Illustration and Use of the Safety Case Concept in the Management of Near-Surface Disposal) hosted by the NEA and IAEA. His relevant expertise relates to an in-depth understanding of the safety case of geological disposal concepts and methodologies to be applied in safety assessments for radioactive waste repositories. <i>Mr. Thomas Schröder</i> (NRG) has a PhD in Soil Chemistry and MSc in Environmental Sciences. He has worked several years on risk assessment of heavy metal contamination in terrestrial and aquatic environments and has strong experience in analytical chemistry, speciation and sorption modelling as well as in execution of field work. Employed at NRG since 2007, he works mainly in the field of geological			

disposal of radioactive waste and contributed to several national, bilateral, and European research projects on technical and methodological aspects of waste disposal (e.g. PAMINA, MoDeRn). His relevant expertise covers the understanding of speciation and surface processes on molecular scale and the ability to combine experimental and modelling work within the framework of performance and safety assessment.

Ms Ecaterina Rosca-Bocancea (NRG) is employed as a risk consultant, model developer and data analyst. She started her international career with a graduation as a MSc in chemistry and chemical engineering at the State University of Moldova. After research assignments in Hungary and Romania she moved to the Netherlands. Mrs Rosca-Bocancea is fluent in Romanian and Russian and also masters English, Dutch and French.

The consultant is involved in the Netherlands' national research program on safe disposal of spent fuel and radioactive waste and participates in associated international research programmes. Furthermore she supports consultancy assignments related to nuclear safety and radiation protection with her modeling and data mining & analysis skills.

Mr. Arjen Poley (NRG) has about 20 years of experience in the field of geological was consortium leader of the ALSA-C consortium project (2002 – 2011) carried out by GRS, Braunschweig (D), AF Colenco, Baden (CH), and NRG, Petten (NL), regarding radionuclide migration as part of Long-Term Safety Assessment Project for closure of the Asse II research mine in Lower-Saxony (D) As team manager he is responsible for scientific supervision, reporting & quality control.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

1. Grupa J, Davis P Report on the OPERA Safety Case structure OPERA-PU-NRG2111 22 January 2014 <http://www.covra.nl>
2. Hart J., J. Prij, G-J. Vis, D.-A. Becker, J. Wolf, U. Noseck, D. Buhmann, Collection and analysis of current knowledge on salt-based repositories, OPERA-PU-NRG221A, 15 July 2015. <http://www.covra.nl>
3. J.C.L. Meeussen, T.J. Schröder, E. Rosca-Bocancea J.J. Dijkstra, C. Bruggeman, and N. Maes Prediction of Rd values for radionuclides in Boom Clay with an independent multi-surface model, Clays in Natural and Engineered Barriers for Radioactive Waste Confinement, Brussels, March 2015.
4. Verhoef E, Neeft E, Grupa J, Poley A, Outline of a disposal concept in clay, OPERA-PG-COV008 rev1, 2014 <http://www.covra.nl>
5. Meeussen, J.C.L., 2003. ORCHESTRA: an object-oriented framework for implementing chemical equilibrium models. Environ. Sci. Technol. 37, p.1175–1182. [] Additional information can be found on www.meeussen.nl/orchestra

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

1. OPERA project (<https://covra.nl/en/downloads/opera-info>)
2. Modern 2020 (<http://www.modern2020.eu/>)
3. CAST (<https://www.projectcast.eu/>)
4. SITEX-II (http://sitexproject.eu/index_2.html)
5. CeBaMa (<http://www.cebama.eu/>)

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

NRG has a large research infrastructure and the direct contact between the researchers allows easy access to available knowledge. The main expertises to geological disposal are in developing safety studies and safety cases (relevant to Eurad Work package Uncertainty Management multi-Actor Network, UMAN) and geochemical modelling (reactive transport code ORCHESTRA) for the Work Packages Assessment of Chemical Evolution of ILW and HLW Disposal Cells and Development and Improvement Of NUMerical methods and Tools for modelling coupled processes (DONUT).

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

Considering a team of 6 experts, the proposed operational capacity of about 5 man-months per year is available.

Participant	No	Name	Acronym
	2	Organisme National des déchets Radioactifs des matières Fissiles enrichies	ONDRAF/NIRAS
Description of the legal entity ONDRAF/NIRAS, the Belgian Agency for radioactive waste and enriched fissile materials, is a public agency established by law (08.08.80, modified by law of 11.01.91; royal decree of 30.03.81, modified by royal decree of 16.10.91 and 04.04.2003). In the meantime, several laws and royal decrees were voted for specific tasks of the agency. The mission of ONDRAF/NIRAS is to protect man and the environment, for the present and the future, against the potential hazards arising from radioactive waste, without thereby imposing any excessive obligations on future generations. Its competences cover transport, processing, conditioning, interim storage and final disposal of radioactive waste and spent fuel, as well as the decommissioning of nuclear facilities. The agency is also competent for technical research and RD&D in the field of radwaste management, especially with regard to disposal and the optimisation of current practices. Since 1997, the agency is also entrusted by law with the inventory of all nuclear liabilities on the Belgian territory. The policy pursued so far is to have its industrial tasks performed by subcontractors as far as transportation is concerned and by Belgoprocess, a 100 % subsidiary of ONDRAF/NIRAS, for the activities with regards to the treatment, conditioning and storage of waste awaiting disposal. Concerning the long-term management of radioactive waste, ONDRAF/NIRAS has the monopoly in Belgium. In this respect, it defines the RD&D needs, steers the RD&D projects and integrates the RD&D results. For the R&D in the field of final disposal of waste the Belgian research centre on nuclear energy SCK•CEN is one of its major contractors. The Belgian Underground Research Laboratory HADES is operated by EURIDICE, a joint Economic Interest Grouping (EIG) of ONDRAF/NIRAS and SCK•CEN.			
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks ONDRAF/NIRAS will participate in the R&D WP6 (GAS) and the Strategic Studies WP9 (UMAN) and WP10 (ROUTES). The Linked Third Parties of ONDRAF, ULiège and EURIDICE, will additionally perform tasks in WP7 (HITEC), see section on LTPs for the description of these tasks. As Lead Participant of WP6 (GAS) ONDRAF/NIRAS tasks notably include the coordination of the work package which entails the follow-up of the R&D programme, fostering interactions between WP6 participants, a task ONDRAF/NIRAS is familiar with considering its mission. ONDRAF/NIRAS will ensure the production, cross reviewing and edition of WP6 deliverables and will also ensure interactions with other WPs. Besides the coordination of the work package, ONDRAF/NIRAS will also participate to Task 4 on the Repository Performance Aspects, providing a WMO perspective, and input from the Belgian programme, about the conceptualisation of gas migration at repository and the assessment of its impact in the context of the Safety Case. In WP9 (UMAN), ONDRAF/NIRAS will contribute to subtask 2.1 by participating in technical meetings, providing an input regarding the strategies considered in their national programme, collecting information on strategies developed and used in other national programmes, providing written material and reviewing the deliverable. ONDRAF/NIRAS will contribute to subtask 3.1 and will collect and synthesise the views of WMOs on the different types of uncertainties that need to be addressed in a safety case and their evolution. ONDRAF/NIRAS will also contribute to subtask 4.3 in order to provide an input on the pros and cons of different uncertainty management options from the viewpoint of the Belgian WMO and to the identification of needs for future activities. In WP10 (ROUTES), ONDRAF/NIRAS will lead Task 4 on waste acceptance criteria, a topic it is familiar with considering its legal role as WMO in Belgium. ONDRAF/NIRAS will provide input to the WP based on its perspective on the management of radioactive waste from cradle to grave. As task leader, it will ensure the production, cross reviewing and edition of Task 4 deliverables as well as the interaction with other tasks of WP10.			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Séverine Levasseur (F) will be the contact person for WP6 (GAS). Séverine obtained a PhD in geomechanics in 2007 at the university of Grenoble (Université Joseph Fourier, France) and worked as scientific researcher from 2007 to 2014 at Université de Liège (ULiège, Belgium) in the geotechnical engineering department. During this period, she participated to several projects on geological disposal of			

nuclear waste including TIMODAZ and FORGE EC projects. Currently at ONDRAF/NIRAS she is co-worker of the RD&D team for long-term management of high-level waste and spent fuel and is responsible of geomechanical studies.

Xavier Sillen (M) will assist Séverine Levasseur in the coordination of WP6. He has close to 30 years' experience as a civil and environmental engineer (University of Louvain, 1989) active in R&D. For the last 20 years, his work has been directly related to the geological disposal of radioactive waste. In 1998, he joined the performance assessment (PA) group at SCK•CEN, the Belgian research centre on nuclear energy. There, he became increasingly involved in the geomechanics research, development and demonstration (RD&D) activities performed by EURIDICE, an Economic Interest Grouping set up jointly by SCK•CEN and ONDRAF/NIRAS, the Belgian agency for radioactive waste management. In particular, he contributed to the design of the PRACLAY large scale in situ heater experiment. In 2009, he joined ONDRAF/NIRAS, where he has been in charge of the follow-up of the studies on the perturbations of the host rock induced by a repository. He also supervised the final stages of the preparation of the PRACLAY experiment until the switch-on in 2014. In 2017, he became Scientific Coordinator, in charge of ensuring the coherency and quality of the science and technology studies carried out in the Belgian programme on long-term radioactive waste management. He has participated in several EC projects in the fields of PA and geomechanics (SPA, BENIPA, BORIS, SPIN, MODEX-REP, NF-PRO, TIMODAZ) and has contributed to the definition of the scientific programme of others (PAMINA, FORGE).

Christophe Depaus (M) is a mining engineer awarded by the Faculty of Polytechnics of the University of Brussels (ULB, Belgium), holds a Master in Advanced Studies in Philosophy of Sciences (DEA) awarded by the Catholic University of Louvain (UCL, Belgium) and an Academic degree in International Nuclear Law awarded by the University of Montpellier (UM1, France). Since 2009, he works in ONDRAF/NIRAS in the field of safety assessment for the long-term management of high-level waste and spent fuel and is responsible of the interactions with the Belgian regulatory body for the geological disposal. As such, he tries actively to integrate the scientific, technical, societal and legal aspects in the geological disposal project. He is also involved in many international projects like IAEA GEOSAF dealing with the impact of the operational safety on the long-term safety where he leads the task group on the operational safety; EC MoDeRn 2020 (WP2 & WP5) dealing with the monitoring of geological disposal and he was also the team leader of the expert team of the IAEA ARTEMIS mission for Bulgaria (2018) to perform the peer review of the national strategy and programme within the framework of the EC Directive 2011/70/Euratom.

Chris De Bock (M) will lead Task 4 of WP "Routes". He holds a degree in civil engineering (university of Leuven, 1989). From 1989 to 2002 he worked for Westinghouse Electric Company, in the design and safety evaluation of nuclear power plants. He managed several smaller and medium-scale study projects for the improvement of safety and/or efficiency in the fields of pressure vessel mechanics, thermo-hydraulics, reactor physics, control instrumentation and emergency response procedures. Chris joined ONDRAF/NIRAS in 2002, where initially he was chairman of the working group on the re-design of the Belgian geological repository and the preparation of its Safety Case. He participated as Module leader in the R&D project ESDRED within the EURATOM 6th Framework Programme, targeted on developing new geological repository technologies. In 2008 and in 2013 he was project officer in charge of the five-yearly cost evaluation of the geological and also surface disposal projects, which lie at the basis of the waste tariffs. Since 2010 he has been performing a key role in the development and management of ONDRAF/NIRAS waste acceptance criteria. This includes the evaluation and judgment of cases of waste nonconformities. He is also co-author of the Safety Analysis Report of the surface repository, planned to be constructed in Dessel (Belgium) in the next decade.

Maarten Van Geet obtained a PhD in geology at the university of Leuven, Belgium in 2001. He immediately started at SCK•CEN, the Belgian research centre on nuclear energy, to work on the characterization of clay materials as barrier within a geological disposal system. This work covered host rock characterization, hydro-mechanical behaviour of bentonites and perturbations of the host rock, including the follow-up and installation of several in-situ experiments in the underground research laboratory HADES in Mol, Belgium. In 2007 he joined ONDRAF/NIRAS, the Belgian agency for radioactive waste management. He first was in charge of the research on perturbations of the host rock. In 2008 he became RD&D coordinator for geological disposal, including the management of the next safety

case. In 2016 he became RD&D Manager, steering all Belgian RD&D on radioactive waste management (treatment and conditioning, surface disposal and geological disposal). At international level he is involved in European research steering, collaboration with and/or member of advisory groups for several other waste management agencies and since 2014 member of the ‘Groupe Permanent d’expert sur les déchets’ (expert group on waste) of the French Autorité de sûreté nucléaire (French safety authority).
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content • ONDRAF/NIRAS (2013) “ONDRAF/NIRAS Research, Development and Demonstration Plan for the Geological Disposal of High-Level And/Or Radioactive Waste Including Irradiated Fuel If Considered as Waste. State-of-the-Art Report as of December 2012.” NIROND-TR 2013–12 E. Brussels, Belgium. • Gonzalez-Blanco, L., E. Romero, C. Jommi, X. L. Li, and X. Sillen (2016) “Gas Migration in a Cenozoic Clay: Experimental Results and Numerical Modelling.” Geomechanics for Energy and the Environment 6 (June): 81–100. • Pardoën B., Levasseur S., Collin F. (2014) “Using local second gradient model and shear strain localisation to model the excavation damaged zone in unsaturated claystone”, Rock Mechanics and Rock Engineering, vol. 48(2): 691–714. • Capouet M.; Depaus C.; Van Geet M.; Lalioux P. (2013) “RD&D steering of a geological disposal programme in poorly indurated clays”, in The Safety Case for Deep Geological Disposal of Radioactive Waste: 2013 State of the Art, Symposium proceedings, NEA R(2013)9. • Topic NFRP-2018-5: “Development of a roadmap for decommissioning research aiming at • safety improvement, environmental impact minimisation and cost reduction”, Euratom Work Programme 2018, Call on Nuclear Fission, Fusion and Radiation Protection Research.
a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal • As the Belgian WMO, ONDRAF/NIRAS has conducted several assessments of options for the long-term management of radioactive wastes in Belgium, including the feasibility and safety of geological disposal (such as the SAFIR and SAFIR-2 exercises in 1989 and 2001 or the 2013 Waste Plan) to support decisions by the Belgian authorities. • ONDRAF/NIRAS and/or its employees have participated in many IAEA, NEA and EC projects related to radioactive waste management including disposal. In particular, connected to the topics in this proposal, - o Séverine Levasseur participated in the FORGE EC project; - o Séverine Levasseur and Xavier Sillen participated in the TIMODAZ EC project; - o Christophe Depaus participated in the EC MoDeRn 2020; - o Maarten Van Geet and Xavier Sillen participated in the NF-PRO EC project; - o ONDRAF/NIRAS has participated to the CAST EC project and participates to the THERAMIN EC project.
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; Through the EIG EURIDICE, ONDRAF/NIRAS ensures the functioning of the Underground Research Laboratory HADES in which it conducts a large part of its experimental R&D programme on many aspects of near-field and far-field THMC processes in Boom Clay.
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task. N/A

		Name	Acronym
Participant	33	Posiva Oy	POSIVA
Description of the legal entity Posiva Oy from Finland is a nuclear waste management company whose main task is the disposal of the spent fuel of its owners' NPPs. It is jointly owned by Teollisuuden Voima Oy (TVO 60%) and Fortum Power and Heat Ltd (FPH 40%). POSIVA have been carried out a research, development and technical design programme for disposal in ONKALO Underground Rock Characterisation Facility (URCF). Posiva will be in charge of the disposal facility in Olkiluoto, Finland, which construction have been initiated. Posiva's ONKALO offers a unique site for practical learning experiences related to repository characterization and construction of underground facilities. Posiva is currently testing in ONKALO the EBS component emplacement and the early evolution of disposal system in full scale. POSIVA started operations in 1996 and has over 50 specialists engaged in research, development and technical design for an environmentally acceptable disposal solution. POSIVA's programme brings together the resources of Finnish research institutes, universities and consulting and contracting companies. POSIVA has unique specialization in Europe related to site characterization and underground site specific activities. POSIVA received the Decision in Principle for the site of the geological disposal facility in 2000 and 2002 and a construction license for a geological disposal facility and encapsulation plant in 2015 as the first in the world. As a part of the preparations for the start of the construction and operations, POSIVA has carried out and continues the planning a series of various full-scale tests and demonstrations on encapsulation and disposal technologies. These will be carried out partly in the ONKALO, the Olkiluoto underground rock characterization facility, partly in suitable surface facilities. POSIVA has participated in many EURATOM projects related to geological disposal since 4th framework program. POSIVA's most recent EURATOM projects include ReCoSy, FORGE, MODERN, SecIGD, SecIGD2, REDUPP, LUCOEX, BELBaR, Petrus II, Petrus III, DOPAS (in FP7) and in H2020 MIND and MODERN 2020. In addition, POSIVA is an end user in several other European R&D projects. POSIVA has gained years of experience in working with and applying R&D results into its underground repository development work. POSIVA has acted as the coordinator of SecIGD and DOPAS projects. In addition, POSIVA has led several work packages in the EURATOM projects with success.			
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks Posiva is mainly participating in HITEC WP3 Tasks 3.1 and 3.2 and Task 4. Posiva is providing planning and review support for the Tasks and coordinating the R&D work by Finnish RE organisations. Posiva also follows other scientific work packages like EJP1 GAS and WP: Spent Fuel Characterization and Evolution Until Disposal.			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities <u>Dr. Mika Niskanen</u> (M) is the scientific contact of POSIVA in the Hitec Project. He graduated in 2011 from the University of Eastern Finland, where he completed his PhD in physical chemistry on modelling “metallic polymers” and examining atomic and molecular interactions. He joined Posiva in 2016 and works as R&D engineer in Posiva's Plant Engineering to maintain up-to-date thermal dimensioning for the planned repository design. Moreover, he is managing several projects that deal with bentonite clay early evolution. <u>Ms. Tiina Jalonen</u> (F) She holds M.Sc.in Metallurgical Engineering from the University of Oulu. She has been working at Posiva since 2001 with R&D and Development for Engineered Barriers. Currently she is Senior Vice President at Posiva and a member in Management Group of Posiva Oy. She acts as a Finnish WMO mandated actor representative in Eurad programme. <u>Ms. Johanna Hansen</u>, (F) She holds M.Sc. in Geology and Mineralogy from the Åbo Akademi University. She has been working at Posiva since 1997 both with site investigations and currently with development of disposal technology in Engineering. She coordinated the FP7 project DOPAS 323273 and she acts as a Finnish WMO mandated actor deputy contact in Eurad programme. <i>Other Posiva's staff members are also engaged in the Programme.</i>			

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- Juvankoski, M. 2013. Buffer design 2012. Report POSIVA 2012-14, Posiva Oy. ISBN 978-951-652-195-7.
- Posiva Oy. Safety case for the disposal of spent nuclear fuel at Olkiluoto – performance assessment 2012. Report POSIVA 2012-04, Posiva Oy. ISBN 978-951-652-185-8.
- Toprak, E., Mokni, N., Olivella S., Pintado, X. 2013. Thermo-hydraulic-mechanical modelling of buffer and backfill. Report POSIVA 2012-47, Posiva Oy. ISBN 978-951-652-230-5.
- Pintado, X., Rautioaho, E. 2013. Thermo-hydraulic modelling of buffer and backfill. POSIVA 2012-48, Posiva Oy. ISBN 978-951-652-229-9.
- Toprak, E. 2018. Long term response of multi-barrier schemes for underground radioactive waste disposal. Doctoral thesis, Universitat Politècnica de Catalunya.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

- BELBaR – Bentonite erosion: effects on long term performance of the engineered barrier and radionuclide transport. FP7-EURATOM project, Grant Agreement No. 295487. POSIVA participated in evaluating the effects of bentonite erosion in dilute waters on the performance of engineered barrier system in repositories.
- DOPAS – Full-scale demonstration of plugs and seals. FP7-EURATOM project, Grant Agreement No. 323273. POSIVA coordinated demonstration project, which targeted to implement full scale plugs and seals and evaluate their functions and workability in repository conditions. The plugs and seals may include swelling clay materials to ensure the tightness. The bentonite behaviour and related saturation process were modelled in many DOPAS Experiments.
- FORGE – Fate of repository gases. FP7-EURATOM project, Grant Agreement No. 230357. POSIVA participated in the investigation of gas migration in the bentonite buffer.
- Prototype Repository. Project was coordinated by SKB (EC project reference No. FIKW-CT-2000-00055) and was conducted as part of Nuclear fission and safety programme 1998-2002 and related Retrieval of Prototype Repository project 2010-2013. Within the project, the emplacement of EBS components was studied and, during retrieval phase, the buffer material in two deposition holes and backfill in above lying deposition tunnel was sampled, analysed and modelled.
- FEBEX (I) / FEBEX II – Full-scale engineered barrier experiment in crystalline host rock. EC-supported (EC project reference No. FIKW-CT-2000-00016) joint project between multiple nuclear waste management organizations and research facilities. POSIVA participated in the monitoring the development of different parameters with on-line measurements at the Grimsel test site.

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

Posiva is currently testing the EBS concept including buffer and backfill emplacement and monitoring of early evolution in ONKALO facility in full scale. In addition Posiva has a ready set up for 1/3 scale deposition holes equipped for monitoring and access to ground water.

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

	No	Name	Acronym
Participant	34	Paul Scherrer Institute	PSI
The Paul Scherrer Institute (PSI), is the largest research institute for natural and engineering sciences within Switzerland. PSI performs world-class research in three main subject areas: Matter and Material; Energy and the Environment; and Human Health. By conducting fundamental and applied research, PSI works on long-term solutions for major challenges facing society, industry and science. PSI has a unique position in Switzerland with respect to nuclear energy research, due to its heavy infrastructure, namely the Hot Laboratory with so-called "hot cells", well equipped and shielded zones for work and research on radioactive material. Based on this infrastructure, PSI's large facilities (SLS and SINQ) and the know-how of its collaborators, the division is involved in three main topics of research: the safety of currently operating nuclear reactors, related fuel cycles, and long-term safety of deep geological repositories for nuclear wastes of all kind. In particular the Laboratory for Waste Management, (LES) is the Swiss competence center for geochemistry and multiscale radionuclide and mass transport in argillaceous rocks and cement and their application to deep geological systems and Swiss radioactive waste repositories. The mission of the LES is to carry out a comprehensive R&D programme in support of Swiss radioactive waste disposal options. Research activities within LES are performed on very different spatial and temporal scales to take advantage of all the information which can (potentially) be obtained from such an approach i.e. from the nano scale (molecular spectroscopy), to the micro scale (XAS), to the cm scale (laboratory) and to field and regional scales (Mont Terri Rock Laboratory, St Ursanne, Switzerland). During the last 30 years, LES researchers have been developing state of the art models for the mechanistic description of radionuclides transport and retention in argillaceous rocks. Particular strength of the research labs is the combination of experimental infrastructure with the state-of-the-art coupled reactive transport modelling capabilities covering the simulation scale from atomistic to pore and the field scales. These tools are applied for quantitative prediction of repository in situ conditions over geological time scales. In the WP-FUTURE PSI coordinates Task 2 on Experimental studies on radionuclides mobility in compacted clay, crystalline rocks and reversibility of sorption with strongly sorbing radionuclides, and conduct laboratory studies in this task. Diffusion experiments will be carried out with moderately sorbing tracers (Fe, Ni and evt. Mn) and a strongly sorbing tracer (Eu) in compacted illite and in intact Opalinus Clay. The speciation of the adsorbed metals will be explored using synchrotron-based techniques. This will help to evaluate the current knowledge on surface mobility of these kind of metals. PSI will carry out adsorption/desorption experiments with Ni/Zn on pure clay minerals (illite/montmorillonite) under different specific experimental conditions (pH, presence of competing ligands/metals, variation of equilibrium concentrations and time). The local structure environment of the surface species will be probed by P-EXAFS. PSI also co-coordinates Task 3 Redox and conduct laboratory studies in this task. Purified reference clays will be prepared to obtain different Fe(III)/Fe(II) ratios (i.e. CBD reduction) or will be altered by sorbing Fe(II) under electrochemically reducing conditions. The sorption of U, and Tc or Se on the different Fe/clay systems will be investigated by combining batch type sorption experiments under different conditions (pH, [RNs], [Fe], Eh), molecular scale speciation using X-ray absorption spectroscopy and sorption modelling. In the WP-ACED PSI coordinates Task 3 on the Modeling of chemical evolution in repositories for HLW and ILW at a scale of individual waste packages (conditioned waste, disposal container, overpack). In this work package, recently developed solid solution models for C-S-H, AFm, and AFt phases will be extended by Fe-uptake, based on wet chemistry and spectroscopic data, using a multi-parameter multi-property optimization method. The resulting internally consistent set of parameters will provide a chemical-thermodynamic basis for improved reactive transport modelling in iron-containing cementitious systems used by the other modelling partners. Further, PSI will carry out simulations on the chemical evolution and gas/water mass balances in waste packages containing metallic and/or organic waste with the GEM-Selektor chemical modelling package and OpenGeoSys-MP-LT, a multi-component two-phase reactive code developed in cooperation with UFZ Leipzig.			

In the **WP-DONUT** PSI co-coordinates Task 3 on Scale transition schemes for coupled processes and participate in Task 2 on Numerical methods for high performance computing of coupled processes. While optimized continuum and pore-level codes exist a cross-coupled overarching code is still missing. Therefore PSI will address multi-scale chemo-mechanical couplings by linking numerical methods and open-source software for integrating pore-scale reactive transport models with continuum-scale THM(C) codes.

In the **WP-GAS** PSI participates in the Subtask 2.1 – Experimental and modelling studies of diffusion and retardation of gaseous species in clay rocks. PSI will work jointly with SCK•CEN to perform diffusion experiments on Boom Clay, Opalinus Clay and sand/bentonite mixtures and the experimental results will be supported by pore network modelling. Experiments will be carried out at different degrees of saturation, with different gases. This will allow determining how the effective diffusion coefficient is influenced by desaturation. By using lattice-Boltzmann modelling, the gas partitioning in pores of different sizes will be estimated.

In the **WP-CORI** PSI participates in Task 2, and will perform hydrolytic degradation experiments of aged samples of cellulose and the identification of degradation products.

In the **WP-SFC** PSI co-coordinates Task 2 on Fuel properties characterization and related uncertainty analysis. PSI plans a characterization of inhomogeneous hydrogen distribution due to impact of pellet on cladding (irradiated samples) with analysis of radial and circumferential hydrogen distribution and quantification in the treated claddings with neutron radiography. Further PSI coordinates and contributes to the Subtask 2.1 – Theoretical study of SNF source terms. PSI plans synchrotron measurements of chemical and structural / crystallographic properties of irradiated doped/undoped fuel at the cladding/pellet interface to determine the bonding /PCI properties.

a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities

Dr. Bart Baeyens (Male) Leader of the Clay Sorption Mechanisms group at the Laboratory for Waste Management (NES/PSI); Expert in experimental radionuclides sorption studies and modelling.

Prof. Dr. Sergey Churakov (Male) Head of the Laboratory for Waste Management (NES/PSI) and full Professor of Mineralogy at the University of Bern. Expert in multiscale modelling of reactive transport processes, radionuclide adsorption and transport.

Dr. Martin A. Glaus (Male) Research Scientist at the Laboratory for Waste Management (LES/NES). Expert experimental studies of radionuclides diffusion in compacted clay systems and radionuclide retention modelling.

Dr. Georg Kosakowski (Male) Senior scientist in the Transport Mechanisms Group at the Laboratory for Waste Management (NES/PSI). Expert in reactive transport simulations.

Prof Dr. Barbara Lothenbach (Female) Head of the Thermodynamic Modelling Group, at the Laboratory Concrete and Construction Chemistry, Empa and Professor, International Chair at the Concrete Group, Department of Structural Engineering, NTNU Trondheim, Norway. Expert in thermodynamic modelling of cement systems.

Dr. Maria do Sameiro Marques Fernandes (Female) Scientist at the Laboratory for Waste Management (NES/PSI). Expert in radionuclides sorption modelling.

Dr. Nikolaos Prasianakis (Male) Head of the Transport Mechanisms Group at the Laboratory for Waste Management (NES/PSI). Expert in pore scale reactive transport simulations and upscaling.

Dr. Dimitri Rochman (Male) Scientist at the Reactor Physics and Thermal-Hydraulics laboratory (NES/PSI). Expert in spent fuel behaviour.

Dr. Luc Van Loon (Male) Head of the Diffusion Processes Group at the Laboratory for Waste Management

(NES/PSI) and Deputy Head of the Laboratory for Waste Management. Expert in radionuclide diffusion and retention in compacted clay systems.

Dr. Erich Wieland (Male) Head of the Cement Systems Group at the Laboratory for Waste Management (NES/PSI). Expert in radionuclide uptake in cement systems and radionuclides – organics interaction.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- Bradbury, M.H., Baeyens, B. (2005). Modelling the sorption of Mn(II), Co(II), Ni(II), Zn(II), Cd(II), Eu(III), Am(III), Sn(IV), Th(IV), Np(V) and U(VI) on montmorillonite: Linear free energy relationships and estimates of surface binding constants for some selected heavy metals and actinides. *GEOCHIMICA ET COSMOCHIMICA ACTA* 69 (4), Pages: 875-892.
- Glaus, M. A.; Baeyens, B.; Bradbury, M. H.; . Jakob, A.; Van Loon, L.R.; Yaroshchuk, A. (2007). Diffusion of Na-22 and Sr-85 in montmorillonite: Evidence of interlayer diffusion being the dominant pathway at high compaction. *ENVIRONMENTAL SCIENCE & TECHNOLOGY* 41 (2), Pages: 478-485.
- Kulik, D.A.; Wagner, T.; Dmytrieva, S.V.; Kosakowski, G.; Hingerl, F.F.; Chudnenko, K.V.; Berner, U.R. (2013). GEM-Selektor geochemical modeling package: revised algorithm and GEMS3K numerical kernel for coupled simulation codes. *COMPUTATIONAL GEOSCIENCES* 17 (1), Pages 1-24.
- Churakov, S. V.; Gimmi, T.; Unruh, T.; Van Loon, L.R.; Juranyi, F. (2014). Resolving diffusion in clay minerals at different time scales: Combination of experimental and modeling approaches. *APPLIED CLAY SCIENCE* 96. Pages: 36-44.
- Safi, M. A.; Prasianakis, N.; Turek, S. (2017). Benchmark computations for 3D two-phase flows: A coupled lattice Boltzmann-level set study. *COMPUTERS & MATHEMATICS WITH APPLICATIONS* 73 (3), Pages: 520-536.
- Rochman, D., Leray, O., Vasiliev, A., Ferroukhi, H, Koning, A.J., Fleming, M. (2016).
- A Bayesian Monte Carlo method for fission yield covariance information.
- *ANNALS OF NUCLEAR ENERGY* 95. Pages: 125-134.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

RECOSY Redox phenomena controlling systems (ID: 212287) FP7-EURATOM-FISSION

FIRST-Nuclides: Fast / Instant Release of Safety Relevant Radionuclides from Spent Nuclear Fuel (ID: 295722) FP7-EURATOM-FISSION

CATCLAY: Processes of Cation Migration in Clayrocks (ID: 249624) FP7-EURATOM-FISSION

FUNMIG: Fundamental processes of radionuclide migration (ID: 516514) FP6-EURATOM-NUWASTE

SKIN: Slow processes in close-to-equilibrium conditions for radionuclides in water/solid systems of relevance to nuclear waste management (ID: 269688) FP7-EURATOM-FISSION

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

State of the art radiochemical laboratories (type A and C) in a hot laboratory and so-called "hot cells", well equipped and shielded zones for work and research on radioactive materials. Radiochemical laboratories are fully equipped with several lines of inert gas glove boxes and analytical equipment for conventional chemical analysis, gamma and beta counting, gas and liquid chromatography analysis.

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

N/A

Participant	No	Name	Acronym
	35	Public Limited Company for Radioactive Waste Management	PURAM
Description of the legal entity PURAM is the national radioactive waste management organization in Hungary, a 100% state-owned enterprise that was established by the Government in 1998. PURAM's responsibility is to prepare proposal for the national radioactive waste and spent fuel management policy and national programme as well as for their revision, take care of the final disposal of radioactive waste, interim storage of spent fuel and decommissioning of nuclear facilities. PURAM operates the Interim Spent Fuel Storage Facility (Paks), National Radioactive Waste Repository (Bátaapáti) and the Radioactive Waste Treatment and Disposal Facility (Püspökszilág). The financial source of PURAM's activities is the Central Nuclear Financial Fund, a segregated state fund within the national budget, which is exclusively earmarked for radioactive waste and spent fuel management purposes that are defined in law.			
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks PURAM is one of the participants in the Knowledge Management Programme, in the Guidance Work Package. Considering Hungary's HLW RWM programme, it is at an early stage of development, with an ongoing site selection process. Nevertheless, PURAM has gained significant knowledge in the site characterisation and licencing of a geological disposal facility, because after 15 years of investigation, in 2010, the Bátaapáti repository for LILW in a granitic formation was successfully put into operation. International experience was widely considered during site characterisation, facility design and safety assessment. Also, PURAM as a targeted end-user was involved into the finalisation of the PLANDIS 2015 Guide. This guidance was applied by PURAM for the compilation of Hungary's National Programme for the RWM. The updated version of PLANDIS Guide and the completed PLANDIS 2020 will contain a lot of useful information for PURAM and supports further development and implementation of the Hungarian RWM programme.			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Péter Pál Molnár: He has been working for PURAM since 2011 and spent significant time on the High Level Waste siting project. Mr Molnár is the Head of Research department of PURAM. He is responsible for the management of the siting project. As a Head of the Research Department, he is also responsible for the management of the natural barrier research projects, compile and manage the research program, including data and knowledge management. He has MSc in Geology and has a degree in nuclear environmental engineering. He participates in the activities of the Knowledge Management Programme. Balint Nős: He is the Strategic and Engineering Director of PURAM since 2014. Mr Nős graduate from Budapest University of Technology and Economics, Faculty of Engineering physics and working in nuclear industry and radioactive waste management from beginning of his career. He is responsible for the technical coordination of the safety analyses completion, define the requirements of development and investment projects. Hungarian national policy and national program was completed with his contribution. Mr Nős directs and supervises the Research Department of PURAM. Gerda Marianna Németh: She has been working for PURAM since 2013. She finished a Master degree in Environmental engineering from the faculty of Budapest University of Technology and Economics and has a degree in nuclear environmental engineering. She will be involved in the Guidance Work Package and will be the administrative coordinator of PURAM.			
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content 1. Current Status of Geological Disposal Projects in Hungary, A. Baksay, K. Benedek, B. Molnár, P. Molnár, B. Nős and Gy. Tungli, to appear in the Proceedings of the Fifth Worldwide Review (WWR-5), a workshop in May 2016 hosted at Lawrence Berkeley National Lab 2. Benedek, K., Molnar, P.: Combining structural and hydrogeological data: Conceptualization of a fracture system. Engineering Geology 163, (2013): 1-10. 3. 4. Benedek, K., Mező, Gy., Szabó, Zs., Molnár, P., Bóthi, Z., Geiger, J., Sidló, T., Dankó, Gy.: The			

Hydrogeological Modelling of the Bataapáti Site. Annual Report of the Geological Institute of Hungary 2009: 149-165 4. Benedek, K., Bóthi, Z., Mező, Gy., Molnár, P.: Compartmented Flow at the Bataapáti Site in Hungary. Hydrogeology Journal. 17 (2009): 1219-1232. 5. Nős, B., Fritz, A., Fritz, L., Molnár, P., Tungli, Gy.: Site Investigation Programme of the Boda Claystone Formation 2018. Manuscript, PURAM report RHK-N-005/18.
a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal PURAM is a member of IGD-TP Executive Group. In the past years it has participated in the end-user groups of several EU projects (e.g.: PLANDIS, CAST, DOPAS, JOPRAD). PURAM is the member of various expert groups under RWMC of NEA: Integration Group for the Safety Case of Radioactive Waste Repositories (IGSC), Clay Club, Forum of Stakeholder Confidence (FSC), Preservation of Records, Knowledge and Memory across Generations (RK&M), Vision Document for the Radioactive Waste Repository Metadata Management Project (REPMET) and Working Party on Decommissioning and Dismantling (WPDD). PURAM also participates in a number of IAEA networks: International Decommissioning Network (IDN), Underground Research Facilities Network (URF), International Low Level Radioactive Waste Disposal Network (DISPONET), <u>Data Analysis and Collection for Costing of Research Reactor Decommissioning</u>
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; There aren't any significant infrastructure or any major items of technical equipment necessary to complete the proposed work. The proposed work is based on the feedback of existing information and experiences.
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task. N/A

	No	Name	Acronym
Participant	36	Regia Autonoma Tehnologii pentru Energia Nucleara	RATEN
The Technologies for Nuclear Energy State Owned Company (RATEN) is a strategic Romanian legal entity coordinating the R&D activity in the nuclear energy field, which maintains and develop the scientific and technologic support for the National Nuclear Energy Program. RATEN manages two subsidiaries: Institute for Nuclear Research Pitesti (RATEN ICN) and Center of Technology and Engineering for Nuclear Projects (RATEN CITON). The activities proposed by RATEN under this proposal will be carried out in the Institute for Nuclear Research Pitesti.			
The Institute for Nuclear Research Pitesti (RATEN ICN) is a complex R&D centre created in 1971 to provide the scientific and technical support to the national nuclear energy program. Its activity covers a wide range of nuclear fields such as nuclear safety, radioactive waste, radioprotection, nuclear fuel and materials, reactor physics. Under the Radioactive Waste Management R&D program, RATEN ICN specialists developed treatment and conditioning technologies for LLW/ILW, established and applied new methodologies for radioactive waste characterization, in parallel with performance and safety assessments mainly for the future LLW/ILW repository designed mainly to dispose of the radioactive waste generated by Cernavoda NPP but also for geological repository for CANDU spent fuel and long-lived waste. The research activity is founded on a modern and complex infrastructure consisting of TRIGA reactor, Hot Cells Facility, Radioactive Waste Treatment Department, radiochemical laboratories operating modern investigation techniques, and sustained by specialists with large experience in the nuclear field.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks			
RATEN will be involved in two R&D work packages, FUTURE and CORI, and two strategic WPs, ROUTES and UMAN.			
In FUTURE WP, RATEN is involved in Task n°3: Redox. Under this task, RATEN will carry out sorption/desorption experiments, under controlled conditions (O₂ content and Eh) to study the retention mechanisms of Tc on individual clay minerals and on the natural and “model” red clay. The influence of FeII/FeIII ratio in clay minerals, change in redox state and reversibility of sorption/incorporation will be studied. Diffusion and sorption experiments will be carried out on natural red clay samples and on a compacted “model” red clay sample. At the end of these experiments the location of Tc (Re) will be investigated using spectrometric and microscopic techniques. The sorption/desorption tests will be sustained by experimental investigations to characterize the individual minerals (clays and iron oxides) and the natural compacted clay used in experimental programme. The total and redox active Fe content and the location of Fe(II) and Fe(III) in clay minerals and in red clay will be evaluated.			
In CORI WP, RATEN is involved in Task n°2: Organics-Cement-Interactions and Task n°3: Radionuclide-Organics-Cement-Interactions. Under CORI Task n°2, RATEN proposed to investigate the interaction (sorption/desorption) of C-14 bearing organic compounds generated by CANDU spent ion exchange resins degradation with non-degraded and degraded HCP (state II, III and carbonated). The potential competitive effect of Fe on organic compounds sorption will be also investigated. Under CORI Task n°3, RATEN has proposed to investigate the effect of organics generated by spent ion exchange resins degradation on Ni (as divalent radionuclide) mobility in cementitious environments. Ni sorption kinetic and isotherms and the effect of organics on Ni sorption will be investigated by batch sorption/desorption tests. Effect of single organics and cocktails of organics and role of iron on Ni sorption on non-degraded and degraded HCP will be investigated, as well as the effect of Ca.			
In the frame of ROUTS WP, RATEN will contribute to Taks n°2 and Task n°4. Under Task 2 “Identify challenging wastes to be tackled in collaborative way within the Joint Program - Mapping and shared understanding at EU level of the practical issues on waste management routes”, RATEN will provide the current status in Romania regarding the RW classification, describe the waste management routs for institutional radioactive waste and for radioactive waste generated from Cernavoda NPP (in close collaboration with Romanian WMO), and will identify the RW generated in Romania that are not complying			

the WAC for the foreseen near surface and geological repositories in Romania. Under Task n°4 “Identification of WAC used in EU Member States for different disposal alternatives in order to inform development of WAC in countries without WAC/facilities”, RATEN will lead the sub-task 4.1 “Current use of waste acceptance criteria” and will organize (together with ONDRAF/NIRAS and GSL) and host a workshop under sub-task 4.2 “Sharing experience on waste management with/without WAC available”.

In the frame of **UMAN WP**, RATEN will lead Task n°3 “Characterization and significance of uncertainties for different categories of actors” contributing to identification of different types of uncertainties that need to be addressed in a safety case; collection and analysis of relevant information on uncertainties associated with the site and geosphere.

For the R&D work packages, RATEN ICN has quite well equipped laboratories used for sorption and diffusion experiments carried out during site selection and characterisation for Romanian near surface repository. Even in this programme we worked with different geologic materials (mostly clays, limestone and loess), different radionuclides and in different chemical conditions (redox or anoxic conditions were not involved in this programme), RATEN specialists have the needed background to continue the sorption studies. The experience gained by participating in EURATOM projects on waste management such as CEBAMA, CAST, FORGE, and CARBOWASTE is useful for the experimental activities proposed by RATEN under FUTURE and CORI WPs. Radiochemical laboratories of RATEN ICN allow performing experiments under anoxic and controlled redox conditions. We are doing experiments in anoxic conditions under CEBAMA project to investigate C-14 and Ra-226 sorption on fresh and degraded HCP, and we carried out leaching/corrosion experiments in controlled conditions under CAST project.

The expertise gained participating in CHANCE project, the knowledge in treatment of uncertainty associated with a near surface repository, as well as the good collaboration with Cernavoda NPP, the main waste generator in Romania and ANDR, Romanian WMO, substantiates RATEN involvement in networking work packages.

a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities

Dr. Crina Bucur (f) - senior researcher, she holds PhD in Physics, has experience in experimental measurements of radionuclide transport parameters in different materials component of natural and engineered barriers of a disposal facility, as well as in performance assessment for LIL waste disposal. She was involved in experimental work performed by ICN under FORGE and CAST projects, coordinating the experimental programs carried out by RATEN ICN. She is developing and coordinating the experimental programme designed to investigate the effect of cement based materials degradation on C-14 and Ra-226 sorption (under H2020 Project CEBAMA, as scientific responsible of the RATEN ICN contribution to the CEBAMA project). She coordinate for RATEN the CHANCE project.

Dr. Daniela Diaconu (f), senior researcher, she holds a PhD in Condensed Matter Physics, has experience in site characterisation, performance and safety assessment, and uncertainty analysis in near-surface and geological disposal in Romania. She coordinated and developed experimental and modeling studies in national and European research projects (CARBOWASTE, FORGE, CAST) and coordinated the 7th FP projects NEWLANCER and ARCADIA.

Eng. Mirela Olteanu (f), senior researcher, she holds a master degree in materials and nuclear technologies, has experience in radionuclide chemistry in different redox conditions, batch sorption/desorption experiments, source term modeling and safety and performance assessment for near surface repository.

Dr. Alina Constantin (f), young researcher, she holds a PhD in Chemistry, has experience in safety assessment of near-surface and geological disposal in Romania.

Eng. Ionut Florea (m), young researcher, he holds a master degree in materials and nuclear technologies, has experience in cement based materials degradation, and radionuclide diffusion in different natural and cementitious materials

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- FEHM, GOLDSIM, RESRAD
- Crina Bucur, Ionut Florea, Pascal E. Reiller, Dorin Dumitrescu, ¹⁴C Content in CANDU spent ion

exchange resins and its release under alkaline conditions, accepted to be published in Radiocarbon Journal. - Crina Bucur, Ionut Florea, Relu Dobrin, Nicolae Dulama, Nicoleta Deneanu, Ra-226 sorption on intact cement pastes based on CEM I and CEM V, Cebama 3rd Annual Workshop, 17 - 18 April 2018, Nantes, France - Daniela Diaconu, Alina Constantin, Sensitivity analysis of C-14 radiological impact for a generic concept of spent fuel disposal in Romania, NUCLEAR 2018, May 23-25, 2018, Pitesti, Romania - Crina Bucur, Radionuclide behaviour in geological media, ISBN 978-606-560-292-2, Ed. University of Pitesti, p.1-204, 2012
a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal - CEBAMA Project, WP2 – Radionuclide retention in high pH concrete - CAST Project, WP 6 - Relevance of results in national contexts and safety assessments - CHANCE Project, WP2 - Methodology for conditioned radioactive waste characterization: Problematic wastes and R&D proposal
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work - Well-equipped radio-analytical laboratories - Refrigerated Centrifuge, model Sigma 6-16 K, max. speed: 15.000 rpm, max. gravitational field: 25.155 g - Liquid Scintillation analyser, model TriCarb3110TR with QuantaSmart Software, TR-LCS background electronics, High Sensitivity Count Mode and Ultra Low Level Count Mode (capable to measure as low as 0-20 CPM above background) - Gamma (with AntiCompton system) and alpha spectrometers - DTG/TG analyser, model Shimadzu DTG-60/60H, allowing to simultaneously performing differential thermal analysis (DTA) and measurement of thermogravimetry (TG); temperature range: room temperature – 1000°C, measurement in air and inert gas. - Electronic microscope, model TESCAN VEGA/LMU for EDS/SEM investigations, with spectral resolution of 3.5 nm, pressure range: 1 – 270 Pa, zoom: x7 – x1.000.000 - Mercury intrusion porosimeter, model PoreMaster Quantachrome Instruments, with low pressure and high pressure
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task. N/A

Participant	No	Name	Acronym
	37	Radioactive Waste Management	RWM
Description of the legal entity Radioactive Waste Management (RWM) is a wholly-owned subsidiary of the Nuclear Decommissioning Authority (NDA), which is an Executive Non-Departmental Public Body of the Department for Business, Energy and Industrial Strategy (BEIS). Our vision is simple: A safer future by managing radioactive waste effectively, to protect people and the environment. All our activity is in support of realising this Vision and is a critical enabler in UK Government Policy, Implementing Geological Disposal. Our Activities support and will eventually fulfil our Mission, to: Deliver a geological disposal facility and provide radioactive waste management solutions. In order to fulfil our mission we will deliver through four key activities: Key Activity 1: Implement government policy on geological disposal of Higher Activity Waste (HAW) – we are working to develop a GDF for the long term management of higher activity radioactivity waste with a view to providing disposal capability for the UK in line with the Government’s 2014 White Paper, Implementing Geological Disposal. Key Activity 2: Work proactively with waste producers, planning for and delivering waste management solutions – we provide solutions for our parent organisation, the NDA, its Site Licence Companies and waste producers in the management of radioactive waste. We aim, to help them retrieve, condition and package wastes now, in ways that make them suitable for disposal later. Key Activity 3: Deliver a robust Technical Programme, support the GDF programme and waste management – The technical programme will provide designs and safety case capability to support the GDF programme and waste management, and will work with the site characterisation team as potential sites are identified. In preparation, RWM needs to acquire capability in business-critical areas e.g. developing GDF designs, disposal concepts, the making of Development Consent Order applications and other permits, environmental assessments, as well as safety and security cases. Key Activity 4: Develop RWM into a high performing delivery organisation – our people are central to our strategy and we need to attract and retain the very best if we are to meet our commitments. RWM needs to be credible both internationally and for the communities we intend to work with, so we plan to build our business to be a high performing delivery organisation. Radioactive waste management is a complex subject, so our vision demands that we employ leaders in this field.			
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks RWM will participate in the EURAD Programme Management Office (PMO), two of the R&D WP’s (GAS and HITEC) and two of the Strategic Studies (UMAN and to a lesser extent ROUTES). RWM will support delivery of the EURAD PMO. In this role we will primarily provide scientific and technical coordination/integration between the RD&D, Strategic Studies and KM activities (Task 2). We will also support the proposed Bureau and General Assembly in SRA/Roadmap extension/update exercises (Task 3) and help to identify suitable subject matter/theme experts from the EURAD colleges. In particular RWM will act to co-ordinate the proposed WMO college and its interactions with the existing IGD-TP. RWM will act as a member of the project steering committee and as task co-leader in the GAS WP. RWM’s involvement will include leading subtask 4.1 conceptualization of gas migration at repository scale. RWM will provide a WMO perspective, and input from the UK programme, about the conceptualisation of gas migration at a disposal facility/repository scale and the assessment of its impact in the context of the Safety Case. Additionally, RWM will co-fund the activities of the British Geological Survey in the GAS WP, noting			

BGS is the other UK mandated actor and carries expertise in the WP specification.

In HITEC RWM will co-fund work of another mandated actor, BGS, to deliver a matrix of laboratory tests. These tests will evaluate the self-sealing capability of clay based materials under thermal loads. For subtask 2.1 tests will consider the near field, where damage from excavation may exist, and subtask 2.2 will consider the far field, where clay based material is intact. For Task 3 laboratory tests at >100C will be undertaken to evaluate the behaviour and evolution of a range of bentonites in response to thermal load. RWM will share knowledge and expertise arising and prepare a synthesis report regarding the relevance of the findings to RWM. This synthesis will underpin RWM's contribution to Task 4, which consolidates the impacts of the learning from the experiments. RWM will also contribute knowledge from our programme to subtask 1.2 which establishes the state of knowledge.

In UMAN, RWM will contribute to subtask 2.1 (generic strategies for managing uncertainties) by participating in technical meetings, providing input regarding the strategies considered in our national programme, exchanging on the pros and cons of strategies and reviewing the deliverable. We will also contribute towards subtask 2.2 (uncertainty identification, classification and quantification) by participating in technical meetings, providing input regarding the approaches considered in our national programme, providing written material and reviewing the deliverable. Likewise RWM are involved in subtask 2.3 (methodological approaches to uncertainty and sensitivity analysis) and will do this via participation in technical meetings and sharing our experience. RWM will also contribute to subtask 5.1 and 5.2. This will be done via a contribution to the development of materials related to Topics 1 and 2, to be discussed in seminars. We will also contribute to the development of deliverables 5.1 and 5.2.

In the ROUTES WP, RWM will act as an observer/contributor. We have not requested any financial support for this involvement as such activities are already funded elsewhere within our national programme (i.e. within the UK Problematic Waste Integrated Project Team).

a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities

Robert Winsley (M) is a Materials Scientist, who obtained a PhD in Corrosion Science at the University of Birmingham, UK in 2008. He worked at SERCO (now Wood), as a corrosion specialist for 4 years, before joining NDA's Radioactive Waste Management Directorate (now RWM) in 2012. Robert is currently a Senior Research Manager within RWM, responsible for RWM's underpinning science knowledgebase in the areas of spent fuel evolution, container corrosion and criticality safety. Robert is the current Secretary General of the Implementing Geological Disposal Technology Platform (IGD-TP). He is responsible for the development and maintenance of the groups Strategic Research Agenda, Deployment Plan and website. Robert will be involved in the EURAD PMO and will act as a link between the WMO College, the IGD-TP and the EURAD programme.

Simon Norris (M) will be the RWM contact person for the GAS WP. He is an Earth Scientist with 25 years' experience in geoscience research relating to the long-term safety case for the geological disposal of radioactive waste. Simon coordinated the EC CAST and GASNET projects, and led EC FORGE project activities on implications of gas generation and migration for the safety case. In addition to EC work, Simon represents the UK at the NEA Clay Club, and works extensively with IAEA. Simon is RWM's subject matter expert for gas generation and migration.

Matt Bailey will be the contact person for HITEC, and he will be supported by Sally Thompson.

Matt (M), positioned as RWM's Research Manager for the bentonite engineered barrier systems since September 2017, is responsible for leading RWM's research agenda in this field. He has managed and reviewed work conducted by external contractors on coupled processes in bentonite and represented the UK's programme at SKB's Engineered Barrier System Task Force. Matt is an environmental geochemist with over 10 years' experience, a fellow of the Geological Society of London and Chartered Scientist (UK) since 2013, obtaining his PhD in hydro-geochemical engineering from the University of Newcastle upon Tyne in 2016.

Sally (F) obtained a PhD in Hydrogeology from the University of London in 2001. She worked in industry

and as an environment regulator, in ground and groundwater improvement projects. She joined RWM in 2014, taking the lead on bentonite and groundwater projects. She has lead RWM's involvement with national and international projects that consider the evolution of bentonite buffers when heated, where these involve experimental, in-situ tests and numerical modelling tasks.

Lucy Bailey (F) will be the RWM contact person for the UMAN WP. She is a physicist with 25 years' experience in developing safety cases for the geological disposal of radioactive waste and leads RWM's post-closure safety and environment team. Lucy is also the current Chair of the OECD NEA's Integration Group for the Safety Case (IGSC) and also co-chairs an IAEA safety case project on human intrusion (HIDRA). Lucy has worked on a number of EC projects in the nuclear safety area and has been an expert reviewer of a number of international safety cases and is an experienced presenter.

Mark Cowper (M) will be RWM's contact for the ROUTES WP. Mark is part of the Core Team of the Problematic Waste Integrated Project Team supporting the NDA strategy which was established in April 2016 to develop a UK wide solution for the improved management of Problematic Radioactive Wastes which either has no treatment solution or the current solution is sub-optimal. Mark joined the nuclear industry in 1990 and, before joining RWM in 2016, specialised in laboratory studies underpinning geological disposal, managing on-site work in support of decommissioning projects at Sellafield and on Magnox Ltd sites and managing experimental programmes involving spent fuel and nuclear materials. From 1999-2002, whilst working for AEA Technology, Mark was the Programme Coordinator for the European Commission 5th Framework "Rates and Mechanisms of Radioactive Release and Retention inside a Waste Disposal Canister "In can processes" programme.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- Radioactive Waste Management, Geological Disposal - Overview of the generic Disposal System Safety Case, NDA Report no. DSSC/101/01, December 2016.
- Radioactive Waste Management, Geological Disposal - Science and Technology Plan, NDA Report no. NDA/RWM/121, May 2016.
- Radioactive Waste Management, Geological Disposal - Methods for Management and Quantification of Uncertainty, NDA Report no. NDA/RWM/153, January 2017.
- J.F. Harrington, C.C. Graham, R.J. Cuss and S. Norris, Gas network development in a precompacted bentonite experiment: Evidence of generation and evolution. Applied Clay Science 147 (2017) 80–89. <http://dx.doi.org/10.1016/j.clay.2017.07.005>. 2017.
- S. Baxter, D. Holton, S. Williams and S. Thompson, Predictions of the wetting of bentonite emplaced in a crystalline rock based on generic site characterization data, Geological Society, London, Special Publications, 482, 7 September 2018, <https://doi.org/10.1144/SP482.8>

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

- As the UK WMO, RWM has produced a number of generic geological disposal facility safety cases for UK's inventory of higher activity radioactive wastes, including the recent 2016 Generic Disposal System Safety Case (gDSSC).
- RWM and/or its employees have participated in many NEA and EC projects related to radioactive waste management and disposal. In particular, connected to the topics in this proposal,
 - o Simon Norris recently co-ordinated the EC CAST project and also participated in the completed EC FORGE and MODERN projects, as well as the ongoing MODERN 2020 project.
 - o Lucy Bailey currently chairs the NEA OECD Integration Group for the Safety Case (IGSC)
 - o Robert Winsley current acts as Secretary General for the Implementing Geological Disposal Technology Platform (IGD-TP).
 - o RWM were central to the recently completed EC JOPRAD project that established the groundwork for Joint Programming in the Radioactive Waste community.
 - o RWM currently participate in the ongoing CEBAMA, BEACON, THERAMIN, DISCO, and CHANCE projects.

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work N/A

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task. N/A

	No	Name	Acronym
Participant	38	Belgian Nuclear Research Center	SCK•CEN
Description of the legal entity SCK•CEN (www.sckcen.be) is a foundation of public utility and is one of the largest research institutions in Belgium, with activities dedicated to the development of peaceful applications of radioactivity. Our developments have already resulted in a long list of innovative and forward-looking applications for the medical world, industry and the energy sector. In the course of our work, there are three main research topics: • <u>The safety of nuclear installations</u> • <u>The well-considered management of radioactive waste</u> • <u>Human and environmental protection against ionising radiation</u> We offer various services and operate BR2, a Material Test Reactor (MTR) with a very high neutron flux, BR1, a graphite-gas research reactor, GUINEVERE a zero-power-critical-facility, several gamma irradiation facilities, a laboratory for High and Medium Activity and Nuclear analysis, as well as different chemical laboratories. Through the EIG EURIDICE, an economic interest grouping between SCK•CEN and ONDRAF/NIRAS, we run our Underground Research Laboratory HADES. Also noteworthy are our European demonstration programs for PWR dismantling and MYRRHA (Multi-purpose hYbrid Research Reactor for High-tech Applications), an Accelerator Driven System (ADS) under development in Mol. SCK•CEN began R&D on geological disposal in clay in 1974 and since then has been an active participant in all EC FP's and the R&D programs of ONDRAF-NIRAS, performing R&D on many aspects of near-field and far-field processes including laboratory experiments in its hot and cold dedicated facilities, state-of-the-art multi-scale and coupled modelling, in-situ tests in the HADES URL and performance and safety assessment for both surface and geological disposal concepts. SCK•CEN actively contributes to the Belgian programme for radioactive waste disposal as a main contractor for the Belgian waste management organisation, ONDRAF-NIRAS, in two projects: 1) the surface disposal facility for short-lived low and intermediate level waste in Dessel, and 2) research on a potential geological disposal facility in poorly indurated clay formations. SCK•CEN received the mandate as research entity (RE)-type programme manager by our programme owner. Also noteworthy is the SCK•CEN Academy for Nuclear Science and Technology (academy.sckcen.be), which has a specific task to foster the transfer of nuclear knowledge, skills and attitudes towards students and professionals who are active in the nuclear field. Following topics are part of the SCK•CEN Academy's mission: 1) guidance for young researchers; 2) organisation of academic courses and customised training for professionals; 3) policy support regarding education and training in nuclear domains; 4) caring for critical-intellectual capacities.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks SCK•CEN contributes to different tasks in EURAD-1: • RD&D work packages: as the largest Belgian nuclear research organization and a major international player in the field of radioactive waste management RD&D, we contribute to different RD&D work packages to a varying degree, reflecting both our own interest and the interest of the Belgian waste management programme in the different studies that will be undertaken. We also coordinate one RD&D WP (Assessment of the Chemical Evolution of a Disposal cell – ACED), for which we have particular interest, because it combines both an experimental programme and coupled process modelling, two items where we score strongly. • Strategic Studies work packages: within the Strategic Studies work packages we follow up the international progress related to several hot topics, including uncertainty management and dealing with legacy waste. In the first topic there is also a more specific interest in looking at the societal aspects related to uncertainty treatment, while in the second topic there is also an interest because we			

- dispose of several difficult-to-manage waste forms on site given our large nuclear heritage.
- Within the Knowledge Management work packages we coordinate the work package on Training&Mobility, where we use the return of experience from the SCK•CEN Academy.

a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities

- **Christophe Bruggeman** (1976) (M) (PhD in Bio-Engineering Science) is the head of the Expert Group Waste&Disposal and Deputy Director of the Environment, Health and Safety Institute at SCK•CEN. As such, he is responsible for the coordination of the RD&D related to radioactive waste disposal on an administrative, financial and scientific level. His scientific career started at the Katholieke Universiteit Leuven where he studied the geochemical behaviour of selenium and technetium oxyanions under Boom Clay environment. In January 2007, he joined SCK•CEN as a scientific collaborator focussed on the drawing of phenomenological models for RN migration behaviour under Boom Clay conditions. He has experience as an experimentalist, geochemical modeller (Phreeqc, CHESS, GWB), and with XAS spectroscopy. Later on he became project leader and in January 2015 he became head of the Expert Group.
- **Elie Valcke** (1966) (M) (PhD in Bio-Engineering Science) joined the SCK•CEN in 1995 as a postdoc in the Radioecology Laboratory. In September 1996 he switched to the Waste and Disposal Expert Group, where he started working on degradation and compatibility studies of various waste forms (bituminised, cemented, and vitrified waste), partly performed within EC co-funded projects, where he co-ordinated the EC 4FP CORALUS project and 5FP CORALUS-II project on the CORrosion of Alpha-doped HLW gLass in Underground Storage conditions. Through the years he became task leader and later project leader for mainly the characterization and compatibility studies on Eurobitum bituminised long-lived intermediate-level waste, funded by ONDRAF/NIRAS, covering both geomechanical and geochemical aspects, and including experimental and modelling work. Since September 2013 he is the head of the Research Unit "R&D Waste Packages", that performs experimental and modelling studies on the long-term behaviour of vitrified waste, spent fuel, different intermediate-level waste forms, and on the corrosion of metallic barriers and container materials.
- **Norbert Maes** (1969) (M) (PhD in Chemistry) joined the SCK•CEN in 1996 as a postdoc in the Waste and Disposal Expert Group, where he developed a new fast technique to determine radionuclide migration parameters in Boom Clay by the use of electromigration. After his post-doc, he became task leader for several contracts with NIRAS/ONDRAF and co-ordinated the EC 5FP TRANCOM-II project (Migration Case Study: Transport of radionuclides in a reducing Clay sediment). In 2005 he became head of the research unit "R&D Disposal" which covers the characterisation of host rocks (including perturbations) and barrier materials (clays, concrete,...), geochemistry and radionuclide migration. His research lines are i) transport of gas and radionuclides through low permeable materials (Boom Clay, Ypresian Clay, bentonite, concrete,...) ii) phenomenological understanding of the impact of humic substances on radionuclide transport: complexation, sorption, colloid transport iii) degradation processes of cement based materials and their impact on microstructure and transport processes. Participated in numerous EU projects (EURATOM): as researcher in TRANCOM-Clay (4FP), researcher in ResealII (FP5), co-ordinator of the project TRANCOM-II (FP5), WP-leader in FUNMIG (FP6), researcher in NF-PRO (FP6), WP leader in CATCLAY (FP7), researcher in FORGE (FP7), Researcher and Chairman General Assembly CEBAMA-Cement Based Materials (H2020).
- **Diederik Jacques** (1971) (Phd in Bioscience Engineering) joined SCK•CEN in 2000 as a postdoctoral-student on the development of a coupled reactive transport code (HYDRUS-PHREEQC). After his post-doc, he worked in the Performance Assessment unit as a numerical modeller combining his previous expertise on flow and transport phenomena in porous media with newly developed skills on geochemistry. Throughout a number of national and international EU projects, he worked on applications in degradation of cementitious materials used in engineered barriers, flow and transport in the near field of surface and geological disposal systems, geochemical evolution of these systems and flow and transport including colloids in soil systems. He is involved in model development both at pore-and continuum-scale. Furthermore, he has built expertise in safety and performance methodologies for surface and deep radioactive waste disposal systems or NORM sites. In 2001, he became the group leader of the unit now called Engineered and Geosystem Analysis of the Waste&Disposal expert group. Management skills are developed as group and project leader (e.g., cAt project for surface disposal of low level and intermediate level short-lived radioactive waste in Belgium). He author and co-authored

more than 100+ publications listed in SCOPUS.

- **Nele Bleyen** (1981) (F) (PhD in Bioscience Engineering) joined the SCK•CEN in 2009 as a scientific collaborator, and is mainly involved in studying the compatibility of bituminised radioactive waste (Eurobitum) with geological disposal. These studies are performed to investigate the potential geomechanical (due to water uptake and related swelling of the waste and due to gas production) and geochemical (due to leaching of salt and organics) perturbations of the host rock due to disposal of Eurobitum in the Boom Clay and include both experimental (in lab and in situ) and modelling work. Furthermore, characterisation of the bituminised waste form and degradation studies are performed. In 2014, she became the project leader for these studies, which are funded by ONDRAF/NIRAS.
- **Elke Jacobs** (1982) (F) (PhD in Sciences: geology) joined SCK-CEN in 2005 as a staff collaborator. In 2008, she started the project “measuring gas diffusion in clay-based materials”. This project lead to the development of a new and innovative technique which has been applied by now on a broad range of materials (Boom Clay, Callovo-Oxfordian Clay, Opalinus Clay, bentonite, shale and concrete), leading to a large set of reliable diffusion coefficients of dissolved gases. From 2009 on, she was task leader of all gas-related experiments, performed at SCK-CEN. In the period 2009-2013, she was strongly involved in 3WP's of EC FORGE (FP7). In 2013, she started her own PhD project (at KU Leuven and RWTH Aachen), which was successfully finished in 2018.
- **Eric Laloy** (1978) (M) (PhD in Bio-Engineering) joined the SCK•CEN in 2011 as a scientific collaborator in the Engineered and Geosystems Analysis unit of of the Expert Group Waste & Disposal. He is doing research on sensitivity analysis, uncertainty quantification and calibration of numerical simulators such as reactive radionuclide transport models. He is also an expert in machine learning, which he uses to construct computationally cheap statistical emulators of CPU-demanding reactive transport models. The derived CPU-efficient emulators can then be used to perform otherwise computationally intractable tasks such as global sensitivity analysis and uncertainty assessment of the original CPU-demanding models.
- **An Bielen** (1987) (F) (PhD in Biological Science) joined the SCK•CEN in 2015 as a scientific collaborator in the department Management of Waste and Liabilities and is working on a method to determine uncertainties which are related to radiological characterization of the nuclear waste of SCK•CEN, taking into account the uncertainties of the measurements itself, as well as the correlation factors included in the isotope vectors. These uncertainties might have an important effect in determining the level of activity in waste packages, and in the acceptance of waste for disposal. Furthermore, she studies and digitizes all available data concerning characterization which can lead to new characterization methodologies.
- **Marc Verwerft** (1965) (M) (PhD Physics) joined SCK•CEN in 1994, became head of the microstructure group in 1996 and is since 2002 head of the Fuel Materials group. He has coordinated the EC 5th Framework Project “OMICO” (2000-2006, 2 M€) on advanced nuclear oxide fuels, the 6th Framework Project “LWR-DEPUTY” (2006-2011, 2.5 M€) on advanced nuclear fuels (CERMET), and thoria-based fuels, and also initiated and led several industry funded projects on the nuclear fuel cycle (front-end, in-reactor performance and back-end) with partners from Europe, Asia and USA. He started his scientific career as fellow of the National Fund for Scientific Research (FWO) in materials science at the University of Antwerp and as post-doctoral researcher at the University of Groningen. Author and co-author of 60+ publications in international journals with referee system (“A1” publications).
- **Kevin Govers** (1982) (M) (PhD in applied sciences) joined the SCK•CEN in 2008 as researcher in the fuel material group. He has participated to several European projects (Actinet, F-Bridge, Inspyre, ...) modelling fuel performance in a multi-physics / multi-scale framework, and is today responsible of research projects oriented towards spent fuel isotopic inventory and source term, such as the Joint International Program REGAL. Next to his position at SCK•CEN, he is also scientific collaborator at the Université Libre de Bruxelles (ULB) in the department of nuclear metrology of the Faculty of Applied Sciences. In 2016-2017 he was the chairman of the Belgian Nuclear Society (BNS) Young Generation, and acts today as Secretary of the BNS.
- **Yves Parthoens** (1972) (M) (MSc in engineering technology) joined SCK•CEN in 2001 as Technical Staff member in the section Fysico-Chemistry and works now in the group Microstructure & Non-destructive Analysis of the Nuclear Material Science institute. He is currently working on different research projects on irradiated fuel as primary engineer in the Laboratory for High and Medium Activity. He is responsible for the exploitation of the instrumentation for non-destructive analyses in the

laboratory, such as gamma spectrometry on spent fuel. He performs within SCK•CEN quality assurance and internal audits. Was the lead engineer for the build and validation of the BONAPARTE (installed at SCK•CEN) and BONA4INL instrumentation (installed at INL USA) for detailed fuel plate swelling measurements on irradiated low enriched MTR-fuel.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- Jacops, E., M. Aertsens, N. Maes, C. Bruggeman, R. Swennen, B. Krooss, A. Amann-Hildenbrand and R. Littke (2017). The Dependency of Diffusion Coefficients and Geometric Factor on the Size of the Diffusing Molecule: Observations for Different Clay-Based Materials. *Geofluids* 2017: 16.
- Liu, S. and D. Jacques (2017). Coupled reactive transport model study of pore size effects on solubility during cement-bicarbonate water interaction. *Chemical Geology*, 466:588-599
- Maes, N., Bruggeman, C., Govaerts, J., Martens, E., Salah, S. & Van Gompel, M. (2011) A consistent phenomenological model for natural organic matter linked migration of Tc(IV), Cm(III), Np(IV), Pu(III/IV) and Pa(V) in Boom Clay. *Physics and Chemistry of the Earth*. 36, 17-18, p. 1590-1599
- Phung Q.T., Maes N., Jacques D., De Schutter G., Ye G. (2016) Investigation of the changes in microstructure and transport properties of leached cement pastes accounting for mix composition. *Cement and concrete research*. 79, 217-234.
- Patel, R.A., J. Perko, D. Jacques, G. De Schutter, G. Ye and K. Van Breugel (2018). A three-dimensional lattice Boltzmann method based reactive transport model to simulate changes in cement paste microstructure due to calcium leaching. *Construction and Building Materials*, 166: 158-170
- G. Leinders, R. Bes, J. Pakarinen, K. Kvashnina, and M. Verwerft (2017) Evolution of the Uranium Chemical State in Mixed-Valence Oxides. *Inorganic Chemistry*, 56(12): p. 6784-6787
- The SCK•CEN Academy for Nuclear Science and Technology (<http://academy.sckcen.be>) has, among others, large experience in organising customised training and academic courses for professionals and the larger civil society. The SCK•CEN Academy services will be of great value for the WP4 on Dissemination and Communication.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

- SCK•CEN has an extensive framework agreement with NIRAS/ONDRAF, covering a wide suite of RD&D domains related to waste management and disposal:
 - o Evolution and degradation of waste forms in disposal conditions (HLW glass, spent fuel, bituminised ILW, cemented cellulose-based waste, metallic container materials and wastes)
 - o Evolution and degradation of engineered barriers (metals, cementitious) in disposal conditions
 - o Geological and hydrogeological site characterisation; long-term evolution of a potential disposal site
 - o Radionuclide/solutes/contaminants/gas transport throughout the engineered and natural barriers of a disposal system
 - o Influence of microbial processes on the disposal system
 - o Societal impact and acceptance of a geological repository
 - o Monitoring and safeguarding a geological repository
- SCK•CEN also performs extensive safety assessment and safety calculations in support of the surface repository site for short-lived LILW for NIRAS/ONDRAF
- SCK•CEN is active as either WP leader or contributor in the following active EC projects
 - o MIND (www.mind15.eu)
 - o CHANCE (www.chance-h2020.eu)

- o DISCO (www.disco-h2020.eu)
- o THERAMIN (www.theramin-h2020.eu)
- o CEBAMA (<https://www.cebama.eu>)
- SCK•CEN is an active partner of the Mont Terri consortium and is involved in the following in situ experiments or projects at the Mont Terri Rock Laboratory (www.mont-terri.ch)
 - o Bitumen-Nitrate-Clay Interaction
 - o Cement-Clay Interaction
 - o Geochemical Data

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

- SCK•CEN has a wide array of radioactive and non-radioactive laboratories for waste degradation studies, which include glove boxes for working under relevant oxygen-free conditions, with radioactive (alpha-bearing) material, oedometer set-ups to investigate the volume deformation behaviour of waste forms, slow strain rate testing autoclaves for metal corrosion studies, and a variety of analytical and material preparation techniques which can be used to obtain and study standardised reference materials. SCK•CEN has also several gamma-irradiation facilities.
- SCK•CEN also has dedicated laboratories for studying the geochemical behaviour of compacted clay systems, and its impact on the speciation, solubility, transport and mobility of radionuclides. The infrastructure includes glove boxes for working under relevant oxygen-free conditions, specific radionuclide transport cells for a wide range of different setups, analytical techniques for studying colloidal properties of organic materials and for elucidating the pore water chemistry in compacted systems. SCK•CEN also disposes of dedicated cement laboratories for studying the long-term behaviour of these engineered barriers.
- SCK•CEN has a strong tradition and a large pool of people experienced with compiled and/or interpreted programming languages. We have both developed our own coupled models or used commercially available software. As a non-exhaustive list are mentioned here: HP1 (in-house developed coupled model between Hydrus and Phreeqc), Yantra (in-house developed pore scale model based on lattice Boltzmann formalism), COMSOL-Phreeqc, Geochemist's WorkBench, ALEPH2 (in-house developed Monte Carlo burn-up code).
- Together with NIRAS/ONDRAF, we run the underground research lab HADES through the EIG EURIDICE

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

N/A

Participant	No	Name	Acronym
	39	Swedish Nuclear Fuel and Waste Management Company	SKB
Description of the legal entity Svensk Kärnbränslehantering AB (Swedish Nuclear Fuel and Waste Management Company), SKB, is responsible for safe management of all nuclear waste arising in Sweden. Over the past few decades SKB has built and operated an underground final repository (SFR) for final repository for short-lived radioactive waste generated by nuclear power plants, hospitals etc., a central interim storage facility for spent fuel (CLAB) and a specially-built vessel for transportation of the wastes and the spent fuel. SKB has also planned, constructed and is operating an underground research facility – the Äspö Hard Rock Laboratory, a chemical laboratory, a bentonite laboratory and an canister laboratory. These facilities are used to execute essential research, development and demonstration before construction of the spent fuel repository and the encapsulation plant. A license application for the final repository for spent nuclear fuel was submitted in 2011 and an application to extend the SFR facility was submitted in 2014 . Reviewing is ongoing. The plan is to start construction of the SF repository around 2022 and the extension of SFR some years later.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks SKB will participate in the RD&D WP7-HITEC and WP8-SFC, as well as the Strategic Studies WP10 (ROUTES). <u>WP HITEC</u> Coordination of the Subtask 3.1– Characterisation of material treated by high temperature. Analyse the chemistry and mineralogy of blocks of the MX80, DepCAN (Milos), Asha505 (Kutch) and Calcigel bentonites from the ABM5 experiment. Provide ABM5 information and samples to other collaborating partners within HITEC. <u>WP SFC</u> SKB-UU will be the leader of WP8 SFC , coordinating the scientific and technical content of the WP. SKB-UU and will coordinate task 1 (S/T coordination, State-of-the-art and training material) and will contribute to the subtask 2.2 (Develop, improve and demonstrate NDA methods/systems form SNF characterisation) <u>WP ROUTES</u> SKB will participate in subtask 2.1 (provide national contribution at exchange meetings) and in subtask 2.2 (Establish and share synthesis on practical issues on waste management routes for challenging wastes), and in task 3.2 (Characterization and segregation of legacy waste)			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Petra Christensen (Female) Master of Political Science with a major in EU integration, holds the position of Legal Entity Appointed Representative (LEAR) at SKB. She is also the project Coordinator of the MIND Project, Administrative Coordinator of the DISCO Project and responsible for the SKB financial reporting of the Modern2020 Project. Petra Christensen is proposed to be the administrative coordinator and Primary Coordinator Contact for the SFC WP Dr. Anders Sjöland (male) is Sr. Co-ordinator of fuel issues at SKB and Executive Secretary of SKB:s Research and Development Council. He has previously been Director of SKB:s Äspö Hard Rock Laboratory. He has a Ph.D. in Nuclear Physics from Lund University, Sweden, and Master on Engineering Physics from the same university. He has been with SKB since 2004. Before he held research and research director positions in the European Commission’s JRC and the Swedish-Danish cooperation Committee for Research and Development of the Öresund Region (Öforsk). Doctor of Philosophy in Nuclear Physics, Lund Institute of Technology, Sweden (1996)			

'Licentiate' degree in Nuclear Physics, Lund Institute of Technology, Sweden (1994)
 Master of Science in Engineering Physics, Lund Institute of Technology, Sweden (1992)
 Theoretical Philosophy, Lund University, Sweden (20 p - one term's studies) (1990)

Positions and work experience:

- Co-coordinator nuclear fuel issues, SKB (2014-)
- Executive Secretary, Research and Development Council, Swedish Nuclear Fuel and Waste Management Company Co (SKB AB), (2007-)
- Director Äspö Hard Rock Laboratory, Swedish Nuclear Fuel and Waste Management Company Co (SKB AB) (2004-2006)
- Director of Research, from 2003, before Research leader, Committee for Research and Development of the Öresund Region (Öforsk) (2000 -) (Lund University, Malmö University)
- Temporary agent (Grade A), European Commission, Joint Research Centre (JRC), Institute for Reference Materials and Measurements (IRMM), Geel, Belgium (1997-2000)
- Auxiliary agent (Grade A), European Commission, Joint Research Centre (JRC), Institute for Reference Materials and Measurements (IRMM), Geel, Belgium (1997)
- Ph.D. position - Department of Nuclear Physics, Lund Institute of Technology, Sweden (1992-1997)
- Employed in a project (Neutron measurement project), Department of Nuclear Physics, Lund
- Barsebäck Nuclear Power Plant (summer 1988)
- Barsebäck Nuclear Power Plant (summer 1987)

Dr. Daniel Svensson (male) graduated as chemist in 2004 from Lund University, Sweden. After his diploma, he was employed at SKB as an industrial Ph.D. student in Materials Chemistry at the Faculty of Engineering at Lund University. From 2006 he has been working with analysis and project management of bentonite field experiments running at high temperatures (90-130 C) with copper or iron heater materials, responsible for various projects (ABM; alternative buffer materials; Prototype repository analysis) running at the Äspö Hard Rock Laboratory, Sweden. Finished his Ph.D. in 2015 with the thesis "The Bentonite Barrier - Swelling properties, redox chemistry and mineral evolution", and has since then continued his work with bentonite clays at SKB with focus on material characterisation, quality control, specialising in X-ray diffraction (XRD) analysis. Also involved in studies with sulphides in bentonite, microbial activity in bentonite, chemical erosion, and bentonite - gas phase interaction. Responsible for SKBs research laboratory for bentonite clays at Äspö, Sweden.

Patrik Sellin (male) is a civil engineer and has worked at SKB since 1988. He is manager of the R&D programme for buffer and backfill long-term performance. He has been scientific coordinator and WP leader of the 7th framework project BELBaR and WP leader of e.g. PEBS and Forge. Patrik Sellin is the scientific and technical coordinator of Beacon.

Claes Johansson (male) is a Senior Specialist in Waste Management and Decommissioning at SKB He had a position as General Manager at SVAFO 2010-2013 and worked as a project leader of low – and intermediate level waste at SKB 1999 -2010.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

Simulation of Spent Fuel Assemblies in Differential Die Away Instrument

Aaron G. Tumalak¹, Holly R. Trellue¹, Garrett E. McMath¹, Vladimir Henzl¹, John S. Hendricks¹, Jianwei Hu², and Anders Sjöland³

¹Los Alamos National Laboratory

²Oak Ridge National Laboratory

³Svensk Kärnbränslehantering Aktiebolag (SKB)

April 11, 2018, INMM proceedings (2018)

NDA Measurement Analysis of Spent Nuclear Fuel Assemblies at the Swedish Clab Facility Using the INDEPTH Code

B. R. Grogana^{*}, A. Favalli^b, P. Jansson^c, H. Liljenfeldt^a, V. Mozin^d, P. Schwalbach^e, A. Sjöland^f,

S. J. Tobin^b, H. Trellue^b, S. Vaccaro^e, D. Vo^b

^a Oak Ridge National Laboratory, Oak Ridge, TN (USA)

^b Los Alamos National Laboratory, Los Alamos, NM (USA)

^c Uppsala University, Uppsala (Sweden)

^d Lawrence Livermore National Laboratory, Livermore, CA (USA)

^e European Commission, DG Energy, Directorate Safeguards, Luxembourg (Luxemburg)

^f Swedish Nuclear Fuel and Waste Management Company, Stockholm (Sweden),
INMM proceedings (2016)

Jansson P., et al.; "**Gamma-Ray Spectroscopy Measurements of Decay Heat in Spent Nuclear Fuel**";
Journal: Nuclear Science and Engineering; Vol: 141; No: 2; DOI: <http://dx.doi.org/10.13182/NSE02-A2272>; (2002)

Jansson P., Tobin S., Liljenfeldt H., Fugate M., Favalli A., Sjöland A.; "**Axial and azimuthal gamma scanning of nuclear fuel - implications for spent fuel characterization**"; Journal: Journal of Nuclear Materials Management; Vol: 45; No: 1; (2016)

P. Helgesson and H. Sjöstrand, "**Fitting a defect non-linear model with or without prior, distinguishing nuclear reaction products as an example**", (editors-pick), Review of Scientific Instruments 88, 115114; DOI: <https://doi.org/10.1063/1.4993697> (2017)

Dueck, A, Goudarzi, R, Börgesson, L, 2014, **Buffer homogenisation, status report 2**. SKB Technical Report TR-14-25, Svensk Kärnbränslehantering AB

Börgesson, L, Åkesson, M, Kristensson, O, Malmberg, D, Birgersson, M, Hernelind, J, 2015, **Modelling of critical H-M processes in the engineered barriers of SFR**. SKB Technical Report TR-14-27, Svensk Kärnbränslehantering AB

Sellin P, Leupin O (2014), **The use of clay as an engineered barrier in radioactive-waste management – a review**. Clays and Clay Minerals 61 (6), 477-498

SKB 2011, **Long-term safety for the final repository for spent nuclear fuel at Forsmark. Main report of the SR-Site project**. SKB Technical Report TR-11-01, Svensk Kärnbränslehantering AB

Åkesson, M, Kristensson, O, Börgesson, L, Dueck, A, Hernelind, J, 2010, updated 2015-08, **THM modelling of buffer, backfill and other system components. Critical processes and scenarios**. SKB Technical Report TR-10-11, Svensk Kärnbränslehantering AB

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

- Fuel characterisation I (2016-18) SKB
- Fuel characterisation II (2018-) SKB
- Action sheet 50 (2015-) (US DoE, Euratom and others)

Relevant to the knowledge field of bentonite mechanical evolution SKB has more than 30 years of research experience, starting with the buffer mass test (BMT) in the Stripa mine, and has participation in a number of projects. Some have had financing from the EU like FORGE (<https://www.bgs.ac.uk/forgue/home.html>), PEBS (www.pebs-eu.de), and BELBaR (www.belbar.eu), where the proposed scientific coordinator of Beacon, Patrik Sellin, has participated in different roles. Some SKB projects to mention could be KBP1001 Operation and retrieval of the prototype repository, KBP1003 System design of backfill.

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

Clab: Clab is the central interim storage facility for all Swedish spent fuel, situated outside Oskarshamn, Sweden. It represents a broad and complete collection of at present more than 8000 tU of spent fuel. SKB in itself and in various broad collaborations has used Clab to perform systematic characterisation on spent fuel, which represent the world reference in several respects.

Fuel database: SKB:s database on the properties and history of its spent fuel represents an important information cache for understanding of the spent fuel in conjunction with characterisation.

Via Uppsala University, the work proposed can utilize large-scale storage and know-how of high-performance computing (HPC) that is part of the Swedish National Infrastructure for Computing (SNIC: <http://www.snic.se>). There are six universities that host HPC resources for SNIC: Lund University, Chalmers University of Technology, Linköping University, KTH Royal Institute of Technology, Uppsala University and Umeå University. With computer clusters located in these centres, several thousand computer cores and very large memory may be allocated for calculations in the proposed work.

The Äspö Hard Rock Laboratory.

The Äspö Hard Rock Laboratory (HRL), constitutes an important part of the Swedish Nuclear Fuel and Waste Management (SKB) work with design and construction of a deep geological repository for final disposal of spent nuclear fuel. It is a facility for research, development and demonstration in a realistic and undisturbed rock environment down to repository depth. Most of the research has concerned processes of importance for the long-term safety of a future final repository and the capability to model the processes taking place at repository depth. Demonstration addresses the performance of the engineered barriers and practical means of constructing a repository and emplacing the canisters containing spent fuel. Äspö HRL includes a research village with office space for 100 persons, a chemistry laboratory, the bentonite laboratory, a material science laboratory and an underground research laboratory to a depth of 460m. Hundreds of laboratory and full-scale experiments and studies on buffer and backfill materials have been performed at Äspö over the last two decades and both the facilities and results from these earlier studies and experiments will be available

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

Operational capacity can be demonstrated

	No	Name	Acronym
Participant	41	Slovak University of Technology in Bratislava	STUBA
Description of the legal entity Slovak University of Technology in Bratislava (hereinafter referred to as "STUBA") is an educational and scientific institution. At present, it consists of seven faculties. All the faculties provide a study in accredited study programmes within the complex system of a bachelor, master and PhD. study. Faculties realise credit system compatible with the European credit transfer system enabling mutual mobility of students within European Union member countries and a larger European space. In the area of scientific and research activities the STU successfully joints European Union programmes. STU is a public university and offers education mainly in technical, technological, technical-economical, technical-information and technicalartistic fields of study. International cooperation is a significant area based on interactive contact with educational as well as scientific-research institutions of the countries all over the world. First of all, it is focused on solution of the joint projects within the EU framework and other international programmes, mobility of students, ect. Institute of Nuclear and Physical Engineering (STUBA-INPE) at Faculty of Electrical Engineering and Information Technology of Slovak University of technology is focusing on research of operation and decommissioning of NPPs, material science, nuclear fuel cycle and decommissioning of NPPs and radiation protection. STUBA-INPE staff is based on 10 professors in physics, nuclear power engineering and material science. There are actually 50 employers (scientific or research workers) and about 20 PhD students. This institute is also a base for activity of Slovak Nuclear Society (SNUS) and the Slovak Centre for operation and Decommissioning of Nuclear Facilities. STUBA-INPE has a long tradition in the NDS investigation of RPV materials by use of Positron Annihilation Spectroscopy and Mossbauer spectroscopy. The partner role to the project: research organisation. The partner contribution to the project: performance of R&D work mainly in field of development of proper methodology for mapping of radioactive material behaviour during its decommissioning, transport and long term storage. Knowledge management in dismantling, decommissioning and geological disposal characterisation is one of the main task in education and research at the University level.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks STUBA will contribute in characterization of actual state of art, mapping and development of activities in decommissioning of Slovak nuclear facilities and knowledge management including organization of seminars for graduate and PhD students			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities <u>Prof. Vladimír Slugen, DSc.</u> (Male) graduated at the Slovak University of Technology (MSc. 1985, PhD. 1993, Prof. 2005, DSc. 2010). Professional experience in: operation and safety of NPPs, radiation damage of nuclear materials, nuclear fuel cycle, non/destructive testing methods. President of European Nuclear Society (2009- 2011). President of Slovak Nuclear Society (since 2004). Member of several EC framework projects as: PERFECT, COVERS, TRASNUSAFE, LONGLIFE. About 70 CC scientific publications and 300 citations. <u>Assoc. Prof. Gabriel Farkas, PhD.</u> (Male) obtained his master Degree (2000) and his PhD. degree (2007) and assoc. Prof. (2014) at the Slovak University of Technology. Professional experience in: operation and decommissioning of NPP, nuclear fuel behaviour, simulation of neutronic physical parameters of nuclear fuel using MCNP code. 9 CC scientific publications and 16 citations. <u>Dr. Kristína Kristífova</u> (Female) obtained his master Degree (1995) and her PhD. degree (2000) at the Slovak University of Technology. Professional experience in: dismantling and decommissioning performance, cost estimation and nuclear knowledge management. 5 CC scientific publications and 10 citations.			
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content			

Slugeň, V., Lipka, J., Tóth, I., Haščík, J., Hincá, R., Lehota, M.: Corrosion of steam generator pipelines analysed using Moessbauer spectroscopy. In: Nuclear engineering and design 235 (2005) 1969-1976
 Mikloš, M., Slugeň, V.: SCALE calculation for evaluation of spent fuel condition during long-term storage. In: Nuclear Engineering and Design 238, (2008), p.2811-2814
 Slugen, V.: Safety of VVER-440 reactors: barriers against fission products release. Springer-Verlag London limited, (2011), ISBN 978-1-84996-419-7, 178pp.
 Slugen, V. et al: Nuclear fuel cycle, (ed. SNUS) Didaktis, (2015), ISBN:80-88682-62-2, 180pp.
 Slugen, V.: European Decommissioning Academy (EDA): Ready to Start. In International Journal for Nuclear Power. Vol. 60, No. 2 (2015), p. 82-84.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

FP6 PERFECT no. F16O-CT-2003-508840 (2004-2008): Prediction of Irradiation Damage Effects in Reactor Components

FP7 TRASNUSAFE no. 249674 (2010-2014): Training schemes on nuclear safety culture FP7 NUGENIA

Plus no. 604965 (2013-2016): Preparing NUGENIA for HORIZON2020

H2020 MEACTOS, Project of the European atomic energy community. (2017-2020)

Centre for operation and decommissioning of NPP (CEPPVYJZ) - Grant of Slovak Ministry of education No 001STU-2/2014 resulted in creation of Eropean Decommissioning Academy 2015

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

Several laboratories for radioactivity measurements and simulations, dosimetry, release measurements, decontamination etc. are available at the STUBA laboratories in Bratislava. Different non-destructive techniques (MS, PAS, CDB, SEM, TEM, AFM,...) are available as well. Since 2014 the STUBA Material science centre for non-destructive testing of high treated materials is in operation in Jaslovské Bohunice NPP. Relevant computer codes as well as computing capacities are available, too.

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

N/A

Participant	No	Name	Acronym
	42	Sprava ulozist radioaktivnich odpadu	SÚRAO
Description of the legal entity The Radioactive Waste Repository Authority (SÚRAO) is a Czech state organisation and its activities and management are regulated by Article 113 of Act 263/2016 (the Atomic Act). SÚRAO's mission is to ensure the safe disposal of existing and future radioactive waste in compliance with the requirements of nuclear safety and human and environmental protection. SÚRAO's most important responsibilities include the operation of 3 low- and intermediate-level radioactive waste repositories. SÚRAO also coordinates the considerable work necessary regarding the development and construction of a deep geological repository for high-level radioactive waste and spent nuclear fuel, the commencement of operation of which is planned in 2065 according to the Policy of Radioactive Waste Management as approved by the Government of the Czech Republic and for which a Strategic Environmental Assessment (SEA) was granted last year as part of the Nuclear Action Plan covering the next few decades.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks SÚRAO is involved in 6 EURAD RD&D work packages as well as in two Strategic Study WPs; SÚRAO also leads the KM Guidance WP (WP 12). WP HITEC: SÚRAO and its LTPs (CTU, CU and UJV Rez) have been involved for many years in the characterisation and modelling of the thermo-mechanical behaviour of bentonite both through Czech and wider European projects. All the previous research experiments were limited to a temperature of 95°C. SÚRAO and its LTPs propose to conduct the characterisation and to model the thermo-mechanical behaviour of bentonite at temperatures in excess of 100°C. WP CORI: SÚRAO will work with the following LTPs: UJV Rez and the Czech Technical University (CTU). Experimental work will focus on the degradation of concrete organic additives and ion-exchange resins and the migration of radionuclides and their complexes. WP FUTURE: SÚRAO, together with the LTP UJV Rez, is interested in attaining a more detailed understanding of radionuclide mobility in crystalline rocks. Determining a fundamental understanding of radionuclide mobility makes up the basic prerequisite for the performance of a credible safety assessment of the future radioactive waste repository. WP ACED: SÚRAO will work with the LTP UJV Rez on the analysis and modelling of the thermal, hydrogeological and mechanical processes and their mutual links that occur in deep geological repositories hosted by crystalline rocks in order to obtain a more detailed understanding of their effects on repository long-term safety. WP DONUT: SÚRAO and its LTPs (CTU, CU, TUL, UJV Rez) will contribute towards the development of robust and efficient numerical methods for the simulation of thermo-hydro-mechanical (THM) processes in bentonite barriers and host rocks. Development will include the use of parallel computing algorithms for the solving of complex associated issues. WP GAS: SÚRAO and its LTPs (UJV Rez and CTU) already have the technical and instrumental infrastructure for the research of gas migration in bentonite materials. The research programme will involve laboratory gas injection tests on bentonite samples using air and hydrogen. SÚRAO would like to attend debates in order to be able to determine the deliverables and form conclusions of the both Strategic Study WPs. SÚRAO is the leader of the knowledge management Work Package (WP 12) which aims to clarify and justify the priorities of Guides for the pre-disposal and siting processes. It is intended that these Guides will lead to the determination of guidelines for the further development of National Programmes in countries with			

early-stage ones and which will help in terms of differentiating between them and countries with small programmes. The optimisation and adaptation of such programmes to the coming decades which will be characterised by the digital economy and the development of robotics will provide inspiration with respect to identifying the advantages of a common approach in several areas that meets the challenges of the new public environment, safety requirements and security with concern to the final disposal projects adopted in countries with early-stage programmes. The collection of positive arguments for decision-makers employing *inter alia* recommendations/conclusions from SITEX and IGD-TP - the outputs will be very useful for developing Summer schools and the exchange of researchers throughout the European Research Area thus improving mutual communication, reducing costs via the sharing of knowledge and experience, etc.

a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities

Ing. Dmitry Lukin (male) is a safety analysis specialist; he has been working for SÚRAO in the Safety and Licensing Procedures Department since 2013. He is an expert in performance assessment and THM modelling and he is also responsible for preparing different models of the three radioactive waste repositories currently in operation in the Czech Republic. He has been involved in several national and international projects (PAMINA, DOPAS, etc.) and now manages the Czech modelling teams involved in the SKB Task Force Groundwater Flow and Transport of Solutes project.

Ing. Lucie Hausmannova, Ph.D. (female) has been working for SÚRAO since 2017 as a materials specialist. She is responsible for the design and development of engineered barriers (especially the buffer and backfill) for the future Czech deep geological repository. She is currently managing several projects and is involved in the CEBAMA and BEACON R&D EU projects.

She studied at the Czech Technical University in Prague, Faculty of Civil Engineering, where she defended her doctoral thesis in 2017. The doctoral thesis focused on the research of bentonite under DGR conditions.

Ing. Zdena Lahodova (female) has been working for SÚRAO since 2017 as a safety assessment technical specialist. She is responsible for the evaluation of the term source (especially the spent fuel inventory) intended for disposal in the future Czech deep geological repository. She studied at the Czech Technical University, Prague, Faculty of Nuclear Sciences and Physical Engineering.

Ing. Jan Smutek, Ph.D. (male) has been working for SÚRAO since 2017 as an in-situ experiment specialist at the Bukov Underground Research Facility (URF). He is responsible for the organisation of development work at the Bukov URF, the preparation of the experimental programme and the management of research projects at the facility.

He studied at the Czech Technical University in Prague, Faculty of Civil Engineering, where he defended his doctoral thesis in 2017. The title of his thesis was the Research of Rock Mass Gas Permeability based on Experimental In-situ Measurement.

Ing. Antonin Vokal, Ph.D. (male) joined SÚRAO in 2012 after working for more than 15 years in the field of nuclear waste management at the Nuclear Research Institute, Rez. He is currently managing a comprehensive project focusing on the gathering of information on the basis of which it will be possible to reduce the number of potential DGR sites considered. He is responsible for preparing site specific safety cases accompanied by supporting safety assessments for all the potential DGR sites. He holds a Ph.D. from the University of Chemistry and Technology in Prague.

Ing. Dalibor Mateju (male) graduated in 1978 at the University of Technology in Brno and specialises as an adviser in the energy, industrial and public services sectors. Examples of his work as a consultant since 1996:

- Senior consultant of a Deloitte project team: “the Application of a Process Model at CEZ PLC/CEZ Group for the integration of IIS SAP at CEZ PLC.” (2006 – 2007),
- Senior consultant to the Czech Ministry of Industry and Trade with concern to the “Eco-energy Programme Projects evaluation” project (2007 – 2010), the creation of methodology procedures and the training of evaluators,
- Consultant for the CEZ – NPP Dukovany project “The Finalisation of the NPP Information Systems Graphics Integrator” (support of knowledge management) and author of the “Description of the Graphic Integrator” (2010 – 2012),

- Member of a UJV project team – expert evaluator for the “Periodical Safety Review and Assessment of the Dukovany NPP – Organisation and management, QMS, Safety Culture” project (2014),
- Head of the Branch Office of UJV Rez in Turkey and project manager – expert concerning support for the Turkish State Regulatory Body for nuclear safety (further “TAEK”) in the context of a contract with UJV Rez PLC – compilation of the documentation to support TAEK during the licencing procedure and the provision of a review and assessment of the Akkuyu NPP construction licence documentation.

Mgr. Martin Elias, (male) has been working for SÚRAO since 2015 as a data manager and GIS and database specialist. He was involved in a major international project (RK&M) and now manages the development of the Knowledge for a Deep Geological Repository in the Czech Republic information system. He studied at the Masaryk University in Brno, Faculty of Science. During the conducting of the Geobariera project he was involved in the development of a geographical information system for the assessment of potentially suitable locations for DGR siting.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- **Smutek J., Hausmannova L., Svoboda J.** (2016) The gas permeability, breakthrough behaviour and re-sealing ability of Czech Ca-Mg bentonite, Geological Society London Special Publication 443(1), London
- **Vetesnik A., Landa J., Vopalka D., Vokal A.** (SÚRAO), (2015): A sensitivity and probability analysis of the safety of deep geological repositories situated in crystalline rock. Journal of Radioanalytical and Nuclear Chemistry 304(1): 409-415, 2015
- **Lahodova Z., Viererbl L., Koleska M., Cernousek T., Cerny Z.** (2016): Research of the radioactive properties of geopolymers carried out at the LVR-15 nuclear research reactor, PHYSOR 2016, Idaho, USA
- **Dvorakova M., Lukin D., Trpkosova D.** (SÚRAO and UJV Rez, a.s.), (2016)
- **DOPAS Work Package 5, Deliverable D5.7: Models and modelling summary report for EPSP**, February 2016
- **Cerny J., Elias M., Dufek J.** (2005): GIS - SÚRAO - Final Report. Report on the “Performing geological and other work for assessing and limiting sites for the deep repository” project. AQUATEST a.s., Prague.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

EC projects:

- **CEBAMA (Horizon 2020):** Collaborative project on “Cement-based materials, properties, evolution, barrier functions”. June 2016 – May 2019. (Coord. KIT-INE)
- **BEACON (Horizon 2020):** Collaborative project on: “Bentonite mechanical Evolution”. June 2017 - May 2021(Coord. SKB)
- **FORGE (FP7):** Collaborative project on the “Fate of Repository Gases”. February 2009 – September 2013. (Coord. Natural Environment research council)
- **DOPAS (FP7):** Collaborative project on “The Full-Scale Demonstration of Plugs and Seals” September 2012 – August 2016. (Coord. POSIVA)
- **NF-pro (FP6):** Collaborative project on “Understanding and the Physical and Numerical Modelling of the Key Processes in the Near-Field and their Coupling for Different Host Rocks and Repository Strategies” January 2004 – December 2007 (Coord. SCK-CEN)

International project:

LTD: Collaborative project on: “Long term diffusion”. 2004 – 2018 (Coord. NAGRA)

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

N/A

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

N/A

	No		Acronym
Participant	43	Statni ustav radiacni ochrany, vvi (National Radiation Protection Institute)	SURO
Description of the legal entity SURO is a non-profit research institution and mandated TSO in radiation protection and nuclear safety. SURO was founded by State Office for Nuclear Safety (SUJB) in 1995. The mission of SURO is focused on research in the field of radiation protection, emergency preparedness and nuclear safety, including radioactive waste management, providing SUJB with research, expertise, methodologies, supervision, legislative support and consultation activities. SURO operates the main part of Czech National Radiation Monitoring Network including independent monitoring of nuclear power plants and radioactive waste disposal sites. SURO is an accredited laboratory in radioactivity measurements. SURO is engaged in training and tutoring in the field of nuclear safety and radiation protection, hosting IAEA trainees (based on signed Memorandum between IAEA and SURO) and cooperating with ENSTTI. With respect to the statutory request (new Atomic law, 263/2016), the Research Centre Rez (CV REZ) has agreed with SUJB on building of an independent technical and expert support in the area of nuclear safety, including RWM, inside the SURO. Due to this decision, human and material resources of CV REZ TSO group have gradually started to be transferred from CV REZ into SURO to ensure a high level of competent and independent expertise in all basic areas related to the evaluation of nuclear safety. This process has started in January 2017 based on signed Agreement between CV REZ and SURO.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks SURO is engaged in both Strategic studies Wokpackages and in Knowledge programme. ROUTES - (T2, T4, T5, T6), UMAN (T4): SURO including TSO team transferred from CV REZ can provide an experience with more than 60 years of national nuclear energy development, including RWM programme establishment and implementation and identification of relevant research needs, in particular in radwaste disposal. SURO team can also provide experience with different kind of waste. Concerning research reactors operation when a certain part of generated liquid and solid waste was put in stores without proper documentation; thus, they have been missing information about their origin, amount, and radiochemical composition. These wastes were contaminated mostly by fission products, but also by transuranium elements. To remove those waste, procedures for their characterisation, retrieval, and re-processing in line with waste acceptance requirements for their disposal have been developed. These activities were accompanied by the assessment of the environmental pollution, esp. monitoring of underground water, airborne measurements; dose risks of involved personnel, and the effectiveness of applied procedures. This knowledge will be completed by experience from both national and international RWM programmes establishment, in particular for countries with small amount of radwaste with different disposal solution. Due to a large international experience in RWM, expert team can contribute to the shared solutions for RWM. Based on experience gathered within national RWM programme development and knowledge obtained at international level, SURO team can contribute to the identification and characterisation of different actors across necessary phases of disposal programme with respect to the management of different types of uncertainties and their management options.			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities: <u>Ms. Jitka Mikšová</u> received her MSc. in applied geophysics and hydrogeology at the Charles University in Prague (CZ) in 1984. Currently, she is providing services to the national regulatory body (SUJB) at SURO in the Section of the Deputy Director for Nuclear Safety, in the field of RWM, in particular in radwaste disposal issues and relevant legal aspects. She is also working as a scientific researcher-expert in CV REZ, in Nuclear Fuel Cycle Department,			

leading a TSO group, responsible for research related to the RWM. She has been actively participating in the national RWM programme since its very beginning in 90s. As a member of expert group established at Czech Geological Survey she was involved in siting, data and information management, GIS implementation, radon programme establishment, etc. Then, she was working in the Radioactive Waste Repository Authority in the Geological Repository Development Department, as a technical development project manager responsible, in particular, for far field research, natural analogues, siting issues, GIS, project management, strategic documents development etc. During her professional carrier she has led or supervised both national and international projects and participated in EC FP6, FP7 and H2020 projects focused on RWM, e.g. Funmig, MoDeRn, CROCK, FORGE, MIND, JOPRAD, SITEX-II, etc. She was involved in IGD TP Joint Activities focused on Knowledge management and on Monitoring of disposal facilities. She has been engaged in the WG on the Operational safety in the IAEA GEOSAF II, now in GEOSAF III projects, in two ETSON expert groups (i) on the safety of Waste Management, Decommissioning & Remediation and, (ii) Knowledge Management. She is a member of Natural Analogues Working Group and SURO representative in the Management Board of SITEX network. She has been involved in the IAEA training and scientific visits activities, organising training courses, tutoring and lecturing within ENSTTI and, lecturing for a state administrative.

Mr. Lumir Nachmilner graduated at Institute of Chemical Technology Praha in Inorganic Chemical Technology and got his PhD in Technology of Nuclear Fuel. His significant working positions were as follows: (i) NRI Rez (Division Director), (ii) SÚRAO (DGR Section Head), (iii) IAEA (Disposal Group Leader – Waste Technology Section) and, since 2012 Freelance Consultant (IAEA, NEA/OECD, EC, CV REZ).

Over 40 years, he has been engaged in research and development, safety studies, planning, budgeting, strategic studies, managerial posts in the field of radioactive waste management (waste treatment, conditioning, acceptance for disposal, safety analyses, near surface disposal, deep geological disposal), R&D regarding the development of a near surface and a deep geological repository; preparatory activities for establishing Radioactive Waste Repository Authority (SÚRAO), and the development of its corporate management system (EC Phare project) He has more than 9 years as the IAEA staff member (2003-2012) - responsibility for the development of IAEA documents, establishing DISPONET network. He has been involved in lecturing at courses and meetings on establishing national infrastructure for managing radioactive waste (more than 20 countries worldwide) and tutoring RWM issues at Czech universities (an external lecturer).

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- 1) J. Miksova, L. Nachmilner (2017): Geological disposal programme. SITEX training course on regulatory review of the safety case for geological disposal. LEI/ENSTTI, Lithuania.
- 2) J. Miksova, L. Nachmilner, F. Bernier, P. Janssens, M. Tichauer, D. Ilett (2017): Optimisation of radiological protection applied to the development and implementation of a geological disposal system. Eurosafe Forum 2017. ISBN 978-2-9545237-8-1. IRSN. France.
- 3) V. Dettileux, D. Pellegrini, F. Bernier, G. Heriard-Dubreuil, J. Miksova, A. Narkuniene (2017): Overview of the Strategic Research Agenda in the field of safety of radioactive waste geological disposal developed by the Expertise Function in the EC-H2020-SITEX-II project. Eurosafe Forum 2016. ISBN 978-3-946607-33-5. GRS. Cologne. Germany.
- 4) F. Besnus, P. Metcalf, V. Wasselin-Trupin, W. Pfingsten, O. Schmit, J. Miksova, O. Tokaresvski (2016): The ETSON Study on Treatment Processes for the Sustainable Management of Radioactive Waste. International Conference on the Safety of Radioactive Waste Management. IAEA-CN-242. Austria.
- 5) L. Nachmilner (2013): Monitoring of Geological Disposal Facilities”. Internal NEA report within the framework of the RK&M International project.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

SURO is: 1) an active member of SITEX Network, 2) involved in EU research platforms NERIS, EURADOS and MELODI 3) engaged in the IAEA and ENSTTI training and tutoring activities 4) SURO experts were involved in: - EU H2020 JOPRAD project focused on EURAD preparation, - EU H2020 SITEX-II project aimed at practical implementation of sustainable independent expertise function in the field of geological disposal safety. - IAEA publication development, e.g.: Radioactive Waste Management Objectives (IAEA Nuclear Energy Series NW-O); Policies and Strategies for Radioactive Waste Management (IAEA Nuclear Energy Series NW-G-1.1); BOSS: Borehole Disposal of Disused Sealed Sources a Technical Manual (IAEA-TECDOC-1644); Options for Management of Spent Nuclear Fuel and Radioactive Waste for Countries Developing New Nuclear Power Programmes (IAEA NES NW-T-1.24), - the development and implementation of the IAEA-EC project TC Project INT9176 Strengthening Cradle-to-Grave Control of Radioactive Sources in the Mediterranean Region 2010-2015, 5) SURO is a National Project Manager for EU JP Concert - European Joint Programme for the Integration of Radiation Protection Research.
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; SURO can exploit its experience and knowledge from laboratory work and/or to use relevant codes for modelling purposes as GoldSim, Geochemist's Workbench, SERPENT 2.1 etc. The SURO laboratories are equipped with high-tech instruments, among others: alpha and beta spectrometers, low-background alpha-beta counters, radio-chemical laboratories, semiconductor gamma spectrometers in special shielding designed for measurement low activities of radionuclides in environment, MEDIPIX/TIMEPIX pixel detectors, devices for collection of aerosols including cascade impactors enabling determination of size distribution of aerosol particles, equipment for collection of radioactive gases, and chemical laboratories equipped for determination of alpha and beta radionuclides. A high-tech Radon chamber is operated for research, development and calibration of new radon monitors, CTP laboratory is operated for monitoring of internal contamination, TLD and OSL laboratory for measurement of external doses, special low energy HPGe detectors are used for in vivo detection of transuranium radionuclides in lung and skeleton of people.
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task. Not relevant.

Participant	No	Name	Acronym
	44	TNO (Alwina Hoving, Jasper Griffioen)	TNO
Description of the legal entity The Netherlands organisation for applied scientific research TNO (TNO) is an internationally oriented knowledge organisation for private industry, government and governmental organisations. It is active in technical, earth, environmental, life, societal and behavioural sciences and has a staff of c. 3,500. The unit Geological Survey of the Netherlands TNO is nationally responsible for all geoscientific data and groundwater monitoring information. As such TNO-GSN is the national information provider on subsurface data, including the 3D groundwater information products REGIS, GeoTop and webservices such as Groundwater Tools. It has built up leading experience in the development of environmental databases. TNO has several laboratories among which a geochemical laboratory, that is shared with Utrecht University and knowledge organisation Deltares. The laboratory comprises analytical and experimental facilities for environmental geochemical and also sedimentological, stratigraphical, paleontological, and petrological applications. In addition, the laboratories comprise electron microscopic and advanced mass spectrometric facilities. TNO has extensive expertise in environmental geochemical characterisation of the subsurface both within the framework of its responsibility as geological survey and for individual purposes. TNO has over 30 years of experience in supporting industries and authorities in groundwater and subsurface management where environmental issues aimed at a sustainable use and environmentally responsible management of groundwater and other subsurface resources become addressed. All kinds of risk assessment studies of anthropogenic, subsurface activities have been performed by TNO: Carbon Capture and Storage, oil and gas production, geothermal energy production, high temperature - aquifer thermal energy storage, storage in salt caverns, etc. It has also been strongly involved in the Dutch, national research programs on disposal of radioactive waste among which the last OPERA program.			
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks TNO will contribute to WP FUTuRE (Fundamental understanding of radionuclide retention). Here, we will participate in Subtask 1.2 where we will contribute to the preparation of the State-of-the-art report and update with our focus on redox reactivity. We will also contribute to Task 3 where we will carry out the geochemical and mineralogical characterization of various model clay minerals, including the electrochemical redox reactivity and we will carry out batch experiments to assess the redox reactivity of model clay minerals towards Se as a radionuclide. This fits well in the overarching goal of task 3 "Redox", which is to contribute to a better understanding of the coupled sorption and electron transfer interface reactions governing the retention of redox-sensitive radionuclides on Fe(II)/Fe(III) bearing minerals so as to improve the capacity to model, and thus predict, the fate of these elements within the safety assessment of radioactive waste storage.			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Alwina Hoving (Geochemist, Female) is a scientist at the Geological Survey of the Netherlands, TNO (2016-date). For the past six years, as part of PhD research at Utrecht University, she has investigated redox processes of Boom Clay, a potential host rock for radioactive waste in the Netherlands and Belgium, in relation to retention of selenium and uranium. To evaluate the redox properties of the sediment, she tested mediated electrochemical methods on relevant mineral standards, such as various clay minerals and pyrite, and on actual (altered) Boom Clay samples. Batch experiments with Se, U and (altered) Boom Clay samples were performed and the resulting Se and U speciation could be linked to the electrochemical redox characterization of the sediment. The interplay of adsorption and reduction of radionuclides in Boom Clay was investigated in detail. Besides this project, she works on various projects involving geochemistry and the subsurface of the Netherlands, incl. nutrient dynamics, geochemical parameterization for 3D subsurface models etc. Jasper Griffioen (Geochemist, Male) is expert researcher at TNO Geological Survey of the Netherlands (1991 to date) and professor of Water Quality Management at Utrecht University (2011 to date). He specialised in environmental hydrology and geochemistry within the framework of sustainable			

management of soil and water resources. He performed studies for a wide variety of geographical settings and a broad range of environmental management issues, ranging from an acid crater lake in Indonesia to disposal of radioactive waste in the deep subsurface of the Netherlands. Many of his projects refer to the risks and impact of anthropogenic measures on groundwater and subsequent effects on drinking water and groundwater-dependent ecosystems. Preferably, he combines field campaigns with modelling studies. He contributed chapters to several text books among which “UNESCO Groundwater Studies” and “Sustainable Groundwater Resources in Africa” in addition to his peer-reviewed publications. As member of the former ministerial Dutch Technical Committee on Soil, he was involved in c. 100 ministerial advices during October 2007 - March 2016; he has been an expert in several cases for Dutch Courts of Justice, too.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- A.L. Hoving, M. Sander, C. Bruggeman, T. Behrends. 2017. Redox properties of clay-rich sediments as assessed by mediated electrochemical analysis: Separating pyrite, siderite and structural Fe in clay minerals, *Chemical Geology*, 457, 149-161
- T. Behrends, I. van der Veen, A. Hoving, J. Griffioen. 2016. First assessment of the pore water composition of Rupel Clay in the Netherlands and the characterization of its reactive solids. *Netherlands Journal of Geosciences*, 95, 3, 315-335
- M.L. Koenen & J. Griffioen 2016. Characterisation of the geochemical heterogeneity of the Rupel Clay Member in the Netherlands. *Neth. J. Geosci.*, 95, 269-281.
- Griffioen, J., Van Wensem, J., Oomes, J.L.M., Barends, F., Breunese, J., Bruining, H., Olsthoorn, T., Stams, A.J.M. & Van der Stoel, A.E.C. 2014. A technical investigation on tools and concepts for sustainable management of the subsurface in the Netherlands. *Sci. Total Environ.*, 485-486, 810-819.
- A.L. Hoving, M.A. Münch, C. Bruggeman, D. Banerjee, T. Behrends. Submitted. Kinetics of selenite interactions with Boom Clay: adsorption-reduction interplay

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

- PhD project on effects of redox properties on the interactions of selenium and uranium with Boom Clay.
- TNO research project on geochemical characterisation of Boom Clay in the Netherlands
- TNO research project on geochemical interactions and groundwater transport in the Rupel Clay at the geological time scale

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

- Set-up for mediated electrochemical measurements inside a glovebox.

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.
not relevant

	No	Name	Acronym
Participant	45	TS Enercon Ltd.	TSE
Description of the legal entity			
TS Enercon Ltd. is a Budapest-based engineering and consulting organization specializing in radioactive waste and spent fuel management issues, safety and reliability of fuel cycle facilities, design of fuel storage methodologies both for nuclear power plants and research reactors, radioactive waste management, storage and disposal technologies. TS Enercon carries out safety assessments, safety cases, and feasibility studies for both nuclear and radioactive waste management installations.			
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks			
TS Enercon Ltd. is participating in DONUT WP, since it has experience in modelling of contaminant migration in various media. Modelling of coupled processes is important for the safety assessments of the Hungarian radioactive waste and spent fuel disposal program, therefore it is essential to be involved in activities that aim to improve modelling tools. Uncertainties in safety cases as the sensitivity analyses are important to understand as well. Experiences in the field of inventory uncertainties are planned to be shared, further developed in the strategic study aiming to examine uncertainties. Experience regarding management of historic waste and development of WAC is planned to be shared in the strategic study for the radioactive waste management.			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities			
Mr. Ferenc Takáts graduated in Moscow Power Engineering University as a physicist in 1973. He was working with the planning and startup phases of Paks NPP as a chief engineer in Hungary's major Power engineering design company: ETV Erőterv. He continued his carrier in the IAEA from 1989 to 1997 as the Team Leader of the spent fuel management unit. He is the founder of TS Enercon Ltd. Since then, he works in the field of spent fuel and radioactive waste management. Mr. Attila Baksay graduated in Budapest University of Technology and Economics in 2003, as an engineer physicist. He was working for Golder Associates Hungary Ltd and Public Limited Company for Radioactive Waste Management. He is specialized in, radiation protection, modelling for contaminant migration and nuclear safety. He worked as project manager for safety cases for Hungarian radioactive management sites. He works for TS Enercon Ltd. since 2017.			
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content			
1. Disposal of Low and intermediate waste in Hungary. Bulletin of Mining School, Zagreb, Attila Baksay Attila, Bálint Nős, Péter Molnár, 2013 2. Safety assessment for the optimized disposal concept of National Radioactive Waste Repository in Bataapáti, Attila Baksay, Regional seminar, Budapest 2014 3. Stochastic inventory calculations and stochastic radiation protection assessment in the safety case for Bataapáti NRWR, Attila Baksay, Hajdúszoboszló, 2015 4. Post-closure safety assessment of Püspökszilágy RWTDF, Attila Baksay, Hajdúszoboszló, 2016 5. Waste Acceptance System for Bataapáti National Radioactive Waste Repository, Attila Baksay, András Fritz, Workshop on Waste Acceptance Systems, Brussels, 2014			
a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal			
1. Sensitivity analyses for contaminant migration in Bataapáti National Radioactive Waste Repository. 2. Safety assessment for Tehran Radioactive Waste Management Facility, assessments of airborne and waterborne releases. 3. Safety assessment for Kozloduy Incineration plant, waterborne releases. 4. Post closure safety assessment for Bataapáti National Radioactive Waste Repository. 5. Post closure safety assessment for Püspökszilágyi Radioactive Waste Treatment and Disposal Facility.			

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

Modelling infrastructure: GoldSim, AMBER, FeFlow, FracMan, Scale, MCNP, VisiPlan

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

N/A

	No	Name	Acronym
Participant	46	TECHNICAL UNIVERSITY OF SOFIA	TUS
Description of the legal entity Technical University of Sofia (TUS) in Bulgaria is the biggest higher technical educational and research complex in the fields of thermal-, nuclear- and electrical power engineering, computer science and technologies, communications, etc. with close contacts and cooperation with governmental energy institutions and nuclear regulatory body. TUS has national role for the distribution of safety engineering knowledge and analysis, and for development of the Energy and Nuclear Energy Research Area in Bulgaria. The Research and Development Sector (R&DS) of TUS organizes, administrates and services of the research activities of TUS. The Safety and Environmental Engineering Laboratory (SE&EL) by the Electrical Power Department at TUS, has significant experience regarding VVER safety analysis and studies, Environmental Impact Assessment of NPPs with caution to the radwaste management, ASTEC benchmark calculations, post-test analysis, etc. In these activities the team of SE&EL often works together with involved experts from Kozloduy NPP plc, Bulgarian Academy of Science and other institutes and companies. TUS, in particular SE&EL has an experience in the nuclear and severe accident research in the frame of 5FP Projects - PHEBEN2 and RMPS; 6FP Projects - SARNET, COVERS and NEPTUNO; 7FP Projects SARNET2, NEWLANCER, ASAMPSA-E and ARCADIA. Since 2002 TUS was participant in the PHEBUS FP Programme. TUS, in particular SE&EL was initiator for preparation and implementation joint with CEA and KIT (then FZK) teams different experiments (2003-2006) for VVER conditions in experimental program PLINIUS - COLIMA tests, and in LACOMERA platform – COMET-1 (MCCI), DISCO-L2 (DCH) and LIVE-L1 tests, etc.			
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks The profile of TUS shows relevant level of expertise and matches the tasks in EURAD-1, and namely TUS' main tasks in the WPs tasks are: WP SFC: T2: To contribute in Subtasks 2.4.1 and 2.4.2 – TUS joint with JSI is responsible to define the big SNF data set packages A to C, collect the relevant information, standardize it and make it ready-to-use for the other partners, and to lead the evaluation of results of both code categories (best practice industry and sophisticated) used. T3: To contribute in Subtasks 3.1 with modelling work, numerical simulations and analysis for evolution studies of SNF rods. To lead the preparation of D 3.1.9 Development of a numerical tool for the evolution studies of SNF rods. T4: To contribute in Subtasks: • ST 4.1 with listing, grouping, ranking and prioritization of internal and external hazards (natural disasters and human factors) which can cause accidents and emergency conditions during extended storage, transport and emplacement of the SNF; Study and description of potential accident scenarios and ranking of the most probable and worst 1-3 scenarios related to the transport and long-term dry interim storage of SNF; Participation in the development of an engineering methodology capable of assessing the scenarios. To lead the preparation of D 4.1.1 Identification and description of potential accident scenarios. • ST4.2 with numerical simulations and consequence analysis of postulated accidents and expert assessment of criticality safety for accident scenarios (fuel release). Participation in the criticality safety analysis for different loading schemes for transport/storage casks. WP DONUT: T4: To contribute with generalised review on the developed and proposed benchmarks for the evaluation of numerical tools and methods for coupled processes; evaluations of the efficiency and applicability of new algorithms by strong non-linearity and non-monotonic systems, and sensitivity analysis of large-scale mathematical models for conditions of pre-disposal and of geological repositories. WP ROUTES: T2: To contribute in Subtasks 2.1, 2.2, 2.4 and 2.5 with providing national data on radioactive waste categorisation/classification, check and complete synthesis on practical issues on waste management routes for challenging waste, and participation in T2 exchange meetings.			

T3: To contribute in Subtask 3.1 with collection, analysis and comparison of the existing knowledge about techniques and practices for characterisation of RWs and identification of the needs for future R&D concerning Bulgaria, and to participate in information exchange for Subtasks 3.2 and 3.3.

T4: To provide input and participate in workshops of the WP.

WP UMAN:

T2: To contribute in Subtasks 2.2 to the compilation, assessment and improvement of approaches for the ranking, selection and prioritisation of uncertainties, reviewing the deliverable, and participating in technical meetings.

T4: To contribute in Subtasks 4.2 to the compilation and review of uncertainty management options, provide an input regarding the options considered in the Bulgarian programme, and to the writing of D4.2.

T5: To contribute in Subtasks 5.2 to the development of materials related to Topic 2 for seminars 2 and 3, and to the development of D5.2. TUS will be responsible for the practical organisation of seminar 2 and preparation of the minutes.

In addition to the above tasks:

TUS could host some project/WPs meetings in Bulgaria.

TUS, on the basis of his experience in previous EC projects, could organize issue of dissemination materials of EURAD project with high quality and good competitive price.

a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities

Prof. Dr. Ivan Ivanov (male) is the person in charge of TUS for participation in this project of EURAD-1 and he is primarily responsible for carrying out the all proposed research and innovation activities of TUS. Currently Dr. Ivan Ivanov is a Research Projects Manager at R&DS of TUS, Professor and Head of the "Safety and Environmental Engineering Laboratory" (SE&EL) at Electrical Power Department of TUS. He has completed a MSc and PhD in Electrical Power Engineering at TUS. He has more than 30 year's research experience in the field of the safety and environmental risk assessment and analyses. His key expertise and studies are on Technical- and Nuclear Safety and Severe Accidents Phenomena Investigations; Environmental Impact Assessment (EIA), Risk Analysis and Assessment; Waste and RAW Management; Assessment of Emissions from NPPs and TPPs and Modelling of Emission Propagation in the Atmosphere; Environmental and Radioecological Monitoring. He has more than 50 completed projects and 140 publications in this fields. He is a Team leader of the EIA of Kozloduy NPP (1999-2000), and a Team leader of the EIA of the Investment proposal of Belene NPP (2004-2005). Prof. Ivanov was a person in charge of TUS for the 5FP, 6FP and 7FP Projects, PHEBUS FP Programme activities and for the carried out experiments in CEA and KIT for VVER conditions mentioned above. Prof. Dr. Ivan Ivanov is an EIA registered expert (for Atmospheric air, RAD Waste, Harmful radiations) and Team leader for EIA in the Ministry of Environment and Water (1983-), member of Bulgarian Scientists' Union (1979-), Bulgarian Nuclear Society (2001-), APCEO „Asia-Pacific CEO Association Worldwide” (Senior Expert 2011-), GSTF “Global Science & Technology Forum” (2013-), etc.

Key persons and experts involved in the Team of TUS for this project of EURAD-1 are:

Prof. Dr. Angel Tzolov – Head of Electrical Power Department at TUS. He is completed MSc Engineer, Specialty “Electrical Power Engineering”, TUS (1985) and PhD degree at TUS (2001) with subject “Electric power stations and substations”. His main expertise and studies are on Programming Assembler, C, Basic, Fortran; Specialized software applications for mathematical modeling and process studies and systems in the EES; Development and implementation of software applications for analysis of the power system; Specialized packages of Atmel, SGS Thompson, Specific management algorithms, etc. Some previous professional him positions are: Engineer R&D, Assist. Professor, Assoc. Professor, Vice Dean on R&D and Staff Development of Electrical Engineering Faculty at TUS (2007-2015). Prof. Dr. Angel Tzolov will participate as leader in some TUS’ tasks in DONUT WP.

Assoc. Prof. Dr. Dimitar Bogdanov is a lecturer and researcher at the Electrical Power Department of TUS. He is completed MSc Engineer, Specialty “Electrical Power Engineering” at TUS (1998) and PhD degree at TUS (2009) with subject “Reliability of the NPP’ safety systems”. He has specializations on “Nuclear Power Generation” in JICA, Japan 2004 and “Protection of future networks with distributed generation” in University of Manchester, UK 2011. He has more than 10 years’ experience in the field of the accidents and safety systems analyses and participation in the reconstructions and modernisation programmes of Kozloduy NPP, Technical Safety Assessment and PSA of the VVER440 and VVER1000 Units of Kozloduy NPP. Assoc. Prof. Dimitar Bogdanov will participate as leader in some TUS’ tasks in UMAN, SF and Route WPs.

Prof. DSc. Ivan Dimov is involved in the TUS' team as tasks leader in DONUT and UMAN WPs. Hi has higher education completed at Moscow Research University at 1977, PhD in Mathematical modelling, 1980 Moscow, and DSc in Numerical Analysis, 1984 Moscow, Russia. His main expertise and studies are on Parallel algorithms and GRIDs, Stochastic numerical methods, Monte Carlo solution of PDE, error analysis and Statistical numerical methods with super-convergent probable error. Some of professional positions of Prof. DSc. Ivan Dimov are: Scientific Secretary of the Bulgarian Academy of Sciences 2014-2016, Chair of Scientific Council of IICT 2009- till now, Director of the Institute for Parallel Processing, BAS, Bulgaria, 1996-2004, Head of the Bulgarian Information Society Centre of Excellence for Education, Science and Technology in 21 Century (BIS-21), 2000-; President of Scientific Council of IPP-BAS, 2004-.
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content - Ivanov I., Overview on the national R&D nuclear strategies in the New Member States (NMS) and in the Old Member States (OMS), NEWLANCER, April 2-4, 2012, Budapest. - Ivanov I., S. Andonov Emergency&Risk zoning reflection in the Environmental Impact Assessment of the Investment proposal for Belene NPP construction in Bulgaria. Proceedings 'Emergency & Risk Zoning around Nuclear Power Plants', 26-27 April 2005, EC, DG JRC, Institute for Energy, Petten, The Netherlands. - Ivanov I., D. Bogdanov. The climatic changes and their impact on the extreme external factors on NPP safety. Proceedings of "Energy Forum", Varna, 2016. Vol. III. pp. 10-16. ISSN 2367-6728. - Alsmeyer H., A. Miassoedov, M. Cranga, R. Fabianelli, I. Ivanov, G. Doubleva, The COMET-L1 experiment on long-term concrete erosion and surface flooding. The 11th International Topical Meeting on Nuclear Reactor Thermal-Hydraulics (NURETH-11), Popes' Palace Conference Center, Avignon, France, Oct.2-6, 2005. Paper: 087. - Miassoedov A., H. Alsmeyer, L. Meyer, M. Steinbruck, P. Grudev, I. Ivanov, G. Sdouz, Results of the QUENCH-L2, DISCO-L2, and COMET-L2 Experiments Performed Within the LACOMERA Project at the FzK, Proceedings of ICONE14 International Conference on Nuclear Engineering, July 17-20, 2007, Miami, Florida, USA and Nuclear Engineering and Design, 238, 2008, pp.2017-2026.
a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal - SARNET (<i>Severe Accident Research Network of Excellence</i>), 2004-2008 and SARNET2 (2009-2012), EURATOM, 6FP and 7FP, EC. - COVERS (<i>VVER Safety Research</i>), 2005-2008, EURATOM, 6FP of EC. - Environmental Impact Assessment (EIA) of the "Kozloduy" NPP, 1999-2000, MOEW and ME, Bulgaria. - EIA of the Investment Proposal for the Construction of the "Belene" NPP, 2004-2005, MOEW and ME, Bulgaria. - BIS-21 (Bulgarian information society center of excellence for education, science and technology in 21 century) ICA1-CT-2000-70016, Central laboratory for parallel processing, BAS, 2001-2004, CORDIS, EC.
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; For the aims of the project the TUS' team will use the existing Supercomputer System Avitohol installed 2015 in the Institute of Information and Communication Technologies of Bulgarian Academy of Sciences (IICT-BAS). It is built with HP Cluster Platform SL250S GEN8 (150 servers), Intel Xeon E5-2650 v2 8C 2.6GHz CPUs (300 CPUs), non-blocking InfiniBand FDR, 300 Intel Xeon Phi 7120P co-processors. The storage system is with 96 TB of raw disk capacity. In collaboration with experts of Kozloduy NPP will be used in the plant relevant to the tasks laboratories, modelling systems, simulators and other equipment.
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task. N/A

No	Name	Acronym
Participant 47	University of Cyprus	UCY
Description of the legal entity The University of Cyprus (UCY) has been established under the University Law 144/1989. UCY is a public corporate body and is operating subject to the provision of its Law, Regulations, Rules and Internal Guidelines. The main objectives of the University are twofold: the promotion of scholarship and education through teaching and research, and the enhancement of the cultural, social and economic development of Cyprus.		
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks The Radioanalytical-Environmental Chemistry Lab of UCY is the only Lab in Cyprus, which activities include research related to the chemical behaviour of radionuclides in the environment and particularly their interaction with inorganic and organic surfaces present in natural systems. Moreover, the Radioanalytical-Environmental Chemistry Lab of UCY is in close collaboration with the local radiation protection authorities and supports (when needed) governmental labs dealing with radiation/radionuclide measurements.		
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Mr. Ioannis Pashalidis, is Professor at the Chemistry Department, University of Cyprus and head of the Radioanalytical-Environmental Chemistry Lab. He obtained his Diploma in Chemistry and PhD at Technical University of Munich (TUM) and served at TUM as post-doctoral researcher (1991-1994). In 1994 he joined the University of Cyprus as post-doctoral researcher/visiting professor and became Lecturer (1999), Assistant Professor (2003), Associate Professor (2008), and became Professor (2015). His research interests are in Aquatic and Radioanalytical Chemistry. He has over 100 publications in international refereed journals, and over 100 participations in International Conferences and two Chapters in books. He has supervised 7(+2 ongoing) PhD and 16 (+1 ongoing) MSc theses. Prof. Pashalidis has extensive work on the interaction of (radio)toxic inorganic species (e.g. B(III), Cu(II), U(VI), Ra(II) etc.) with natural organic matter (humic acids and biomass by-products), and metal oxides and mineral surfaces. Other research activities include analysis and speciation of uranium and boron in Cypriot ground and seawaters, as well as phosphogypsum disposal at a coastal area in Cyprus. More recently, he has been investigating non-treated and chemically modified plant fibers for effective and selective removal of (radio)toxic metal ion from waters.		
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content - KILIARI T., PASHALIDIS I.: Selective Separation of Actinyl(V, VI) Cations from Aqueous Solutions by Chelex-100, <i>Radiochimica Acta</i> , 100 (2012) 439-443 - LYSANDROU M., PASHALIDIS I.: Uranium Chemistry in Stack Solutions and Leachates of Phosphogypsum Disposed at a Coastal Area in Cyprus, <i>J. Environmental Radioactivity</i> , 99 (2008) 359-366. - PASHALIDIS, I., CZERWINSKI, FANGHAENEL TH., K.R., KIM, J. I.: A Study of Solid-Liquid Phase Equilibria of Pu(VI) and U(VI) in Aqueous Carbonate Systems. Determination of the Carbonate Stability Constants, <i>Radiochimica Acta</i> 76 (1997) 55-62 - PASHALIDIS, I., KIM, J. I., LIERSE, CH., SULLIVAN, J. C.: The Hydrolysis of Pu(VI) and Time-Dependent Polynucleation Reactions, <i>Radiochimica Acta</i> 61 (1993) 29-34		
a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal - EU-Project (FP5, 2001-2004): "Humic Substances in Performance Assessment of Nuclear Waste Disposal: Actinide and Iodine Migration in the Far-Field". - EU-Project (FP6, 2005-2008): Fundamental Processes of Radionuclide Migration, as Contractor. - Research Promotion Foundation Program (2004-2007), "Assessment of the Radiological Impact on the Environment nearby a Phosphate Fertilizer Industry", Principal Coordinator/Investigator. - EU-Project (FP7-212287, 2008-2012): "Redox Phenomena Controlling Systems", Participation as Contractor.		
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; N/A		
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the		

concrete measures that will be taken to obtain it by the time of the implementation of the task.		
N/A		
	No	Name
		Acronym
Participant	48	University of Helsinki
		UH
The University of Helsinki, established in 1640, is the most versatile research university in Finland. It includes eleven faculties. The University has ca. 31 000 students and 7 800 employees. (https://www.helsinki.fi/en/university/the-university-of-helsinki-in-brief). High-level research is carried out at the departments of the faculties and departmentally affiliated research stations, as well as at independent research institutes. In 2017, the University of Helsinki placed 56th in the Shanghai Ranking, 90th in the Times Higher Education World University Ranking and 102th in the QS World University Ranking and 81th in the Taiwan (NTU) ranking. The University lays special emphasis on the quality of education and research. The University monitors the research quality by organising research assessment exercises using international peer review process approximately every six years. The University of Helsinki is a member of the League of the European Research Universities (LERU). The Research Funding Services of the University of Helsinki was established in 1994 with an aim to provide centralised research administration and management services for the researchers of the University. The unit is part of the Research Services, which is one of the six sectors of the University Services. In the previous EU's Framework Programmes the unit has gained valuable experience from providing support services to over 800 projects, out of which to 240 FP7 and currently over 140 Horizon 2020 funded projects. The Department of Chemistry is the leading hub of chemistry teaching and research in Finland. The research carried out at the department is highly valued internationally, and it is divided into three research programmes: Materials Chemistry, Molecular Science, and Synthesis and Analysis. The molecular research unit of the Department of Chemistry combines many complementary molecular and methodological approaches, both experimental and theoretical. The main directions of experimental studies are exhaled human air monitoring, photochemistry, low-temperature chemistry, fundamental reaction studies, gas kinetics, solid phase and surface reactions, and combustion chemistry. We actively develop infrared optical frequency combs, precision laser spectroscopy and mass spectrometric techniques, to name a few. In parallel to experimental techniques, we develop and employ a multitude of theoretical and computational methods. The radiochemistry research is a part of molecular science research programme. The radiochemistry research is focused on four areas, the largest one of them being study on behaviour of radionuclides in the geosphere in reference to final disposal of spent nuclear fuel. Another are related to nuclear waste is the development of inorganic ion exchangers for the selective removal of radionuclides from nuclear waste effluents. Third area is radiopharmaceutical chemistry and fourth environmental radioactivity. The Disposal of nuclear waste team is based at the Department of Chemistry on the Kumpula Science campus. The research is focused on providing realistic parameters for safety analysis of the final disposal of nuclear waste and improving the understanding of chemical and physical processes of elements in geomaterials. The team provides a wide range of services from structure characterization to transport modelling.		
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks EURAD-1 FUTURE: Sample characterisation by C-14 PMMA autoradiography, XRD, SSA and X-μCT. Sorption and matrix diffusion experiments with ²²⁶Ra on pure minerals and rock samples and interpretation of the results from sorption and matrix diffusion experiments. EURAD-1 HITEC: Batch type tests to follow bentonite mass loss and characterization of the clay properties in micro or nanoscale after the heat treatment. Determination of the rheological (flow) properties as a function of temperature (20 – 150 °C) of sol, sol-gel, gel and colloidal phases.		
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Marja Siitari-Kauppi is a University Lecturer at the radiochemistry unit at the Department of Chemistry. She has been the group leader of the Radionuclides migration in porous bedrock group since year 2000. Siitari-Kauppi has 30 years of experience in the research field of spent nuclear fuel disposal. Her interests are in sorption and diffusion of safety relevant radionuclides in the engineered and natural barriers of the spent nuclear fuel repository. In addition she has developed in collaboration with the Finnish Radiation and Nuclear Safety Authority STUK a method for analyzing the porosity and pore structure of low porous		

materials with C-14 PMMA autoradiography technique.

Siitari-Kauppi completed her Ph.D. thesis within the framework of Cotutelle agreement that granted her the Ph.D. both in Finland and in France leading to the strong research connections in France. These include the Institut de Chimie des Milieux et Matériaux at Poitiers University, French Institute for Radiological Protection and Nuclear Safety and the French Geological Survey. Siitari-Kauppi has been a member of the International Steering Committee for Grimsel Test Site (GTS) Phase VI since 2004 and her group has worked in the in situ projects in GTS together with an international research groups managed by Nagra, Switzerland. During years 2009-2013 she had an EU project together with Poitiers University and ERM company to transfer the knowledge and build them a shared laboratory for the use of C-14 PMMA method. She has research collaborations also with Posiva, Finland, University of Jyväskylä, Finland, Geological Survey of Finland, University of Bern, Switzerland, JAEA, Japan, VTT Technical Research Centre of Finland, NRI-Rez, Czech Republic, Royal Institute of Technology, Sweden and Technical University of Gothenburg and Geosigma, Sweden. She is also an expert member in the national CCE fission group in the Ministry of Economic Affairs and Employment in Finland.

Pirkko Hölttä is a University Researcher at the radiochemistry unit at the Department of Chemistry and has 30 years of experience in the research field of spent nuclear fuel disposal. She has her M.Sc. and Ph.D. degree from the University of Helsinki, majoring in radiochemistry. Her Ph.D. thesis was about radionuclide migration in crystalline rock fractures and demonstration of matrix diffusion affecting the transport and retardation behaviour of radionuclides in fracture flow. Her research is related to the safety relevant radionuclide migration in granitic rock and the long-term performance of the bentonite buffer. Her projects are on the bentonite erosion, the stability of formed colloids, the radionuclide-colloid interaction and the colloid-facilitated transport of radionuclides. She is collaborating with Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Karlsruher Institut für Technologie (KIT) and Nagra Grimsel Test Site programme Colloid Formation and Migration (CFM). She is also an expert member in the national CCE fission group in the Ministry of Economic Affairs and Employment in Finland.

Mikko Voutilainen is a University Researcher with a strong experience in research concerning transport radionuclides in bedrock from both experimental and modeling perspectives, X-ray microtomography, and porosity and pore structure characterization. He has a Ph.D. degree focused in Applied Physics from University of Jyväskylä. Topics of his doctoral dissertation were experimental characterization of structural heterogeneities in crystalline rock and effect of heterogeneities to transport of elements in it. The focus of the work was on safe disposal of highly radioactive spent nuclear fuel. After his PhD he has been working in University of Helsinki, first as a Postdoctoral Researcher and from 2017 as University Researcher. His current research projects are related to transport of radionuclides in conditions of deep geological repositories of spent nuclear fuel and paleo-hydrogeological evolution of pore and fracture waters in crystalline rock formations.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

Kuva, J., Sammaljärvi, J., Parkkonen, J., Siitari-Kauppi, M., Lehtonen, M., Turpeinen, T., Timonen, J. & Voutilainen, M., 2018. Imaging connected porosity of crystalline rock by contrast agent-aided X-ray microtomography and scanning electron microscopy. *Journal of Microscopy* 270, 1, 98–109.

Muuri, E. M., Sorokina, T., García, D., Grivé, M., Bruno, J., Koskinen, L., Martin, A. & Siitari-Kauppi, M. K., 2018. Modeling Transport of Cesium in Grimsel Granodiorite With Micrometer Scale Heterogeneities and Dynamic Update of K_d . *Applied Geochemistry* 92, 188–195.

Muuri, E. M., Matara-aho, M. H., Puhakka, E. H., Ikonen, J. O., Martin, A., Koskinen, L. & Siitari-Kauppi, M. K., 2018. The sorption and diffusion of ^{133}Ba in crushed and intact granitic rocks from the Olkiluoto and Grimsel in-situ test sites. *Applied Geochemistry* 89,

Voutilainen, M., Kekäläinen, P., Siitari-Kauppi, M., Sardini, P., Muuri, E., Timonen, J. & Martin, A., 2017. Modeling Transport of Cesium in Grimsel Granodiorite With Micrometer Scale Heterogeneities and Dynamic Update of K_d . *Water Resources Research* 53, 11, 9245–9265.

Elo, O., Müller, K., Ikeda-Ohno, A., Bok, F., Scheinost, A. C., Hölttä, P. & Huittinen, N., 2017. Batch sorption and spectroscopic speciation studies of neptunium uptake by montmorillonite and corundum. *Geochimica et Cosmochimica Acta*. 198, 168–181.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

Finnish Research Programme on Nuclear Waste Management (KYT) 2015-2018 projects: Behaviour of radionuclides in the geosphere; in situ studies and Bentonite erosion and radionuclide interaction processes

Posiva: Retention properties of rock matrix (Repro) and Paleohydrogeology projects Grimsel Test Phase VI: Ling Term Diffusion (LTD) and Colloid Formation and Migration (CFM) EU/BELBaR: WP3 Colloid radionuclide & host rock interaction
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; B- and C-type radiochemistry laboratories Wide range of modern instruments for the measurement of all types of radiation Digital autoradiography (FLA) and Electronic autoradiography (BeaverTM) ZetaSizer Rheometer UV/VIS spectrometer GC-MS, HPLC-ICP-MS LA-ICP-MS and ICP-OES FE-SEM/EDAX and FIB-SEM/EDAX XRD, SAXS He gas diffusion and permeability Ar gas pycnometer Optical microscopes Electro migration equipment C-14 PMMA method for pore structure characterization
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task. N/A

Participant	No	Name	Acronym
	49	British Geological Survey – United Kingdom Research and Innovation	BGS-UKRI
Description of the legal entity The British Geological Survey (BGS) is an applied geoscience research centre that is housed in UK Research and Innovation (UKRI) and affiliated to the Natural Environment Research Council (NERC). It is a world leading geological survey that provides a core science mission to inform government of science related to the subsurface and its interfaces and also undertakes applied research for solutions to earth and environmental processes, both in the UK and globally. It is funded directly by UKRI as well as through research grants and via private sector contracts. BGS has an annual budget of approximately £60 million and employs 650 people. It has two main sites, a head office in Keyworth near Nottingham and the Lyell Centre, which is a joint collaboration with Heriot Watt University in Edinburgh. BGS works with more than 150 private sector organisations as well as having close links with 40 universities and sponsors approximately 100 PhD students each year.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks BGS contribution will be within work package: Mechanistic understanding of gas transport in clay materials (GAS). Within this, BGS in partnership with ONDRAF/NIRAS will co-lead subtask 1.2 State-of-the-art (SOTA), producing a SOTA report based on the state of knowledge before EURAD-1. This will be available by month 12. BGS will contribute to subtask 2.1 Diffusion and retardation which focuses on diffusion and gas adsorption experiments. Specifically BGS, specifically will perform and model experiments on clay simulants to investigate the impact of mineralogy on the diffusion coefficient. A series of tests will be performed providing reference values for different mineral combinations, yielding data of interest to multiple end-users. This main body of experimental work be undertaken between month 6 and month 36 with reporting following this. BGS will lead subtask 2.2 Advection performing experiments to identify the governing processes for natural and engineered materials and on simulant materials to explore the dependency of transport mechanisms to petro-physical properties. Pathway imaging techniques will also be used. Finally, observations will also be up-scaled to include in-situ measurements of gas migration at a repository-relevant scale using the Lasgit facility at the Äspö URL managed by SKB. Experiments will run from month 6 to month 48 with reporting to follow. BGS, in partnership with CNRS (GeoResources – Nancy and IC2MP – Poitiers) will contribute to Subtask 3.1 Gas induced impacts on barrier integrity undertaking phenomenological experiments using a direct shear rig for water/gas injection experiments. Shear fractures will be created within the apparatus while tensile fractures will be created externally. Quantitative textural information of all fracture surfaces will be determined prior, and after, detailed experimental work by BGS. This will be undertaken between month 6 and month 24. Under subtask 3.2 Pathway closure and sealing processes, BGS, in partnership with CNRS will extend the experimental work in subtask 3.1 beyond the shut-in phase to visualise at pore scale the complex HM-C interactions, which are associated with the self-sealing process. BGS will contribute to meetings, reporting and dissemination throughout the lifetime of the project.			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Dr Jon Harrington (Male) is Head of the fluid processes Research Laboratories and a senior principal scientist at the British Geological Survey. He has 26 years of research experience examining the multiphase flow and associated rock deformation behaviour of low permeability materials. In 1995, he co-founded the Transport Properties Research Laboratory, a state-of-the-art experimental facility undertaking custom-			

designed laboratory and field-scale experiments. Since then his research has focussed on issues relating to mass-transport and the coupled deformation of clay-rich media, cements and halite, with particular application to the underground disposal of radioactive waste, the sequestration of carbon dioxide, unconventional hydrocarbons, domestic waste disposal, and gas storage. He has extensive experience of managing and delivering multidisciplinary research for a host of organisations including national waste management companies, and provides expert advice and guidance on containment properties of low permeability materials to industry and government. He has co-chaired sessions and given keynote talks at international conferences and workshops and has presented evidence on multiple occasions to the Commission Nationale d'Evaluation, (France) as part of the French legislative framework on the treatment of gas in radioactive waste disposal. He currently coordinates TASK A of DECOVALEX, an international multi-phase flow modelling consortium comprising of 10 world-leading numerical modelling teams. As part of his research, Jon has also designed numerous bespoke experimental systems and has pioneered the development of a new conceptual model describing the immiscible flow of gas in clays, mudrocks and shale. This work has included development of novel tracer techniques including nano-particle injection and the use of deuterium based porewaters. He also designed and continues to manage the 'Lasgit' experiment in Sweden, and was instrumental in the development of the EU FORGE project and the current EURAD WP on gas.

Dr Caroline Graham (female) is a Senior Geomechanics Specialist at the BGS with nearly 15 years experience in the field of rock mechanics. During the majority of that time she has conducted research testing on natural and engineered barrier materials, within the context of the disposal of radioactive waste and other forms of geological containment. She became manager of the Transport Properties Research Laboratory in 2013, which specialises in conducting world-class, bespoke, multi-phase flow experiments on low and ultra-low permeability geomaterials. Caroline has worked on hydromechanical properties of clays and rocks for geological disposal concepts in a range of countries including the UK, Sweden, Switzerland and the Netherlands. Her experimental work includes hydraulic and gas flow permeametry, examination of hydromechanical coupling and gas flow in bentonite under variable pore-pressure conditions (Graham et al., 2014a; Graham et al., 2016), investigating the influence of density gradients on gas flow in bentonite and tracing of gas migration pathways in clays (Harrington et al., 2012). In 2012 she was one of a UK delegation of six, sent to Beijing to participate in a UK-China collaborative workshop on the geological disposal of radioactive waste, as part of the BIS Global Innovation Scheme.

Dr Robert Cuss (male) is a Principal Scientist at the BGS specialising in multi-phase flow in low permeable material. With a PhD in rock mechanics he joined BGS in 1999 and has specialised in detailed investigations of host rock and engineered barriers, with complementary research in the fields of CCS, shale gas, and underground gas storage. In 2013, he setup the Fracture Physics Laboratory, a constituent of the Fluid Process Laboratory, to study multi-phase flow in fractures using conventional and novel techniques. Robert has experience of flow problems related to radioactive waste disposal from a theoretical, laboratory-scale, and field-scale prospective. Robert has participated in numerous projects for many of Europe's Waste Management Organisations, including work for UKAEA & RWM (UK), SKB (Sweden), Andra (France), Nagra & ENSI (Switzerland), Ondraf (Belgium), and Covra (Netherlands). These studies have included coupled flow in host rocks, engineered barriers, and fracture flow. Research has been conducted as direct commissions or through several EC projects (NF-Pro, FORGE, CeBaMa), working at the forefront of the gas research topic.

Dr Elena Tamayos-Mas (female) is a mathematical modeller at the BGS with nearly 10 years' experience in developing mathematical models to improve our understanding of physical phenomena. With a PhD in applied mathematics (within the Civil Engineering School at Universitat Politècnica de Catalunya, Spain) and a postdoc in computational fluid dynamics (within the Mining and Materials Department at McGill University, Canada), she joined BGS in 2016. Since then, her research has focused on developing mathematical models to address a wide range of issues relevant to hydrological and groundwater processes and the safety of deep geological disposal of radioactive waste. She is actively collaborating with the coordination of TASK A of the current phase of the Decovalex project, where she assesses and validates the different numerical approaches that the participating modelling teams are developing to describe advective movement of gas in low-permeability materials.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

J.F. Harrington, C.C. Graham, R.J. Cuss and S. Norris, Gas network development in a precompacted bentonite experiment: Evidence of generation and evolution. *Applied Clay Science*, 147, pp.80-89, 2017. <http://dx.doi.org/10.1016/j.clay.2017.07.005>.

Harrington, J.F., Cuss, R.C. and Talandier, J. (2017). "Gas transport properties through intact and fractured Callovo-Oxfordian mudstones." In: Rutter, E. H., Mecklenburgh, J. & Taylor, K. G. (eds) *Geomechanical and Petrophysical Properties of Mudrocks*. Geol. Soc. London, Spec. Pub. 454, <https://doi.org/10.1144/SP454.7>.

R.J. Cuss, J.F. Harrington, R. Giot and C. Auvray, Experimental observations of mechanical dilation at the onset of gas flow in Callovo-Oxfordian claystone. In: *Clays in Natural and Engineered Barriers for Radioactive Waste Confinement*; S. Norris et al. (Eds), 400, Geological Society Special Publications: London, United Kingdom, Geological Society of London, pp. 507-519, 2014. doi:10.1144/SP400.26

C.C. Graham, J.F. Harrington and P. Sellin, Gas migration in pre-compacted bentonite under elevated pore-water pressure conditions. *Applied Clay Science*, 132, 353-365, 2016.

Harrington, J.F., Milodowski, A.E., **Graham, C.C.**, Rushton, J.C., and **Cuss, R.J.** (2012). "Evidence for gas-induced pathways in clay using a nanoparticle injection technique." *Mineralogical Magazine*, 76 (8), 3327-3336, doi: 10.1180/minmag.2012.076.8.45.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

Gas migration behaviour in compact bentonite (for SKB and RWM): BGS has undertaken extensive studies examining the processes and mechanisms governing gas migration in pre-compacted bentonite. Laboratory and field scale experiments have been undertaken to better understand key phenomenological processes including the conditions governing: gas entry; peak gas pressure; gas breakthrough pressure; the coupling between gas flow, stress and porewater pressure; the stability of gas pathways; the amount of water displaced during gas flow. In combination with other studies, the output from this research has shaped the way in which gas migration is treated within performance assessment and has led to the development of a new conceptual model governing gas flow.

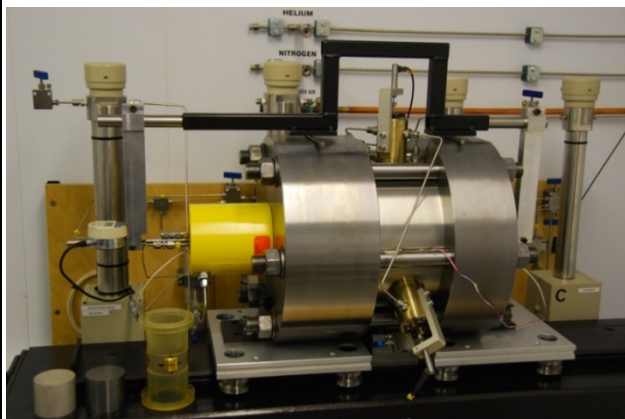
Gas migration in Callovo-Oxfordian mudrock (Andra): In 2007 BGS began an experimental study to examine the fundamental conditions governing gas migration in the Callovo-Oxfordian mudrock (COx). This project questioned the validity of gas transport models then applied to COx, and defined a new conceptual model based around micro fracture and rock dilatancy. This work remains ongoing and key issues focused around the processes controlling dilatancy, the coupling of gas flow to stress and the impact on gas flow on the integrity of the host rock.

DECOVALEX-2019 (Task A): BGS is the task leader for this activity. The purpose of Task A is to better understand the processes governing the advective movement of gas in both low-permeability repository host rocks and clay-based engineered barriers. Based on laboratory scale experiments, new numerical representations for the quantitative prediction of gas migration fluxes have been developed. Work is ongoing, with the project scheduled to finish in December 2019.

FORGE (EC FP7 Euratom) BGS led the co-ordination of the Fate Of Repository GasEs (FORGE) project, a 12 M euro pan-European project studying gas generation and migration in a repository context. BGS also led Work Package 4: Disturbed host rock (DHR) formations undertaking small scale laboratory experiments, large scale field tests (performed at a number of underground research laboratories throughout Europe), data and numerical modelling to understand the roles of the stress tensor, the stress path and associated mechanical deformation in determining permeability changes affecting the sealing efficiency of the host rocks.

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

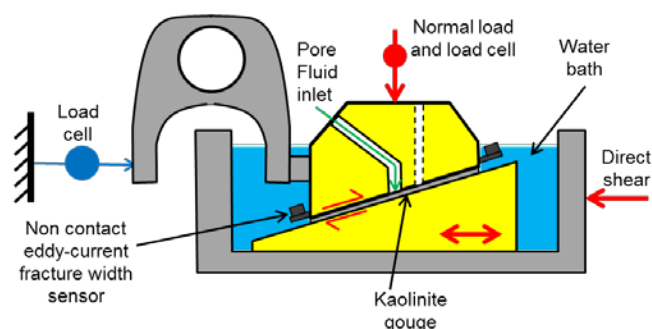
The research proposed in the project will be undertaken in the *Transport Properties Research Laboratory (TPRL)*.



The TPRL is one of the leading centres in Europe for the study of fluid movement in ultra-low permeability media. The facility is well known within the radwaste and CO₂ sequestration sectors for long-term high quality experimental work and process-based interpretation. Focus is on multi-phase flow in natural and engineered, low permeability geomaterials (e.g. caprocks, well bore cements and engineered clays), and their associated deformation behaviour. Measurements include: saturation and consolidation properties; intrinsic permeability (or transmissivity); anisotropy; specific storage; coupled flow parameters (e.g. osmotic permeability); capillary entry,

breakthrough and threshold pressures; gas permeability function; drained and undrained compressibilities; and rheological (creep) properties. Laboratory experiments are performed under simulated in situ conditions (stress, pore pressure, temperature and chemical environment). Three key areas explored are: (i) baseline characterisation of hydromechanical properties, (ii) influence of stress path and stress history on transport properties and (iii) transmissivity of fractures, faults and discontinuities (e.g., wellbore interfaces).

Tests are designed to provide quantitative data for mathematical modelling of ultra-low permeability materials, together with process understanding of key transport mechanisms. Key equipment includes: high pressure isotropic permeameters (70 MPa); constant volume permeameters (70MPa); high pressure triaxial permeameter (70 MPa); heavy-duty, high-precision shear-rigs; high temperature, high pressure geochemical flow reactor (130 MPa at 140° C); and novel tracer systems (nano particle injection or radiological tagging of gas) to characterise and identify potential migration pathways.



Operational constraint:

High pressure isotropic permeameters - Up to 70 MPa

High pressure triaxial permeameter – Up to 70 MPa

High temperature, high pressure geochemical flow reactor – Up to 130 MPa at 140 C

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

Not applicable

	No	Name	Acronym
Participant	50	Teknologian tutkimuskeskus VTT (VTT Technical Research Centre of Finland Ltd)	VTT
Description of the legal entity VTT Group is the largest public applied research activity in Northern Europe with a staff of 2600 and turnover of M€ 279. VTT has 75 years of experience in addressing the needs of industry and the knowledge-based society. Over the years, VTT has participated in more than 1000 European R&D Framework Programme projects, within various thematic programmes. VTT is currently involved in over 10 H2020 Euratom projects and is an active member of IGD-TP. VTT has partnership agreements and works in close cooperation with both the waste management producers and repository operators (Fortum, TVO, Fennovoima, Posiva) and the Finnish Nuclear Regulatory Authority (STUK). VTT is a multi-technological research organisation providing high-end technology solutions and innovation services.			
Description of main tasks in EURAD-1, with an explanation of how its profile matches the tasks VTT is a mandated actor, reporting to the Ministry Economic Affairs and Employment within the Finnish government. VTT (Erika Holt), together with Posiva and University of Helsinki, coordinate the Finland partners' involvement in EURAD. Regarding specific WPs identified in the 1st wave, VTT participates to the following: - WP HITEC: Coordinator (Markus Olin). - WP ACED: Task 4 leader (Pauliina Raijala, Markku Leivo) - WP SFC: Contributor (Silja Häkkinen) - WP UMAN: Contributor (Marja Ylönen, Rafael Popper) VTT also has the coordinator role for the Finnish Research Program on Nuclear Waste Management (ongoing KYT2018, in planning KYT2022), where there may be complimentary domestic R&D compared to EURAD. http://kyt2018.vtt.fi/en/			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities <u>Dr. Erika Holt</u> (F, Ph.D. 2001) has degrees in Civil and Environmental Engineering, with an emphasis in construction materials, from the University of Washington, Seattle USA. She also has training in geotechnical engineering and tunnelling. She has been a Principal Scientist, Project Manager, and Research Team Leader for a team of 28 experts in the field of Infrastructure Materials at VTT. Her expertise is in concrete material durability, sustainability and nuclear waste containment. She has worked with Posiva on the performance of low-pH grouting material, as well as bentonite product manufacturing and bentonite performance for buffer design, quality management, tunnel plug demonstrations. She has participated in EU FP5-7 projects and serves as a project evaluator for the EC. She has over 25 publications in journals and conference proceedings. In EURAD, her roles are within the Finnish program coordination and scientific advising/review. <u>Professor Markus Olin</u>, (M, Ph.D. 1994) earned his degree in Physics from the University of Helsinki. He is a Research Professor having more than 30 years of experience in the field of modelling spent nuclear fuel disposal. His research is concentrated on thermodynamics, surface chemistry and transport in porous media with an emphasis on nuclear waste containment (bentonite and rock materials). He has been involved in over ten EU and national funded large (multi-year) studies as a researcher and project manager. He is an author over 150 article and reports, 2 chapters in books and over 50 conference presentations. He has had leading technical roles in the EU-BELBAR, EU-THERAMIN and EU-BEACON projects most recently. In the HITEC WP of EURAD, he serves as the coordinator and technical supervisor of VTT's activities on high temperature clay performance in crystalline rock environments. <u>Dr. Markku Leivo</u>, (M, D.Sc.Tech, 2005) earned his degree in Civil Engineering and Surveying from Helsinki University of Technology. He is a Principal Scientist has more than 30 years of experience on building materials research and coordination. His research is concentrated on the performance of buildings, material properties and manufacturing processes. He has been involved in over ten EU-funded studies as a researcher and project manager. He is an author of tens of scientific papers and presentations from 1985 on. Most recently he has been working on the EU-DOPAS (plug demonstration) and EU-CEBAMA (cement-			

bentonite) projects in the technical lead roles. In the ACED WP of EURAD, his expertise contributions are related to concrete material evolution.

Dr. Pauliina Rajala, (F, D.Sc., 2017) has a degree in Microbiology, specializing in Microbially Induced Corrosion, from University of Helsinki, Finland. She has worked with nuclear repositories related topics since 2011 at VTT as a Research Scientist and Project Manager in the field of Material Performance. Her expertise is in deep biosphere corrosion, biofouling and microbiology, with a special emphasis on geological repository environments. She has over 30 scientific publications on these topics. In the EURAD WP ACED her expertise is in corrosion of steel materials and general understanding of geological repository concept and chemical changes taking place during the repository time scale.

Mr. Veli-Matti Pulkkanen (M., MSc (Tech.), 2010) has a degree in Engineering Physics from Aalto University School of Science and Technology with an emphasis on continuum level material modelling and numerical methods. He has worked at VTT over 10 years on modelling nuclear waste management related problems ranging from radionuclide transport calculations for safety analysis to complex, strongly coupled bentonite models. Currently, he is finalizing his Doctoral Thesis on bentonite modelling and working within the BEACON project. He will contribute to the HITEC WP.

a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content

- Pulkkanen. 2018. A large deformation model for chemoelastic porous media – bentonite clay in spent nuclear fuel disposal. Dr. (Tech.) Thesis, Aalto University. expected ready autumn 2018.
- Holt, Olin, Jalonen. 2016. Recent Research and Technology Highlights for Finnish Implementation of Geological Disposal of Radioactive Waste. ATS Ydintekniikka,, 1/2016, Vol. 45, Suomen Atomiteknillinen Seura, Finland, pp. 26-29.
- Holt, Koho, Hansen. 2016. Posiva's Tunnel End Plug POPLU Experimental Summary Report, DOPAS project Deliverable D4.5, European Commission Contract #FP7-323273, 170 p.
- Hakola, Kivikoski, Löija, Marjavaara. 2015. Designing, Commissioning and Monitoring of 40% Scale Bentonite Buffer Test. Posiva Working Report 2015-08, 148 p.
- Itälä, Laitinen, Tanhua-Tyrkkö, Olin. 2014. Modeling Transport of Water, Ions, and Chemical Reactions in Compacted Bentonite: Comparison Among Toughreact, Numerrin, and Comsol Multiphysics, Nuclear technology 187(2), 169-174.

a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal

- “Full-Scale Demonstration of Plugs and Seals (DOPAS, 2012-16)”, FP7-EURATOM project, Grant Agreement No. 323273. VTT and Posiva participation evaluating low-pH concrete recipes & performance, as well as monitoring of EBS performance.
- “Cement-based materials, properties, evolution, barrier functions (CEBAMA, 2015-19), H2020-Euratom project Grant Agreement No. 662147, VTT conducting experiments and long-term safety modelling of concrete-bentonite interaction for crystalline host rock.
- “Development and Demonstration of monitoring strategies and technologies for geological disposal (MODERN2002, 2015-19), H2020-Euratom project Grant Agreement No. 662177, VTT and Posiva participating on monitoring strategies and methods in the near-field during repository operation phases.
- “Development of the safety case knowledge base about the influence of microbial processes on geological disposal of radioactive wastes (MIND, 2014-18)”, H2020-Euratom project Grant Agreement No 661880, VTT participating with evaluating influence of microbial processes on waste forms and their behaviour, and the technical feasibility and long-term performance of repository components
- “Thermal treatment for radioactive waste minimisation and hazard reduction (THERAMIN 2017-2020)”, H2020-Euratom project Grant Agreement No 755480. VTT coordinator, developing methods for gasification and characterization of materials during waste reduction processes.
- “Bentonite Mechanical Evolution (BEACON, 2017-2021), H2020-Euratom project Grant Agreement No 745942. VTT modelling thermal-hydro-geo-chemical-mechanical evolution of bentonite, for process understanding of homogenization for repository safety.

a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;

Over 10 000 m² of experimental lab space in divisions of radioactive waste management and building materials (over 100 000 m² whole VTT). VTT's Centre for Nuclear Safety (CNS) includes class A, B and C facilities for experimental research and handling of radioactive materials. Most relevant EURAD equipment

includes radiological material characterization labs (gloveboxes, optical microscopy, TEM, SEM, ESEM, XRF, Xray diffractometer, EDS, AFM, MIP, thermal analysis, ICP-MS, wet chemistry). Building materials (metals, bentonite, cementitious) production and characterization labs (i.e. mixers, sieves, high-speed centrifuge, rheometers, calimetry, diffusion cells, shrinkage, creep, chloride diffusion & migration, sulphate attack, chemical leachate, resistivity, accelerated weather simulation, strength testing, etc). Radiochemistry and hotcells for irradiated material studies (gamma cell, alpha spectrometry, neutron measurements, etc). Micronova laboratories for sensor development. Biorukki pilot plant for gasification of waste and associated characterizations. Non-destructive evaluation laboratory (ultrasound, eddy current, radiography, etc). Water chemistry and microbiology laboratory. Infrastructure also includes computational modelling tools and associated licenses (such as COMSOL, TOUGH2, TOUGHREACT, GEMS, @Risk, Abaqus/Ansys, GOLDSIM, Geochemists's Workbench, Serpent, ORIGEN, FDS2FEM, etc).

NOTE! VTT has "Large Research Infrastructure" (LRI) costs calculated based on working hours of the project and according to VTT's ex-ante assessment of the methodology on Direct Costing for Large Research Infrastructures (LRI), approved by the Commission on 24th February 2015.

VTT's methodology on LRI complies with the clauses of the H2020 Grant Agreement (Capitalised and operating costs of large research infrastructure Article 6.2.D.4, the extent verified during the audit) and therefore, the LRI costs should be considered as direct costs of the project.

LRI Rf Nuclear Safety description: Centre for Nuclear Safety (CNS) will include class A, B and C facilities for experimental research and handling of radioactive materials. Research facility consists of hot cells and equipment used in CNS. Hot cells that protect employees from radiation are situated in class A laboratory in two separate floors. Equipment that are used to examine the properties of radioactive material samples are located inside the hot cells. Samples are handled behind lead glass utilizing manipulators and cameras. Opening of transport capsules of radioactive materials, storing of radioactive samples and specimens as well as handling of radioactive waste will also occur in class A laboratory. A Comprehensive set of microscopes will be linked to the class A laboratory.

if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task.

N/A

	No	Name	Acronym
Participant	51	VUJE, a.s.	VUJE
Description of the legal entity VUJE a.s. is an engineering company that performs design, supply, implementation, research and training activities, particularly in the field of nuclear and conventional power generation.			
IDescription of main tasks in EURAD-1, with an explanation of how its profile matches the tasks VUJE, a.s. shall be involved in Task No. 3 “Description and comparison of radwaste characterisation approaches”. Its profile matches the following subtasks: - Identification of characterisation techniques for radioactive waste (selected in Task 2); - Comparison of the characterisation methods applied for the same radioactive waste in different countries; - Analysis of the existing approaches and identification of the knowledge gaps; - Recommendations for the future R&D to eliminate knowledge gaps; - Recommendations for characterisation approaches for countries with non-developed waste management concept.			
a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities Dr. Prítrský is a senior research worker with wide experience in implementation of safety analyses of RAW management facilities. He has detailed knowledge of decommissioning and radioactive waste management, including legal aspects and practical skills in safety assessment. Since 1997, he has been involved in numerous projects in Slovakia and abroad. He is author/co-author of more than 120 papers and studies in: - safety assessment of the radioactive waste repositories, - identification of the appropriate waste management concept, - development and improving models and computer codes.			
a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content Publications: • Novak, M., Prítrský, J., Daniska, V., Juhar, P.: Conditional Clearance of Radioactive Demolition Waste in Motorway Scenario. Progress in Nuclear Science and Technology, Volume 4 (2014) pp. 854-857, ISSN: 2185-4823, April 2014. • Prítrský, J., Nečas, V.: Impact of Advanced Nuclear Fuel Cycle IMF on Geological Repository Performance. In: Progress in Nuclear Energy, Volume 54, Issue 1, January 2012, pp. 36-40. • Prítrský, J., Frankovská, J.: Derivation of clearance levels for solid radioactive materials from nuclear installations decommissioning. Proceedings of the 20th International Conference on Nuclear Engineering ICONE20, July 30 - August 3, 2012, Anaheim, California, USA • Prítrský, J.: Radiological Limits and Conditions for Conditional Release of Materials from Nuclear Installations Decommissioning. 15th Regional Seminar on Radioactive Waste Disposal. Třešť, 4-6 September 2012. • Matejovic, I., Hok, J., Madaras, J., Slaninka, I., Prítrský, J.: Status of the Deep Geological Disposal Program in the Slovak Republic. In: Geological Challenges in Radioactive Waste Isolation. Fourth Worldwide Review. Ernest Orlando Lawrence Berkeley National Laboratory, University of California Berkeley, California 94720 U.S.A. April 2006. Report LBNL-59808, pp. 173-190. • Prítrský, J., Matejovič, I., Ondra, F., Nečas, V.: Safety assessment of gas producing radioactive waste			

disposal. In: Journal of Electrical Engineering No. 4/2006. ISSN 1335-3632.
a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal • CND - Coordination Network on Decommissioning of Nuclear Installations • IPPA - Implementing Public Participation Approaches in Radioactive Waste Disposal • SITEX - Sustainable network for Independent Technical Expertise of Radioactive Waste Disposal - Interactions and Implementation • SAPIERR – Support Action on a Pilot Initiative for European Regional Repositories • CONRELMAT - Conditional Release of Materials • Alliance - ALLEGRO Implementing Advanced Nuclear Fuel Cycle in Central Europe • COMPASS - The Comparison of Alternative Waste Management Strategies for Long-lived Radioactive Wastes • ARGONA - Arenas for Risk Governance • RedImpact – Impact of Partitioning, Transmutation and Waste Reduction Technologies on the Final Nuclear Waste Disposal • BIDSF - Bohunice International Decommissioning Support Fund: - o B6.1 The V1 NPP Conceptual Decommissioning Plan, - o B6.2 The Environmental Impact Assessment Report of V1 NPP Decommissioning, - o B6.3 The V1 NPP Decommissioning 1st Stage Plan & Other Documentation
a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work; Laboratory: - Test laboratory for radiation dosimetry - Test laboratory for chemical regimes and physiochemical analysis - Calibration laboratory temperature and pressure gauges - Test laboratory for chemical regimes and physiochemical analysis Software: - software intended for radiation safety assessment (GoldSim, AMBER), - PRIMAVERA, MS Project, MS Office, - OMEGA - computer code for decommissioning calculations, - graphics (AutoCAD, Adobe Photoshop, Corel Paint Shop Pro, Graphic Surfer), - relational databases (Oracle).
if operational capacity cannot be demonstrated at the time of submitting the proposal, describe the concrete measures that will be taken to obtain it by the time of the implementation of the task. N/A

4.2. Third Parties involved in the project

1/ Andra

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	Y
Andra plans to get support from a subcontractor for its work under WP1 – Programme Management and more specifically under: - task 3 - Extension/update of the Roadmap/SRA; - task 4 - Identification of Experts; - task 5 - Internal communication/meetings and - Task 6 – Dissemination.	
Does the participant envisage that part of its work is performed by linked third parties	Y
BRGM is a public institute and acts as the French Geological Survey. It embraces activities in the field of applied Earth Sciences, e.g. geology, hydrology, hydrogeology, geochemistry, geophysics, biotechnologies, hydrometallurgy, and analytical chemistry. For 20 years, BRGM cooperates with Andra in the framework of a scientific partnership. Thanks to this partnership and its implication in many EU projects, BRGM has acquired internationally renowned experience in several fields including coupled geochemistry-transport modelling, validation of the concepts of storages, transfers of pollutants in the environment, performances of the barriers and durability of materials of the artificial barriers. Within EURAD, BRGM, as a linked third party of Andra, will be involved in - WP3 DONUT - o BRGM is the WP leader of DONUT and contribute to task 1 Coordination - o Task 2 - BRGM will 1) develop numerical schemes to include advective transport in reactive transport codes dealing with the presence of a charged diffuse layer in the porosity; 2) develop a Poisson-Nernst-Planck model in Openfoam and 3) make available a toolbox to the community to help in the interpretation of laboratory studies (e.g. in-situ experiment running in Underground Research Laboratories) with state-of-the-art reactive transport codes capabilities. - o Task 3 – BRGM will apply pore-scale and micro-continuum models to pore-scale data sets to derive Darcy-scale properties of electrochemical transport. - o Task 4 - BRGM will investigate advanced techniques to take into account uncertainties from coupled process in nuclear waste disposal : development of surrogates in the time-space-parametric (such as polynomial chaos expansions (PCEs)), use of adapted method to sensitivity analysis with dependent parameters (estimation of a posteriori distributions in order to minimize the difference between observations and simulations) - WP5 FUTURE - o Task 2 – Mobility: Task 2.3: BRGM will contribute as follows: Fine characterization of U-bearing phases/surfaces in clay-rocks and of radionuclides (or their stable isotopes counterpart). Adsorption processes on clay minerals surface using wet chemistry and spectroscopic, diffractometric and microscopic techniques. Unravelling of retention mechanisms from site localization as a function of chemical conditions and linking to the reversibility or irreversibility of the processes and thus the type of thermokinetic description that should be considered (surface adsorption, incorporation, co-precipitation etc.). Modelling of reversible adsorption processes using electrostatic surface complexation models adapted to the specificities of clay minerals surfaces. - o Task 3 - Redox reactivity of radionuclides on mineral surfaces: BRGM is the leader of this task. BRGM could prepare and provide sample to the partners: an anionic, a cationic clay, and an iron oxide of interest for the partners. These samples could be provided in various Fe oxidation states (various Fe(II)/Fe(III) ratio and different structural location of Fe). The abundance and structural location of Fe(II) and Fe(III) will be determined using a combination of methods: Mossbauer spectrometry and chemical methods for macroscopic	

average Fe oxidation state, transmission electron, and diffractometric methods (powder X-ray diffraction and synchrotron techniques) to determine the crystal chemistry of the samples. - WP7 HITEC: - o Task 3.2: [Andra (BRGM)] will measure swelling pressure during the hydration of a bentonite (Kunipia-G or MX-80) at temperatures between 100 and 150°C with solutions of different compositions (cations and ionic strength) using an oedometer cell suitable for X-ray tomography acquisition to visualize in situ the evolution of the microstructure evolution. Swelling experiments will be simulated accounting for both mechanical compaction, temperature changes, water flow and chemical effects. A comparison of modelling approaches will be made with the Charles University hypoplastic model for swelling clays. - WP3 CORI : - o Task 2 Organic degradation –BRGM will perform g-radiolytic/hydrolytic degradation of Superplasticizer/PVC or IER with identification of degradation products by complementary work with ISTO - WP2 ACED: - o Task 3.2 - modelling the selected reference experiments studied in subtask 3.1 and the evolution of a HLW waste package for vitrified waste consisting of a glass core encapsulated in an iron/steel canister and in contact with a cement or cement/clay backfill. It will involve testing and comparing different conceptual models including different features (description of heterogeneities, e.g. voids) and processes, and/or waste alteration models and/or different corrosion models and/or degradation of concrete materials models and/or different reactive transport codes (PhreeqC, Hytec, Crunch, OpenGeoSys-GEM, etc.). - o Task 3.3 - modelling the long-term chemical evolution of ILW waste packages and to provide upscaled effective parameters for usage in disposal cell scale reactive transport models. investigate the chemical evolution considering different scenarios and different processes. This task will involve testing and comparing different models, including different features and processes, like waste alteration models, corrosion models or concrete degradation models with different reactive transport codes. The choice of scenarios and processes has to be coordinated with task 4 in order to avoid inconsistencies between waste package and disposal cell scale. The planned scenarios are related to intermediate storage of waste packages (important for definition of initial state at emplacement), after emplacement the evolution under fully liquid saturated conditions and the evolution under partially saturated conditions.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

2/ ARAO

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

3/ BEL V

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

4/ BGE

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

5/ CEA

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
EDF (<i>Electricité de France</i>) group is the world's leading electricity company and global leader for low-carbon energy production. Particularly well established in Europe, especially France, the United Kingdom, Italy and Belgium, as well as North and South America, the Group covers all businesses spanning the electricity value chain – from generation to distribution and including energy transmission and trading activities – to continuously balance supply and demand. The R&D Division is made up of 13 technical departments. Their skills cover all the Group's field of activities: renewable energies and storage, networks, nuclear generation, thermal, hydropower, energy management, environment. EDF and CEA are linked through a cooperation agreement, which includes research activities on radioactive waste and spent fuel management, and on the behaviour of engineered/natural barriers in disposal.	

The tasks performed by the third party concern thermo-mechanical modelling of clay rocks. EDF will contribute to the development of numerical methods for high performance computing of coupled processes (WP DONUT), to numerical modeling of gas induced damage and self-sealing of barrier (WP GAS), and to the benchmark exercise on THM modelling of effect of temperature in near and far field using the code_Aster. EDF launched a glass/steel/cement buffer/clay experiment in April 2018. In the framework of WP ACED, EDF will provide characterization of this experiment at various time steps, in collaboration with CEA. This experiment is complementary to the long-term glass/steel/clay experiment, proposed by CEA. Since a long-time, ORANO Cycle (previously AREVA-NC) has been the industrial partner of CEA in the development of innovative processes and technologies for the nuclear fuel cycle, from the mine to the treatment of spent fuel. ORANO Cycle develops solutions for the management of radioactive wastes produced by spent nuclear fuel treatment operations. The most famous one is the vitrification process developed for the confinement of high-level wastes. In parallel, ORANO Cycle develops also new conditioning processes for ILW. In the framework of EURAD, ORANO Cycle will contribute to the WP ROUTES by sharing its experience on methodologies of characterization of radioactive wastes and waste conditioning. ORANO is particularly involved in the task dedicated to the development of shared solutions in European countries for the management of radioactive wastes.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

6/ CIEMAT

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
Third Party: The Spanish National Research Council (CSIC) is a public institution dedicated to research in Spain. Belonging to the Spanish Ministry of Science, Innovation and Universities through the Secretary of State for Universities, Research, Development and Innovation, its main objective is to develop and promote research that will help bring about scientific and technological progress, and it is prepared to collaborate with Spanish and foreign entities in order to achieve this aim. The Institute for Construction Sciences “Eduardo Torroja” (IETcc) belongs to CSIC. Its mission is to develop research and technology in the construction field infrastructures and its materials. The IETcc is specialized in: physic-chemistry of cement and concrete, raw materials, sustainability, nanotechnology and multifunctional building materials, structural engineering, risk and safety of structures, roads, building energy saving, environment, durability, circular economy and life cycle analyses. Link of the participant to the third party: CSIC and CIEMAT subscribed a framework agreement entitled “Convenio marco de colaboración entre el centros de investigaciones energéticas medioambientales y tecnológicas y el consejo superior de investigaciones científicas” and since June 1989 with ref. UCA1989010008 that establishes the will and conditions for continuous collaboration in the research in all the fields of CIEMAT R&D including nuclear technology. The framework agreement is every 4 years updating and both institutions have used this agreement to collaborate in a number of projects on research programs cooperation, nuclear advice and management, personal exchange and training in different areas of nuclear research including topics on waste management.	

- Tasks to be performed by the third party:

1.- Cement-Organics-Radionuclides-Interactions (CORI). Within this WP, CSIC will contribute in Task n°3 - Organics-Cement-Interactions. CSIC will study the interactions that take place between different organic species (tentatively ISA, Acetate, EDTA and carboxylic acid) when they are incorporated (individually and combined) into HCP (CEM V, with pH < 12.5 and alkali-free as possible) through different transport mechanisms (adsorption, natural diffusion and electrically-driven diffusion). In addition to the plain cement, twin samples with an extra addition of Fe will be incorporated when casting to decipher the role of iron.

2.- Assessment of chemical evolution of ILW and HLW disposal cell. T2: Steel Concrete Interface: The CSIC contribution consist in the study the chemical evolution of the steel corrosion phenomena due to the interaction with the concrete in variable environmental conditions: Concrete pH, type of aggressive ion, T^a, moisture content and oxygenation level) will be under the focus of research. The main objective is to obtain reliable kinetic and microstructural data of the relevant parameters causing steel corrosion and further instability in the concrete that allow to understand the phenomena occurring at the interface and contribute to the modelling of the long-term service life of the repository.

Third Party: Universidad Politécnica de Cataluña (UPC) is a public university created in March 1971, aims to offer high-quality training and education leading to prestigious degrees, diplomas and courses. Regarding research and technology. The research group of the Geotechnical Engineering and Geosciences Division of the Department of Civil and Environmental Engineering has developed an advanced state-of-the-art in-house computer code (CODE_BRIGHT) able to perform coupled thermo-hydro-mechanical (THM) analyses. The code also incorporates constitutive laws appropriate for the description of the behaviour of the types of material involved in nuclear waste disposal. The group has an advanced laboratory to perform THM tests on materials often used in radioactive waste disposal such as bentonite and argillaceous rock. The group has also access to facilities such as ESEM (environmental electron microscope) and MIP (mercury intrusion porosimeter) to determine microscopic features of the materials.

- Link of the participant to the third party: UPC and CIEMAT subscribed a framework agreement entitled “Convenio marco de colaboración entre el centros de investigaciones energéticas medioambientales y tecnológicas (CIEMAT) y la universidad politécnica de Cataluña (UPC)” since February 2018 with ref.8266/2018 that establishes the will and conditions for continuous collaboration in the research in all the fields of CIEMAT R&D including nuclear technology. CIEMAT and UPC are using this agreement to collaborate in the nuclear research including topics on radiological protection, waste management, environment protection, computational studies, materials studies and fission & fusion Energy. In addition CIEMAT and UPC are members of the CEIDEN Spanish nuclear platform for nuclear research where they collaborate on the definition and development of research projects on nuclear technologies including aspects of the nuclear waste management.

- Tasks to be performed by the third party:

1.- Mechanistic understanding of gas transport in clay materials (GAS) into the Modelling of experimental work by CIEMAT will be developed by UPC team. The main effort will be devoted to the modelling of laboratory data sets in order to interpret the results and offer directions for future experimental work. The focus will be on the identification and quantification of the phenomena that govern gas flow behaviour. Heterogeneity will be introduced via consistent random and auto-correlated distributions of properties or parameters that will be coupled between them. A special type of finite element formulation will be used that allows the simulation of discrete gas flow paths embedded in a continuum. The information and expertise gathered during the performance of the modelling work will be put into operation in the final synthesis of the results and in the evaluation of the scientific achievements.

2.- Influence of temperature on clay-based material behaviour (HITEC) UPC will make available a recently developed advanced stress-strain law for clay rocks which includes non-linearity and plasticity before peak strength, softening after peak, anisotropy of stiffness and strength, creep (visco-elastic and visco-plastic) and permeability variation due to damage and self-sealing. The law will be further

developed by introducing thermo-plasticity. Another key development will be the simulation fracture generation due to overpressure and/or temperature and their propagation. A non-local formulation has proved capable of predicting the development and propagation of discontinuities under isothermal conditions. The formulation will be generalised to include specific thermal effects taking into account the variation of permeability in the discontinuity.

Third Party: Universidad Autónoma de Madrid (UAM) hosts one of the largest scientific communities in Spain whose research meets international standards which is recognized as “Campus de Excelencia” that incorporates highly qualified research groups from the Spanish National Research Council (CSIC).

- Link of the participant to the third party: UAM and CIEMAT subscribed a framework agreement “Convenio de colaboración entre la Junta de energía nuclear (CIEMAT) y la Universidad Autónoma de Madrid” since October 1985 with ref. 25/84 that establishes the will and conditions for continuous collaboration in the research in all the fields of CIEMAT R&D including nuclear technology. The framework agreement is still valid and CIEMAT and UAM have used this agreement to collaborate in a number of projects on different areas of nuclear research including topics on waste management.
- Tasks to be performed by the third party: 2.- Influence of temperature on clay-based material behaviour (HITEC) into the Task 3.1 UAM will focus on the post mortem analyses of the laboratory-scale thermo-hydraulic cells performed by CIEMAT in Task 3.3, mainly concerning mineralogical changes that could explain the macroscopic changes observed. The research group involved, belonging to the Department of Geology and Geochemistry in the Faculty of Sciences, is devoted to the study of geochemical reactions in the clay-waste system. The group has expertise, acquired during at least 20 years, in mineralogy and geochemistry of clay minerals (sheet silicates, oxides, zeolites, salts...). In this field they manage the main techniques used for materials characterization, including XRD, surface analysis and electron and optical microscopy.

Third Party: IDOM Nuclear Services is an area of IDOM Consulting, Engineering and Architecture company. Its experience in the nuclear sector has its origins in the early nuclear generation projects in Spain in the late 70s and 80s. IDOM NS develops projects where effective protection measures are integrated at all stages of the life cycle of nuclear fuel and radioactive waste: Ageing Management, Operation Consultancy, Engineering, Accident Evaluation, Project Management, Advanced Analysis, Decommissioning.

- Link of the participant to the third party: IDOM and CIEMAT have subscribed a framework agreement since April 2011 that establishes the will and conditions for continuous collaboration in all activities related to the Nuclear field. The framework agreement is removable and still valid and both institutions are using such agreement to collaborate in a number of projects on different areas of nuclear research including topics on waste management and training. In addition CIEMAT and UPM are members of the CEIDEN Spanish nuclear platform for nuclear research where they collaborate on the definition and development of research projects on nuclear technologies including aspects of the nuclear waste management.
- Tasks to be performed by the third party: Spent Fuel characterisation and evolution until disposal (SFC) IDOM will identify the main BWR and PWR fuel data that would affect the evolution of accidents, in order to understand the relationship between the data used in the fuel characterisation task and the accident analysis during storage, transport and fuel management. This activity (included in Subtask 4.2) contributes to the main goal of the WP helping to understand fuel behaviour under normal and postulated accident scenarios.

Third Party: Technical University of Madrid, (UPM) is the largest Spanish technological university as well as a renowned European institution. With two recognitions as Campus of International Excellence, it is outstanding in its research activity together with its training of highly-qualified professionals, competitive at an international level. More than 2,400 researchers carry out their activity at the UPM,

which is committed to transforming this knowledge into advances applied to the production sector.

- Link of the participant to the third party: UPM and CIEMAT has been collaborating under the framework agreement entitled “Convenio de cooperación científica entre la Junta de energía nuclear (CIEMAT) y la Universidad politécnica de Madrid” since November 1983 still valid that establishes the will and conditions for continuous collaboration in the research in all the fields of CIEMAT R&D including nuclear technology. The framework agreement is still valid and CIEMAT and UPM have used this agreement to collaborate in a number of projects on different areas of nuclear research including topics on waste management. In addition CIEMAT and UPM are members of the CEIDEN Spanish nuclear platform for nuclear research where they collaborate on the definition and development of research projects on nuclear technologies including aspects of the nuclear waste management.

- Tasks to be performed by the third party:

1.- Spent Fuel characterisation and evolution until disposal (SFC) UPM group plans experiments on unirradiated cold-worked stress-relieved Zirlo™ cladding samples according to the following activities such as experimental reproduction on unirradiated cladding of the hydride geometry observed in spent fuel cladding, after discharge, drying, transport and long-term dry interim storage. Mechanical testing of pre-hydrated samples. It is proposed to perform ring compression (RCT) and three-point bending (TPB) tests on unirradiated pre-hydrated samples before and after the simulated drying treatment at three temperatures: 20°C (worst case), 135°C (representative of long term dry interim storage) and 300°C (representative of operation conditions). 3. Analysis of failure mechanisms of unirradiated pre-hydrated cladding to elucidate the fracture micro-mechanisms. The fracture surfaces of broken samples after the ring compression and three-point bending tests will be studied by means of a scanning electron microscope (SEM). The three tasks are the ones that UPM group is going to perform in subtask 3.1 (Thermo-mechanical-chemical properties of the SNF rods and cladding) and therefore its profile matches perfectly the tasks defined in EURAD-1.

2.- Knowledge Management Work Package, UPM will provide educational materials and lectures developed by professors and teachers experts into the nuclear field.

Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners ⁶ (Article 14a of the General Model Grant Agreement)?	N

7/ ChRDI

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y

1. National Science Center Kharkov Institute of Physics and Technology, (NSC KIPT, PIC Number: 969818320, information about NSC KIPT on site: <http://www.kipt.kharkov.ua/en>). The Kharkov Institute of Physics and Technology conducts scientific research in the field of nuclear physics and solid state physics. And also is one of the most active participants in scientific and research work in the field of nuclear fuel cycle.

⁶ International Partner' is any legal entity established in a non-associated third country which is not eligible for funding under Article 10 of the Rules for Participation Regulation No 1290/2013.

Tasks to be performed by the third party:

NSC KIPT - WP7- HITEC.

NSC KIPT will contribute to work package:

Task 3.1 Assessment of the impact of high temperatures over long time periods on the clay buffer properties, from specific laboratory tests.

Task 3.2 Measurement/processes at high temperature + process modelling.

Using data from T3.1 and T3.2, we will be able to develop the model to simulate material behaviour for temperatures more than 150 °C.

Bentonite clay MX 80 will be used for research tests. The scientific institutes of Ukraine did not yet participate in the research programs of the European Commission. We do not have samples that were got before within the framework of joint researches with foreign partners. Therefore, the fresh samples of bentonite clay will be prepared for tests.

We plan to use saturated and unsaturated samples with various dry densities: from 1400 to 1800 kg/m³. The maximal parameters of swelling pressure will be determined for each samples and relationship between initial dry density, water content and treatment time will be obtained. Analytical investigations will be carried out to investigate the structure and chemical/transport changes in bentonite during 150°C heat treatment.

2. Institution State "Institute of Environmental Geochemistry of the National Academy of Science of Ukraine", (IEG NAS of Ukraine, PIC Number: 953812253, information about IEG NAS of Ukraine on site: <http://www.igns.gov.ua/>).

State Institute "Institute of Environmental Geochemistry of the National Academy of Sciences of Ukraine" (SI "IEG NAS of Ukraine") is a state (a public research organization, PIC: 953812253) nonprofit scientific institution with the rights of a legal entity.

SI "IEG NAS of Ukraine" is a leading scientific institution dealing with the problems of radioactive waste management, and ecological and radiation safety. The Institute is subordinated to the National Academy of Sciences of Ukraine as a part of the Nuclear Physics and Energy Department.

The Institute staff carries out fundamental and applied research on:

- scientific support of nuclear fuel cycle;
- geochemistry, radiogeochemistry;
- technogenic and environmental safety;
- problems of decontamination of territories and equipment;
- instrument-making in the sphere of nuclear, radiation and environmental safety.

Institute has contributed into development of the scientific basis for long-lived radioactive waste disposal in stable geological formations and technological concepts for creation of barrier materials for ensuring safety of radioactive waste repositories.

Since 2004, the Institute participates in the project "Technologies for the disposal of radioactive waste in underground research laboratories". The Institute supported the scientific program of the European Commission project "European Technology Platform - Implementation of the Geological Waste Disposal" and became its member (<http://www.igdt.eu>).

The Institute was responsible for management many international projects:

- CAST project (CArbon-14 Source Term #604779, 7 FP EURATOM)
- "Feasibility Study for an Underground Repository for Long-lived Non-heat-generating Radioactive Waste in Ukraine" / EUR 17631, Contract № B7-6340/95/001028/MAR/C3/, 1999.

Institute took part in coordinated research projects of IAEA:

- "Extrapolation of short term observations to time period's relevant to the isolation of long-lived radioactive waste ", IAEA-TECDOC-1177, IAEA, 2000;
- "Characterization and performance studies and demonstration in underground research laboratories of swelling clays as engineered barriers of geological disposal", IAEA-TECDOC-1718, IAEA, Vienna, 2013;

Tasks to be performed by the third party:

SI "IEG NAS of Ukraine"- have been involved for many years in the characterisation and modelling of the thermo-mechanical behaviour of bentonite both through Ukrainian and IAEA projects. All the previous research experiments were limited to a temperature of 22°C.

SI "IEG NAS of Ukraine will contribute to work package 7 - HITEC: Task 3.1 Assessment of the impact of high temperatures over long time periods on the clay buffer properties, from specific laboratory tests, two of the materials included in EURAD-1. Task 3.2 of the impact of elevated temperature (> 100°C) on geochemical mineralogical properties of a suite of different bentonites.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

8/ CNRS

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
• Université de Poitiers (UPoitiers) Founded in 1431 by Pope Eugene IV, then confirmed by the patent letters of King Charles VII, the University of Poitiers consists from the outset of five faculties: theology, canon law, civil law, medicine and arts (letters). After the Revolution, which suppresses provincial universities, the University of Poitiers is reborn and enriched with new faculties: letters, sciences ... Today, the University of Poitiers, it is 28000 students, 4000 international students from 136 different countries, 3000 staff, 14 faculties, institutes and schools, 1000 professors-researchers, 1100 doctoral students, 37 laboratories, 8 doctoral schools, 2000 national diplomas, 180 PhD thesis defended each year, 500 partner institutions around the world and 1600 professional speakers participating in the teachings . • The Centre National de la Recherche Scientifique (CNRS) will participate in the EURAD WP Gas project via the IC2MP laboratory which is a Joint Research Unit (UMR 7285) between the CNRS and the University of Poitiers (UP). Thus the University of Poitiers is a third party linked to CNRS. Personnel with permanent positions in this project (Rochard Giot, Stephen Hédan, Baptiste Dazas) are employees from the University of Poitiers (UP). The Institute of Chemistry of Poitiers: Materials and Natural Resources (IC2MP) is a multidisciplinary research institute that specializes in the study of materials, the natural environment, and reactions. The Institute particularly focuses on the synthesis, decontamination and exploitation of natural resources. The Institute is composed of a total of ~250 persons including a staff of 100 researchers (75 faculty members from the University of Poitiers and 25 CNRS), 50 Engineers & Technician staff, ~80 PhD students and ~20 postdoctoral researchers. More specifically, they belong to the research tem E2 "HydrASA" of IC2MP laboratory. The IC2MP HydrASA team's scientific objective is the study of multiscale transfers in surface and sub-surface geosystems. The activities of the team are organized into three themes: - o Functioning of reactive geosystems (soils, sedimentary basins, aquifers, hydrothermal systems and more widely alteration systems), - o Properties and reactivity of clay mineral solutions systems - o Spatialization and multi-scale modeling of reactive transfer. Reactive geosystems refer to a wide variety of natural objects with very different characteristic dimensions: clay minerals and their aggregates (from nanometers to hundreds of microns), clay soil profiles (from centimeters to tens of meters) and large geological systems (from a hundred meters to a hundred kilometers). The general topic of the team is the understanding and modeling of transfers in reactive geosystems, which is based on two strong cognitive issues: the relationship between the different scales of space brought into play through these objects and the integration large time scales (geological time) in its approaches. More specifically, the team is internationally	

recognized thanks to its ability to mobilize multiple skills (mineralogical, crystallochemical, microstructural and geomechanical) for the study of clay media and materials.

Link of the participant to the third party: The University of Poitiers is a co-partner together with the CNRS of the Institute of Chemistry of Poitiers: Materials and Natural Resources.

Tasks to be performed by the third party:

It contributes in WP6 GAS: experimental study of the micro-structural and mineralogical changes of claystones in relation with self-sealing and gas migration on the one hand, and to the micro-macro upscaling and development and implementation of a numerical HM model accounting for gas migration and self-sealing. It fits in the scope of the priorities of the research thematic developed and the IC2MP regarding the understanding of the microstructure of clays and clayey rocks as well as upscaling of their hydro-mechanical properties.

- **Université de Montpellier (UMontpellier)**

Since 800 years, the University of Montpellier (UM) has played important scientific and societal challenges. It is composed of 16 faculties, high schools and institutes. The 78 research units are involved in 9 scientific departments, working in the fields of science and technology, medicine, pharmacy, law, economy, sport and management. The university gathers 48,000 students and 4,800 employees (teachers, researchers and administrative). In the field of chemistry, the research activities are structured in the Pôle Chimie Balard composed by four institutes (Institute Charles Gerhardt, Institute of Biomolecules Max Mousseron, Membranes European Institute and Institute of Separative Chemistry). In particular, concerning the activities devoted to nuclear energy, the University of Montpellier is involved in the Institute of Separative Chemistry of Marcoule (ICSM, Joint Research Unit shared with CEA, CNRS and High School of Chemistry of Montpellier - ENSCM). This institute is involved in several aspects dealing with the nuclear fuel cycle (separative chemistry, nuclear materials, spent fuel reprocessing, waste management,...).

- Since ICSM is a Joint Research Unit (UMR in French) between CNRS, CEA, University of Montpellier and ENSCM, several researchers from the University of Montpellier will be involved in the project. The CNRS will solicit from University of Montpellier, i.e. 1 professor: Nicolas Dacheux and 1 assistant professor: Laurent Claparède, will be involved in the project and will particularly contribute to all the tasks included in the WP Spent Fuel Characterization and Evolution until Disposal.

Link of the participant to the third party: The University of Montpellier is a co-partner together with the CNRS, the CEA and the ENSC Montpellier Institute Max Planck Chemical Physics Solids of the Institute for Separative Chemistry in Marcoule.

Tasks to be performed by the third party:

It contributes in WP8 SFC: UMontpellier will be involved in in the WP Spent Fuel characterization and evolution until disposal (Subtask 3.2. Behavior of SNF pellets under interim storage conditions). The main actions proposed by CNRS and University of Montpellier deal with the development of a micro-/macro-dual approach to examine the role of several families of FP on the behavior of UO₂ sintered samples during leaching tests. The proposed action is divided in 3 parts. The first one focuses on the role of lanthanide elements incorporated in the UO₂ ceramic during alteration (especially in terms of chemical durability and surface reactivity modifications). The second one deals with the role of platinum group metals (PGM) elements (especially as metallic particles) as well as molybdenum present in UO₂. The last aspect will be the role of perovskite type phase on the inventory of the released elements.

- **IMT Atlantique**

The **IMT Atlantique (IMTA)** is leading French engineering school, a public Technical University created on January 1, 2017 through the merger of the École nationale supérieure des mines de Nantes and

Telecom Bretagne, administered by the french General Council for the Economy, Industry, Energy and Technologies.

Research is organized within thirteen departments of teaching and research : Automation, Computer-Integrated Manufacturing and IT (Nantes), Electronics (Brest), Information Technology (Brest), Image and Data Processing (Brest), Languages and International Culture (Brest), The Logic of Practices, Social and Information Sciences (Brest), Microwaves (Brest; Toulouse), Optics (Brest), Subatomic Physics and Related Technologies (Nantes), Social Science and Management (Nantes), Signals and Communications (Brest), Energy and Environmental Systems (Nantes), Network Systems, Cyber Security and Digital Law.

- All tasks of the LTP IMTA in the EJP EURAD will be performed by the department SUBATECH, which is a Joint Research Unit with the CNRS, the IMT Atlantique and the University of Nantes, headed by Dr. Gines Martinez. Principal research subjects of Subatech are in the area of nuclear physics and radiochemistry. SUBATECH has a staff of about 190 engineers, scientists and technicians, including as well post docs and PhD students. Research on nuclear waste management of relevance for the EJP is conducted by the radiochemistry group which consists of a staff of about 40.

Link of the participant to the third party: IMT Atlantique is a co-partner together with the CNRS and the University of Nantes of the joint research laboratory Subatech.

Tasks to be performed by the third party:

- 1) It contributes in Participation in the WP1 PMO
- 2) WP2 ACED : Participation in Subtask 2.1 on Steel/clay material interface reactivity with the characterization of interface experiments and in the Subtask 2.2 on Steel/cement material interface reactivity IMTA participates in the characterization in existing interface experiments between Portland cement or grout cement in contact with steel in saturated conditions and in the subtask 3 (waste package scale), IMTA will support the CEA in the dismantling and characterization of an ongoing Glass/steel/clay experiment (5 year, 50°C) and it supports SCK.CEN in the dismantling and characterization of a glass/steel/cement system experiment, already ongoing since 30 month.
- 3) In the WP10 UNAM IMTA will contribute to the Subtask 2.3 on Methodological approaches to uncertainty and sensitivity analysis and IMTA is the leader of the task 3.1 Subtask 3.1 on the the identification of the types of uncertainties relevant to the safety analysis and the safety case. IMTA will participate also in task 4.3 on Preferences of the different actors on uncertainty management options

Principal actors of IMTA in its role as LTP are:

-Abdesselam Abdelouas (CNRS/IMT-A, male) is Professor of Radiochemistry and Nuclear Materials at IMT Atlantique, and Head of the Radiochemistry Group at Subatech Laboratory, Nantes. He graduated from the University of Strasbourg, and spent a US DoE-funded Postdoc working on radioactive waste management. He was named an Expert for the European Commission in the field of Education & Training for the nuclear sector. He is also Adjunct Professor at Mody University, India. He is coordinator of the recently accepted ERASMUS mundus project SARENA. He will participate in WPs ACED and GAS

-Bernd Grambow (CNRS/IMT-A, male) is Professor of Excellence at IMT Atlantique, Nantes, holding a Chair on nuclear waste disposal and former director of Subatech laboratory. He received his PhD from the FU Berlin, and held research positions at the Pacific Northwest National Laboratory, Hahn Meitner Institute Berlin, and Forschungszentrum Karlsruhe. He is an expert in radiochemistry, nuclear waste disposal science, geochemical modeling, and radionuclide migration in the environment. He will participate in the PMO and in UMAN.

- **Université de Lorraine (ULorraine)**

The Université de Lorraine (UL) is a large multidisciplinary university, open to international collaboration. With more than 3,700 teaching and research faculty and approximately 60,000 students, including nearly 8,000 foreign students, the Université de Lorraine (UL) is one of France's largest

multidisciplinary universities. Its location in the heart of Europe, with borders on three European member states (Germany, Belgium and Luxembourg) offers to UL a privileged position for strong international partnerships. The scientific activity of UL is organized in 60 research laboratories located in 10 scientific centers and 6 research federations covering a wide range of disciplinary fields and topics. In addition, the university houses several technology platforms including large-scale facilities and large measurement instruments, providing research teams with the most efficient equipment. UL is committed to numerous European and international collaborations and exchanges, including multi-partnership projects and initiatives that, in many cases, go beyond European borders. UL is currently engaged in 15 European projects, including the Biomore, Lights, Newores, and EIT Knowledge and Innovation Community Raw Materials (Eurocore, TravelEx), more specifically in the scope of the NEXT program.

- The GeoRessources Laboratory is a Joint Research Unit which brings together Nancy's most important players in the field of Applied Geology having as supervising institutions the University of Lorraine and CNRS. GeoRessources employs a total of 190 personnel and orientates itself around three main research themes:

- "GeoModels" is a meeting-place for specialists in geometrical, geostatistical and physical-process modelling. The objectives are to forge strong collaborations between experts in digital and experimental simulation and to unite geometrical, inverse, hydrogeochemical and mechanical approaches.
- "Raw Materials" is a place for interaction and exchange between experts in the exploration, exploitation and treatment of carbon and mineral resources. Geologists, geochemists, metallogenists and mineralogists can interact freely with one another. The 'Raw Materials' mission is to develop models that explore upstream and downstream resource cycles.
- "GeoSystems" is a synergistic space that hosts experts in underground exploitation for the storage of waste and geothermal energy, as well as specialists in the hazards and risks associated with anthropogenic activity such as mining and excavation. Because the field of resource exploitation is developing like never before, it is essential that specialists from across the different research themes work together in finding new ways to minimize the environmental impact of resource exploitation.

The Geomodels and Geosystems themes conduct interdisciplinary research concerned with the use and management of the surface and sub-surface environment, with a strong focus on the safety of underground structures. Applications address local and national socio-economic issues, including geotechnics, environmental protection, and the surface and sub-surface storage of waste, CO₂ and H₂. The originality of the team's work lies in addressing these issues from the points of view of hydrodynamics and transfer mechanisms, as well as from poro-mechanics and geochemical perspectives.

Scientific goals of the Raw Materials theme concern a better understanding of: i) metals concentrations associated with crustal growth and evolution within the frame of plate tectonics (multimethod approach combining field geology, structural analysis, petrology, geochemistry, geochronology), ii) the processes governing the extraction of metals from rock sources, their transport by fluid phases (speciation, especially through experimental studies, and spectroscopic monitoring, fluid origin), and iii) ore formation (PVTX reconstruction through integrated paleo-fluid studies (microthermometry, Raman, spectroscopy, LA-ICP-MS), thermodynamic and experimental modeling dating of ore stages), the overall data yielding to conceptual and numerical modelling of the genesis of ore deposits within their geologic and geodynamic contexts.

Link of the participant to the third party: The University of Lorraine is a co-partner together with CNRS and the research center CREGU of the GeoRessources laboratory.

Tasks to be performed by the third party:

It contributes in :

- WP2 ACED task 3, UL-GeoRessources, based on its strong experience on solid phase characterisation, proposes to use its platforms to rigorously and finely perform chemical and mineralogical analyses of solid phases coming from the dismantlement of experiments carried out

by SCK/CEN on the Glass(SM359)/Steel/Cement. The goal is to highlight mineralogical transformations in the solid phases and at the different interfaces and to follow the chemical gradients along the materials and linked to the geochemical reactivity of the different phases in contact.

- WP6 GAS: UL-GeoRessources will conduct numerical simulations of multiphase fluid transport through deformable nanoporous geomaterials using a lattice-Boltzmann model applied to FIB-SEM images of actual material. Numerical results will be used to upscale effective properties (deformation-dependent saturation curve, relative permeability). Experiments will be also conducted to follow the evolution of damage and self-sealing processes in the argillaceous rock samples during gas injection and after shut-in using a high-resolution X-ray CT scanner.
- WP7 HITEC UL-Georessources will perform mechanical tests on different clay host rocks (Boom Clay, Opalinus Clay, Callovo-Oxfordian clay) to study the propagation of fractures at elevated temperatures (40 °C, 60°C, 80 °C, 100 °C), characterize fracture shape and size at different loading stages and self-sealing process. Tests will be conducted in a transparent triaxial cell under X-ray nano-tomography, on fractured samples (with two bedding orientations) mimicking the damage expected in the near field.

The short- and long-term thermo-mechanical behaviour of 2 claystones (Opalinus Clay, Callovo-Oxfordian claystone) will be investigated at elevated temperatures (40, 60, 80 and 100 °C). Short-term triaxial tests will allow characterising mechanical properties (failure criterion, elastic coefficients). Thermal profiles will be performed before and after TM tests with the optical scanning method to determine the evolution of thermal properties with damage. Long-term triaxial tests under 2 confining pressures (2 and 12 MPa) will allow characterising creep properties. For all tests, ultrasonic velocities and acoustic emissions will be measured to assess the evolution of elastic properties and then micro-cracking damage.

- **Université de Grenoble (UGrenoble)**

University Grenoble Alpes (UGA) is a public university created in January 2016 that aims to offer high-quality training and education leading to prestigious degrees, diplomas and courses. Regarding research and technology. The research group of ISTerre laboratory has as a long experience on gas sorption (M. Didier PhD thesis (2012) – supervisor L. Charlet; IDEX innovation grant to L. Truche to study H₂ sorption on clay minerals applied to energy storage), clay minerals crystallography (BET, X-Ray, FIB-TEM, ATG-DTG, infer-red spectroscopy, neutron scattering at ILL), and hydrogen experiments (ATEX lab).

- UGA is a Linked Third Party of CNRS for the participation of its employees in the project within the unit ISTerre. ISTerre is a Joint Research Unit between UGA, CNRS, as well as USMB, IRD, and IFFSTAR. ISTerre: 280 pers. including 108 researchers. Rank 18 in Earth Science (Shanghai). 3 main scientific priorities: 1) Understanding earthquakes, landslides, volcanic eruptions and Earth's Magnetic fields, 2) What is shaping the Earth? And 2) How rocks change as a function of natural and human constraints.

Link of the participant to the third party: The University of Grenoble is a co-partner together with the CNRS and the Grenoble INP of the 3SR laboratory and ISTerre.

Tasks to be performed by the third party: It contributes in :

- WP5 FUTURE: Measure hydrogen uptake by clay minerals (e.g. montmorillonite, illite, chlorite, Fe-serpentine) and clayrocks (bentonite, Callovo-Oxfordian claystone and Boom clays) as a function of H₂ partial pressure, temperature, water saturation (relative humidity), and presence of other gases competing for sorption (CO₂, CH₄, He). H₂ sorption isotherms will be measured over a wide range of pressure (typically from 1 mbar to 100 bar) to study the retention mechanisms and fundamental thermodynamic properties of the retention process (adsorption enthalpy, role of pore size distribution, crystallographic properties of the sorption sites).

- WP6 GAS: 2. Study the desorption processes to evaluate hydrogen mobility and retention mechanisms in clay-rich porous media.

Outcomes: 1) amount of hydrogen trapped in the disposal surroundings, 3) stability or reversibility of H₂ sorption with respect to near and far field perturbations (temperature, water resaturation, secondary minerals formation triggered by iron-clay interactions), and 3) positive and negative feedbacks of hydrogen sorption regarding: i) hydrogen overpressure and associated mechanical stress (in connection with tasks 2.1 and 3.1), ii) propagation of a redox front in the geological media, and iii) radionuclides mobility (in connection with WP FUTURE).

- **Université de Nice-Sophia Antipolis (UNice)**

Université Nice Sophia Antipolis is part of Université Côte d’Azur (UCA) which is a recently created cluster of higher education establishments on the French Riviera that brings together the major players in higher education and research on the Côte d’Azur. Université Côte d’Azur aims to develop a new, 21st-century model for French universities, based on new interactions between disciplines, a new form of coordination between research, teaching, and innovation, and strong partnerships with the private sector and local authorities. In January 2016, Université Côte d’Azur won a prestigious “IDEX” award from the French government for its UCAJEDI project, placing it among the top 10 world-class, comprehensive universities in France.

- The LJAD laboratory is a Joint Research Unit between the CNRS and Université Nice Sophia Antipolis (Laboratoire Dieudonné UMR 7351 CNRS), the mathematical laboratory of UCA, is structured around 6 research teams: Algebra, Topology and Geometry Geometry, Analysis and Dynamics, EDP and Numerical Analysis, Numerical Modeling and Fluid Dynamics, Probability and Statistics, Interfaces of Mathematics and Complex Systems. Bringing together 135 researchers and teacher-researchers, 16 administrative staff and research assistance engineers and 74 doctoral and post-doctoral students, the laboratory is also a partner of INRIA, of the CEA (CEA) under the LRC Fusion of the Doctoral School (EDSFA) and participates in many ANR projects. This project takes place in the LJAD team Partial Differential Equations and Numerical Analysis (around 40 permanent researchers and 20 PhD students) which has developed for a few years a group on geosciences applications including 2 permanent researchers, Konstantin Brenner and Roland Masson, and several doctoral and postdoctoral students. CNRS/INSMI/LJAD has specific roles in DONUT.

Link of the participant to the third party: The University of Nice-Sophia Antipolis is a co-partner together with the CNRS and INRIA of the LJAD laboratory.

Tasks to be performed by the third party:

- It contributes in WP4 DONUT to develop an efficient algorithm to couple a nonisothermal compositional liquid gas Darcy flow and a RANS nonisothermal compositional free gas flow. This type of coupled models plays a key role to study the mass and energy exchanges at the interface between the radioactive waste disposal and the ventilation galleries with two main objectives: to improve the modelling of the porous-medium desaturation and to model the variations of relative humidity and temperature in the galleries over a period of say one to two hundred years. A Domain Decomposition Method (DDM) has been developed during the postdoctoral position of Nabil Birgile ended in march 2018 in collaboration with Andra. It has been prototyped on 2D test cases with simple geometry and simple pipe flows with an algebraic turbulent model. The objective is to increase the complexity of the geometry and of the free flow using a code coupling strategy between the porous-medium code ComPASS co-developed by BRGM and LJAD-Inria and the free-flow code CimLib developed by the CFL team of CEMEF Mines ParisTech.

- **Université de Lille (ULille)**

Université de Lille is a public university created in January 2018 as a merging of 3 universities. It aims to offer high-quality training and education leading to prestigious degrees, diplomas and courses with wide disciplinary range.

Regarding research and technology. The research group on numerical analysis and partial differential equations of the Laboratoire Paul Painlevé (LPP, mathematic department) has built a strong expertise in numerical methods that remain accurate in the long time regim for dissipation driven systems, as well as on modeling based on variational principles. The team has a great experience in the certification of the numerical method it designs, thanks to mathematical proofs of stability, convergence and asymptotic behavior.

- LPP is a Joint Research Unit between Université de Lille and CNRS. LPP already experienced contractual collaborations with ANDRA and CEA on the numerical approximation of corrosion models. They particularly focused on the design of schemes implemented on the code CALIPSO which is the ANDRA and CEA reference code for the simulation of the Diffusion Poisson Coupled Model (DPCM) for corrosion.

Link of the participant to the third party: The University of Lille is a co-partner together with the CNRS of the LPP Laboratory.

Tasks to be performed by the third party:

It contributes in WP4 DONUT: Even though the DPCM model is now a well established model for modeling the corrosion process in nuclear repositories, many fundamental questions still remain open. In particular, it is not clear if the model has an energy formulation of generalized gradient flow type as it would be expected in view of the large time scales. Such an energy formulation is key to guarantee the long-time behavior of the model. This motivates the following workplan.

- Task 1: Derivation of the energy, link with the DPCM model, mathematical results of existence of solutions and long-time behaviour of the DPCM model
- Task 2: Development of numerical methods based on the energetic formulation, validation of their energetic stability, study of the long time behavior
- Task 3: Implementation of the new methods in the electrochemical code CALIPSO, validation.
- Task 4: Investigation of the coupling with a reactive-transport model in porous media.

- **Université d'Orléans (UOrléans)**

University of Orleans, a public university, aims to offer high-quality training and education leading to prestigious degrees, diplomas and courses. In this university, the observatory of universe sciences (OSUC) is composed of two main laboratories. Among these, the “Institut des Sciences de la Terre d'Orléans” (ISTO). ISTO is a research laboratory in Earth Sciences, a Joint Research Unit (UMR) depending on three supervisory authorities (the Université d'Orléans, CNRS, BRGM). ISTO is leading two France-scale excellency projects (VOLTAIRE, 2012-2022; PLANEX, 2012-2019), two of the six platforms of one Région-scale excellency project (PIVOTS, Région Centre Val-de-Loire – Europe), the INSU national observatory “SO Tourbières”, and the “Val d'Orléans” site of the national observatory Karst. Our research reaches from Earth's atmosphere and surface to the upper mantle with studies focusing on exchange processes at mantle-crust and crust-atmosphere interfaces. We are organized in five research teams. Among these, Continental Biogeosystem team has a long expertise in unraveling evolution of climates, ecosystems and human activities from organic matter and fossil molecules (biomarkers) preserved in lacustrine sedimentary archives. This team studies the stability of organic molecules, their sorption on clays and their transformation products under different environmental conditions. ISTO is involved, together with BRGM, in a partnership with ANDRA (CTEC and DRO project), to investigate the degradation of organic molecules in cementitious medias.

Link of the participant to the third party: The University of Orleans is a co-partner together with the CNRS of the CEMHTI laboratory (Extreme Conditions and Materials: High Temperature and Irradiation) located at Orleans and the ISTO laboratory.

Tasks to be performed by the third party:

- It contributes in WP3 CORI – Task 1 to study the effect of gamma irradiation on the degradation

of superplasticizers and phthalate in cements and alkaline solutions in partnership with BRGM. The media considered would be alkaline (pH 12.5) in synthetic cement solutions. The various degradation media will be selected so as to form a consistent experience plan considering the following parameters: concentration of the molecule, redox conditions, nature of the alkaline/calc-alkaline cation and dose rate (1 kGy/h and 0.1 kGy/h). Degradation tests will be conducted on both irradiated and non-irradiated molecules and monitored as a function of time, up to 6 months. Analyses will be performed for the initial molecule and their degradation products. Degradation rates will be extracted from the experiments results, together with the production rates of the degradation products. ISTO beneficiaries from a cutting-edge organic geochemistry platform allowing bulk, molecular and isotopic characterization in a wide set of matrices and is able to develop detection and quantification methods adapted to a large range of organic molecules.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

9/ COVRA

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
Delft University of Technology (TU Delft) With approximately 23,500 students and 5,200 staff, Delft University of Technology (TU Delft) is the largest university of technology in the Netherlands. The university covers virtually the entire spectrum of engineering sciences, divided across 40 departments in 8 faculties, and it offers an equally broad, high-quality array of degree programmes and unique facilities. The mission of the university is to contribute to solving global challenges by educating new generations of socially responsible engineers and expanding the frontiers of the engineering sciences. Description of the link between COVRA and TU Delft (including scientific and technical scope) COVRA have since 2012 sponsored the Faculty of Civil Engineering and Geosciences at TU Delft for work relating to research and education in the area of radioactive waste management. Several projects have been conducted within this scope of both national and international significance. A memorandum of understanding has been signed recently (between COVRA and TU Delft) to develop the relationship into a long term collaboration, with a focus on the following areas: • Investigation of technical feasibility of constructing a radioactive waste repository in the Netherlands. • Investigation of sub-surface layers (Boom Clay and other clay layers, and salt deposits). • Investigation of multi-physics processes occurring within a radioactive waste repository. • Education. Involvement of the TU-delft in GAS and the tasks to be performed (5-10 lines maximum) TU Delft is involved in three subtasks of the workpackage GAS, namely 2.2 (Advection), 3.3 (Model-based interpretation and synthesis of results) and 4.2 (Model assisted assessment of gas induced effects). In these subtasks, TU Delft will numerically investigate (using the FE code LAGAMINE) the effects of natural heterogeneities and induced discontinuities (able to self-seal) on the gas transfer mechanisms. TU Delft will back analyse laboratory experiments in order to feed in the development of a conceptual process model of gas-induced damage evolution and self-sealing processes for damaged or intact host rocks and EBS materials. Validation of this model will take place in a series of prediction-evaluation exercises, covering different loading paths in different geometric configurations. TU Delft will finally apply their numerical approach to a generic repository configuration with different sets of properties, conditions and	

scenarios. TU Delft will work with other partners in the EURAD project, who will also use the same computer code to harmonise the research efforts, and with partners inside and outside the project (where needed) to select appropriate experimental cases.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

10/ FTMC

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

11/ CV REZ

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

12/ DEKOM

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

13/ EEAE

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

14/ ENRESA

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	Y
ENRESA plans to subcontract certain task to ENUSA and UDC. The subcontractors have been selected in accordance with the requirements of Article 13 of the grant agreement. Total budget of ENUSA: 208 750,00 € Total budget of UDC: 229 852,50 € <u>WP SFC</u> ENRESA will subcontract with ENUSA for Task 2: Fuel properties characterization / Develop, improve and demonstrate NDA methods/systems for SNF characterization. The contribution of Enusa to Task 2 will include the nuclide inventory by radiochemical analysis of a set of BWR SNF samples irradiated to an average burn-up of above 40 MWd/kgU, covering a range of initial enrichment and coolant void histories, as well as the modelling with SCALE and estimation of uncertainties. <u>WP ACED:</u> Task 1; State of the art. The contributions of UDC as subcontractor include: Task 1: 1) The compilation of previous modelling studies and 2) The identification of the remaining model uncertainties on the mineralogical alteration at the carbon steel/bentonite interface and 3) The proposal of a revised conceptual and mathematical model for the carbon steel/bentonite interactions which will be useful for other tasks of the WP Task 2: UDC as subcontractor will perform multicomponent geochemical reactive transport models (RTM) under saturated and unsaturated conditions of steel/bentonite laboratory experiments. The models will account for time-varying corrosion rates depending on ambient conditions (T, pH, Eh) and will be based on the revised conceptual and mathematical model of the steel/bentonite interactions identified in Task 1. The main outcomes include: 1) Improving the understanding of the dependence of the corrosion rate and the bentonite mineralogical alterations on thermal, hydrodynamic, solute transport and geochemical conditions; 2) Gaining confidence on RTM of the steel/bentonite interactions; and 3) Reducing the uncertainties of RTM. The outcomes of this task will be most useful for the modelling at the disposal cell scale (Task 4). Task 4 UDC as subcontractor will perform multicomponent geochemical reactive transport models (RTM) of steel/bentonite, bentonite/concrete and concrete/clay interactions for a HLW repository in clay host rock and of steel/bentonite, bentonite/granite interactions for a HLW repository in granitic host rock. The model will be based on the revised conceptual and mathematical model of the steel/bentonite interactions identified in Task 1 and will incorporate the knowledge gained from the laboratory experiments of Task 2. The main outcomes include: 1) Improving the understanding of the geochemical evolution of the repository and the role of thermal, hydrodynamic, solute transport and geochemical conditions; 2) Gaining confidence on RTM; and 3) Reducing the uncertainties of RT	

<u>WP DONUT</u> Task 4: UDC as subcontractor will contribute with innovative numerical methods for uncertainty and sensitivity analysis for coupled THC models (nonisothermal reactive transport models). The proposed methods include: 1) Adjoint-state methods and 2) Uncertainty quantification (UQ) methods. The main outcome of the UDC contribution is the development of innovative numerical methods for uncertainty and sensitivity analysis for coupled THC models. Task 5: UDC as subcontractor will contribute with benchmark test cases for the evaluation of the numerical tools and methods for coupled processes of relevance for the performance assessment of the engineered barrier of ILW and/or HLW repositories. The main outcomes of the UDC subcontractor contribution include: 1) Evaluation of the methods and tools derived in other tasks and 2) Evaluation of the efficiency of the numerical methods in terms of CPU time, ability to deal with large and complex problems at the disposal scale, comparison of multi-scale approaches and model uncertainties.	
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

15/ JUELICH

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
Part of the work will be performed by linked third parties, namely: (1) Helmholtz Zentrum Dresden-Rossendorf, HZDR, (2) Helmholtz - Zentrum für Umweltforschung GmbH, UFZ. The link of the participant to the above listed TLP is their membership to the Helmholtz Association of German Research Centers, which was founded in 1995 and is today one of the leading research organizations worldwide. The Helmholtz Association is a registered association of eighteen (18) legally independent research centers, funded by the German Federal Ministry of Education and Research (BMBF). The activities of the Helmholtz Association are governed by its statutes. With its programme-oriented funding (POF) system, in which cross-center research programs compete with one another for funding, the Helmholtz Association performs cutting-edge research in six research fields: Energy, Earth & Environment, Health, Aeronautics, Space and Transport, Matter, and Key Technologies. Further, the Helmholtz Associations enables research using their large-scale devices and infrastructure, cooperating closely with national and international partners. Helmholtz Zentrum Dresden-Rossendorf, HZDR (PIC: 999470541) is a non-profit research organisation and a member of the Helmholtz Association of German Research Centers. It is funded by German Federal and Saxonian Authorities. HZDR is dealing with application-oriented basic research, focused on three major research fields: matter, energy, and health. It has been collaborating with JUELICH in various national and international projects. Within the national program HZDR and JUELICH are interlinked via the research program Nuclear Waste Management, Safety and Radiation Research (NUSAFE). WP CORI: HZDR will study the influence of small- to middle-size organic molecules (EDTA, ISA and gluconate as reference) on the retention of radionuclides (U(IV, VI), Cm(III), Am(III)) by cementitious	

material (CSH, CASH) by the mean of complexation and batch sorption experiments. WP Spent Fuel: The local structure of the U oxides and of the FP secondary phases will be accurately determined by EXAFS and synchrotron XRD. WP DONUT: HZDR will deliver uncertainty quantifications and probability density functions for a variety on physico-chemical processes within THMC relevant et near and far field of a nuclear waste repository. This will be accompanied by the development of respective robust models. WP FUTURE: HZDR will carry out PET/ μ CT measurements using fractured samples with conservative and reactive tracers, interferometry/ confocal microscopy measurements of fracture surfaces, and petrographic analysis. In addition. The HZDR will perform sorption experiments, spectroscopy analyses, surface potential analyses, radiography analyses, and data reduction using the smart Kd concept. WP Strategic studies Uncertainties: HZDR will contribute to Subtask 2.2 by coordinating the work, organizing and participating in technical meetings, contributing to the compilation, assessment and improvement of approaches for the characterization and quantification of uncertainties associated with THMC models and leading the writing of the deliverable. KM WP - State-of-Knowledge: The HZDR together with the BGE are responsible for coordinating the EURAD Knowledge Management Platform, which is an Open-source knowledge sharing tool (IT system and associated management procedures) for organising and capturing key sources of knowledge on radioactive waste management.

Helmholtz - Zentrum für Umweltforschung GmbH, UFZ (PIC: 999994632)

The UFZ is one of the world's leading research centres in the field of environmental research, enjoying high social recognition. It demonstrates ways in which a sustainable use of our natural resource base is possible for the benefit of both humankind and the environment. In the energy sector (resources and waste management), the spectrum of topics covered ranges from process modelling and simulation through the development of innovative monitoring strategies to the investigation of socio-economic aspects. The Department of Environmental Informatics (ENVINF) is developing numerical methods and software components for simulating coupled processes in porous media based on the finite element method. In addition, questions of the development of simulation platforms for the treatment of these problems as well as the benchmarking for model and software validation also take up wide space. An integral part of these platforms are workflows and system components for the 3D visualization of complex, heterogeneous data from different sources. In this context, the ENVINF acts as the lead developer and coordinator of OpenGeoSys, the international scientific open source software project. In addition to method and software development, there is a strong relationship to applications in hydrology, geotechnics and energy storage research.

WP DONUT (Task 3): The UFZ Team will develop numerical multi-scale scheme for coupled processes able to link different simulators as well as develop and test parallel execution capabilities. WP GAS (Task 3): UFZ together with BGE, BGR will employ and extend the open-source software OpenGeoSys, in which localization can be described using enriched approximation spaces, non-local elasto-plasticity or phase-field models of fracture. Together with existing multi-phase flow and swelling formulations, these models will be used in the modelling tasks described above. Random-field initialization will be used to trigger localization. WP ACED (Task 4): The UFZ team contributes to the methodology comparison and also inter-code benchmarking of reactive multiphase transport process relevant to the ILW at the scale of a waste repository. Together with PSI they will carry out simulations on the chemical evolution and gas/water mass balances in waste packages containing metallic and/or organic waste with the GEM-Selektor chemical modelling package and OpenGeoSys-MP-LT, a multi-component two-phase reactive code developed in cooperation with UFZ Leipzig.

Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

17/ INPP (IAE)

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

18/ ICHTJ

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

19/ IRSN

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
IRSN envisage that part of its work will be performed by 3 linked third parties : Mutadis, NTW and MINES ParisTech Mutadis is an independent research organisation specialized in the area of the governance of activities entailing risks for people or the environment as well as in the field of ecological, economical & societal Transition. It operates for public and private organizations. Mutadis has a long-standing expertise and field experience regarding interaction between civil society and technological processes (in the context of decision-making, expertise processes and research) in the French, European and international context since 1990. Mutadis had a role of methodological expert and facilitator of interactions with the Public in many research, surveys, and field projects. Mutadis has also developed projects and research regarding the	

adaptation and transformation of legal and institutional frameworks, in order to create the conditions for a permanent and influential participation of Civil Society Organisations and local communities in the governance of activities associated with risks and impacts on health and environment (notably on the ground of the Aarhus Convention - 1998). In France, Mutadis has been cooperating with IRSN in the field of health, food, environment and work hazards, in order to propose a vision and tools for the governance of expertise processes, and their approaches regarding stakeholders' involvement.

Link of the participant to the Third party: Since its creation, Mutadis has developed numerous research projects and partnerships with IRSN in the two last decades. Currently, a research partnership between Mutadis and IRSN, that began in September 2017, focuses in particular on structured dialogue tools facilitating interactions between experts and civil society on the field of Radioactive Waste Management. Mutadis also cooperated closely with IRSN in the context of the European projects SITEX (2012-2013) and SITEX-II (2015-2017) coordinated by IRSN, by providing its expertise, as Work Package leader, on governance and understanding of the socio-technical issues involved in the implementation of geological disposal, by developing a specific interaction model enabling meaningful engagement of civil society representatives in the context of RD&D on radioactive waste management and by developing a tool for pluralist dialogue on these issues. Together with IRSN, Mutadis was also partner of the European R&D project JOPRAD and contributed to the development of a participatory framework of governance for consideration by the future EURAD proposal. Mutadis, as a representative of the Civil Society function, is also member of the SITEX.network association that is chaired by IRSN.

Tasks to be performed by the LTP:

- 1- Mutadis will carry out the work in the task 5 of the Strategic Study WP – Uncertainty Management multi-Actor Network (UMAN). The work will consist in gathering views and contributions from a pluralistic stakeholder group on Uncertainty Management. The task will be organised through seminars gathering pluralistic stakeholder groups (task 5.1). Mutadis will also coordinate the contribution of stakeholders from the public and CS experts participating in specific subtasks of Tasks 2 to 4 (task 5.2).
- 2- Mutadis will also lead task 8 of the Programme Management Office (PMO), dedicated to the coordination of CS contribution within EURAD. It will ensure the finalisation of the composition of the CS group involved in EURAD. It will contribute to the organization of a yearly workshop as part of EURAD annual meeting (involving the participation of the CS group, the CS experts together with a panel of WMO, TSO and REs from the different WPs). Mutadis will also ensure the subtask “*Assessment of the experimental model of Interaction between EURAD participants and Civil Society*”.

Nuclear Transparency Watch (NTW) is a European network that promotes a citizen watch on nuclear safety and transparency. The European network Nuclear Transparency Watch has been created in order to promote transparency and vigilance on nuclear safety issues and increase the contribution of civil society in the governance of nuclear activities, raise awareness among policy makers and European society about the need for transparency on nuclear decision-making processes at the local, national and European level. The network was launched in 2013 after a Public Call of Members of the European Parliament from different Political Parties. The action of Nuclear Transparency Watch is regarding most activities of the nuclear cycle: nuclear safety, ageing of NPPs, life-time extension, new build, emergency preparedness and response, post-accident management (including liability issues), radioactive waste management, decommissioning, etc.

Link of the participant to the third party: NTW is member of the SITEX.network association chaired by IRSN, that results from SITEX and SITEX-II European projects, in which civil society experts, members of NTW, collaborated with IRSN as research partners of SITEX II, in order to develop experimental interactions between institutional experts (expertise function) and civil society (society function). Since 2013, NTW also coordinates, together with the DG-ENER of the European Commission, the second phase of the Aarhus Convention & Nuclear (ACN) process where IRSN is involved. The ACN process is regarding the concrete implementation of the Aarhus Convention Principles in the nuclear field in the European Union. It involves the organisation of pluralistic roundtables at European level, gathering concerned stakeholders of European countries (operators, regulators, institutional experts, civil society

representatives).

Tasks to be performed by the LTP:

- 1- In the strategic study ROUTES, NTW will be Task 7 leader. It will provide CS experts involved as partners in WP activities, and will gather the contribution from CS larger group. The objectives of this task are NTW will also contribute to the UMAN WP, see MUTADIS task 1..
- 2- NTW will contribute to the task 8 of the Programme Management Office, dedicated to the coordination of CS interactions within EURAD. In order to organize the general session of a annual workshop in the frame of the EURAD Annual meetings, NTW will translate the results of the scientific/technical WPs to the CS group during the session and gather CS views on future EURAD activities. NTW will provide a small team of CS experts dedicated to this task and will work together with representatives from WMOs, TSOs and REs from the different WPs. NTW will also ensure the administrative work related to the invitation and reimbursement of the CS stakeholders.

MINES ParisTech

The graduate school MINES ParisTech (www.mines-paristech.eu) is one of the oldest French higher education institutions in engineering. The Geosciences Department of MINES ParisTech is dedicated to all the research and teaching activities in the field of earth, geo-engineering and environmental sciences. In particular, the Geosciences Department has a great expertise in numerical modelling of hydrogeological and geochemical processes applied to the geological disposal of radioactive wastes.

Over the last two decades, IRSN and MINES ParisTech collaborated on the following projects:

- Clay/concrete interactions (3 joint publications, co-supervised Ph.D. of P. Lalan –collaboration agreement IRSN /LS 11862)
- Concrete carbonation modelling (Post Doc N. Seigneur 2013 – 2016 - collaboration agreement IRSN/LS 20506)
- Iron/concrete interactions (2 joint publications, 1 co-supervised Ph.D.)
- Study of the oxidizing transient (1 joint publication)
- Numerical modelling of these interactions at long term (2 joint publications).

All these matters are highly relevant for the study proposed by IRSN (iron/concrete/clay interactions) as part of the WP chemical evolution.

In ACED WP, the collaboration between IRSN and MINES ParisTech will be part of task 2 (reactivity at the interface scale) and task 4 (disposal cell scale). The core approach of MINES ParisTech will be reactive transport modelling (RTM) with the HYTEC code. This code is developed in MINES ParisTech in partnership with IRSN since 2000.

In task 2, MINES ParisTech will do the RTM of the experiment on steel/concrete interface (IRSN) and of the experiment on steel/bentonite interface (Uni Bern); to discriminate the most relevant reactive pathways, develop a solid solution of Fe-solid phases and provide parameters for up-scaling the temperature and heterogeneity effects. One main outcome will be to provide the bases for up-scaling the RTM to waste package and near-field of HLW disposals.

In task 4, MINES ParisTech will do the RTM to assess of sensitivity to heterogeneities and temperature gradient (evolving with time) of the long-term chemical evolution of a reference HLW disposal cell by two-phase reactive transport modelling, partly based on the up-scaling of the modelling of steel/bentonite and steel/cement experiments (task 2). These RTM results will be useful for the more abstracted models and performance assessment of TSO such as IRSN.

Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

20/ IST-LPSR

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

21/ IST-ID

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

22/ JSI

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y

EIMV

The EIMV – Elektro inštitut Milan Vidmar is the leading Slovenian engineering and scientific research organisation acting in the area of electric power engineering. It has a long tradition in operation and, in 2018, it celebrates its 70th anniversary. The EIMV addresses the issues of generation, transmission and distribution of electricity from the technological, environmental and economic perspective. The experts at the institute prepare feasibility and implementation studies, expert reports, they implement technological, environmental and other analyses, inspect the quality and operation of electric power systems and facilities as required by electric power utilities, ministries and national as well as regional authorities. The staff of EIMV also performs research and analyses in relation to different aspect of ionizing radiation, work on use of nuclear energy, radioactive waste management, emergency preparedness and response, and different applications of nuclear technology. The institute also implements R&D projects in the EURATOM frame (Horizon 2020) and regional levels, which are developed from idea to their realisation.

The EIMV is also one of the Technical Support Organisations (TSOs) licensed by the Slovenian Nuclear Safety Administration (SNSA), the Nuclear Regulatory Authority (NRA) in Slovenia. EIMV provide opinions with regards to specific issues related to radiation and nuclear safety. The EIMV's license covers all related fields linked to nuclear safety and radiation protection of nuclear and radiation facilities and radioactive waste repositories. On the basis of extensive practical experience, the EIMV coordinates preparation of the expert opinion for refuelling and maintenance outage for the Krško NPP (NEK) where it organises the work of authorised institutions involved in the evaluation of implemented works during the outage. EIMV also provides, as the TSO, expert opinions for NEK in specific fields, such as maintenance and changes related to the main and emergency diesel generator, power and auxiliary transformers, cables, high voltage motors, control and protection systems and other equipment in the high voltage switchyard. EIMV likewise performs authorised expert opinions in collaboration with other institutions for activities

which combine various topics (e.g. establishment of Emergency Control Room, Dry Storage for Spent Fuel, ...). Lately, EIMV has also been involved in the evaluation of licensing documentation for radioactive waste repository in Slovenia.

EIMV will contribute to several WPs in the EURAD:

In ROUTES the technical data on different radioactive waste types will be provided for Slovenia and all input information of different waste management routes will be collected and analysed. EIMV will be also involved in the interaction with civil society.

In UMAN the contribution to common understanding among the different categories of actors on uncertainty management for RWM will be addressed by EIMV. EIMV will contribute to analyses and mitigation procedures on activities related to risk & safety.

In KM, EIMV will participate mainly in the WP on Guidance where it will contribute to identification of topics for early-stage of RWM programmes and development of guiding documents.

EIMV will also be an organisation, which will be involved in Interaction with Civil society activities, in the SFC WP and in ROUTES WP, but also in the coordination of CS group.

ZAG

Slovenian National Building and Civil Engineering Institute (ZAG) is the leading research and testing institute of its kind in Slovenia. It is a state-owned, independent, impartial and non-profit organization, which fulfils all the requirements of the EEC Council Directive No. 89/106 regarding approval bodies, which carry out the testing and attestation of conformity of construction products. The main activities of ZAG are: research, quality assurance programs, and testing and assessment in the fields of building materials, structures (buildings and infrastructure) and geotechnics. For the last 20 years, ZAG has been involved in development of new highly efficient and sustainable construction materials and structures and infrastructure construction, including building energy efficiency, and has been the leading independent quality control and counselling organization. It has been developing and implementing tools for efficient inspections of structures and infrastructures' asset management, monitoring and safety assessments, evaluation of material degradation processes, and rehabilitation for many decades. ZAG performs comprehensive research of the waste material into the various possibilities for its use in the construction industry. ZAG employs 178 researchers, among them 40 PhD and it has approximately 10 million EUR of turnover. In the field of tasks deriving from the CPR (Construction Product Regulation) it has two independent services: the Certification Service and the Service for Technical Assessments, the latter including also system for issuing Environmental Products declaration. ZAG is involved in the international co-operation in science and technology with institutions from the EU, the USA and other countries. Over the last 10 years ZAG has participated in more than 60 projects funded by the EU (4th - 7th FP, H2020, LIFE, and EIT Raw Materials).

ZAG will contribute in ACED: in task 2 by an in-situ monitoring of corrosion of steels in their ongoing experiments and potentially in the new experiments proposed by IRSN (NE2-2/1) and to assist at the identification of corrosion type, rate and corrosion products. In task 3 ZAG will provide the test fields at three hydroelectric dams on Drava River in order to get reliable samples of concrete in different locations of saturated zone of the dams. Laboratory investigation of samples in terms of microstructure characteristics.

Does the participant envisage that part of its work is to be performed through financial support to third parties	N

Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N

Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

23/ JRC

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N

Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

24/ KIT

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
The link of the participant to the listed LTPs is an: AGREEMENT FOR COLLABORATION ON THE FIELD OF MANAGEMENT AND DISPOSAL OF RADIOACTIVE WASTE Between Karlsruhe Institute of Technology (KIT) and: - University of Potsdam, Am Neuen Palais 10, 14469 Potsdam, represented by the President; Executing Unit: Institute for Chemistry, Apl. Prof. Dr. M. Kumke - Clausthal University of Technology, Adolph-Roemer-Straße 2a, 38678 Clausthal-Zellerfeld, represented by the president; Executing Unit: Institute for disposal research, represented by Prof. Dr. Klaus-Jürgen Röhlig - Johannes Gutenberg-University Mainz, represented by the President, Prof. Dr. Georg Krausch, Saarstr. 21, 55122 Mainz; Executing unit: Institute for Nuclear Chemistry, Contact: Prof. Dr. Tobias Reich - Federal Republic of Germany, represented by the Federal Minister of Economic Affairs and Energy, who in turn is represented by the President of the Bundesanstalt für Materialforschung und -prüfung (BAM), Unter den Eichen 87, 12205 Berlin - Federal Republic of Germany, represented by the Federal Minister of Economic Affairs and Energy, who in turn is represented by the President of the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Stilleweg 2, 30655 Hannover - Amphos 21 Consulting S.L. Passeig de Garcia i Faria 49-51, 1-1. Barcelona E08019 Spain - PreussenElektra GmbH, Tresckowstrasse 5, 30457 Hannover, Germany University of Potsdam: WP CORI The research entity University of Potsdam (Physical Chemistry, UPPC) is a collaborator for more than a decade investigating the interaction of actinides (lanthanides) with key components of the near as well as the far field of a potential repository for nuclear waste. UPPC has its core competence in the development and application of high-end laser-based spectroscopy in the spectral and time domain. UPPC has (and is currently) been participating in national research projects on radioactive waste storage managed by the PTKA-WTE. Experiments performed at UPPC aim to improve the molecular understanding of organics-radionuclide complexes interplay with calcium-(aluminium)-silicium-hydrate phases (CSH, CASH) in order to strengthen the knowledge on the mobility of radionuclides under hyperalkaline conditions in cementitious environments under consideration of the redox state. The organics may be originating from the degradation of organic additives (cement components) or from polymers of waste components. The redox state +IV, +V as well as +VI will be investigated using novel (to be developed) spectro-electrochemistry techniques for speciation (time-resolved emission as well as absorption techniques). Additionally experiments on the redox state +III are performed as well. The cement phases considered are of CSH and CASH type. Investigations deal with the competition between organic ligands (e.g., ISA, phthalate etc.) in solution and sorption sites on cement phases (CSH, CASH) as well as the possible formation of ternary complexes with organics acting as partners. The influence of elevated calcium or sulphate concentrations (e.g., calcium as	

intrinsic cation contained in the system may act as a potential partner in the formation of mixed multicomplexes) will also be addressed. Investigation of the competition between organics and cementitious system for radionuclides (in different redox states) as well as the alteration of the cementitious system due to the presence of organics and the subsequent effect on the sorption/release of radionuclides are in the focus of the experiments performed at UPPC.

University of Mainz: WP CORI, FUTURE

The Johannes Gutenberg University Mainz (JGU) is one of the ten largest universities in Germany with about 31,500 students from about 120 nations. Teaching and research activities of JGU's Institute of Nuclear Chemistry (JGU-INC) cover the full range of nuclear chemistry and radiochemistry. In particular, JGU-INC has performed research activities in the field of management and disposal of radioactive waste for more than twenty years and is currently the coordinator of the joint national research project GRaZ (Geochemical retention of radionuclides on cement alteration phases) that has been funded by BMWi and managed by PTKA-WTE since 2015. About 50 bachelor, master, diploma, and graduate students are working in JGU-INC.

JGU-INC has the necessary infrastructure (controlled areas, inert gas glove boxes etc.) to work with all actinides, including Np and Pu. In addition to the standard radioanalytical techniques, the research reactor TRIGA Mainz and sophisticated equipment (XPS, TOF-SIMS, Laser-SNMS, ICP-MS, CE-ICP-MS, and RIMS) are available for investigations. JGU-INC has also vast experience in synchrotron-based X-ray techniques (XANES, EXAFS, μ -XRF, μ -XRD).

The contribution of JGU-INC to CORI aims at extending the knowledge about the effects of organics on the mobility of radionuclides in cement-based systems. In order to obtain a mechanistic understanding of the radionuclide interactions with cementitious phases, batch and diffusion experiments will be combined with speciation studies. The focus of these investigations will be on tri- and tetravalent plutonium (Pu). The cementitious phases will include pure cement preparations (HCP – CEM I) and cement phases (CSH). For investigating possible effects of organics on the Pu mobility, strong complexing organic agents as prioritized in Task 2 of CORI, i.e., isosaccharinic acid, phthalate, EDTA, and short-chained carboxylic acids, will be employed by JGU-INC.

Within FUTURE JGU-INC will address the role of the different mineral constituents of argillaceous rocks (Opalinus Clay) on the mobility of actinides (Np, Pu), which is governed by diffusion and sorption processes. There are open questions on whether redox transformations and sorption of actinides during their diffusion in intact clay rocks are decoupled, subsequent, and spatially separated processes involving several mineral phases or are related mostly to a particular mineral phase.

The combination of speciation calculations (Pourbaix diagrams based on Eh and pH measurements, thermodynamic database) with simultaneous speciation measurements both in solution (CE-ICP-MS) and on the solid surface (XPS, XANES, EXAFS) will provide the basis for developing a unified and complete model of the sorption of Np and Pu on mineral phases considered in FUTURE. Application of techniques with high spatial resolution to heterogeneous natural clay, the identification of most reactive mineral phases responsible for sorption and retardation of Pu and Np, and determination of diffusion parameters from nondestructive measurements are unique and beyond the state-of-the-art.

University of Clausthal: WP UMAN

Clausthal University of Technology – Institute of Disposal Research (TUC-IELF):

The Institute of Disposal Research (IELF) is the only university institute in Germany dealing with radioactive waste disposal in research and education in a comprehensive way.

Interdisciplinary research concerning site characterisation, site investigation, geotechnical barrier systems, and safety cases takes place in the departments of

- Geochemistry-Mineralogy-Salt Deposits,
- Geomechanics (co-opted department),
- Hydrogeology and Hydrogeochemistry,
- Mineral Resources,
- Repository Systems.

The planned research will be carried out by the Department of Repository Systems, which is active in the research areas of Safety Assessment Methodology, probabilistic methods and sensitivity analysis as well as of socio-technical issues related to radioactive waste disposal (co-ordinator of the interdisciplinary ENTRIA

project s.o.).

TUC-IELF plans to contribute to the Uncertainty Management multi-Actor Network (UMAN):

- It will become the responsible organisation for Subtask 2.3 – Methodological approaches to uncertainty and sensitivity analysis: TUC-IELF will coordinate the work, organize and participate in technical meetings, share their experience with uncertainty and sensitivity methods and write the deliverable.

Since CEC's PAMINA project, TUC-IELF has taken a leading role in the field of sensitivity analysis (SA) methodology, contributed to deriving a holistic view of SA methods, and developing numerically efficient approaches. It is therefore excellently qualified for the task.

- Subtask 5.1 – Preparation, support and reporting of pluralistic analyses: TUC-IELF will be leader of Topic 1 and coordinate the development of materials to be discussed in seminar 1. TUC-IELF will lead the development of deliverable D5.1. TUC-IELF will also take part to Topic 4, contributing to the development of proposals of methods for a pluralistic assessment of uncertainties.

Due to its co-ordination role in the interdisciplinary research project ENTRIA and its leading role in several OECD/NEA activities at the interface of social, natural and engineering sciences in the area of repository development and safety cases (jointly carried out by the working parties IGSC and FSC), TUC-IELF has excellent prerequisites for carrying out the aforementioned tasks.

Bundesanstalt für Materialforschung und -prüfung (BAM): WP Spent FUEL

The Bundesanstalt für Materialforschung und -prüfung (BAM) is a senior scientific and technical Federal institute with responsibility to the Federal Ministry for Economic Affairs and Energy. It tests, researches and advises to protect people, the environment and material goods. BAM sets and represents high standards for safety in technology and chemistry for Germany and for its global markets, to further develop the successful "Made in Germany" culture of quality. BAM fulfils this role through its dedicated employees. According to its founding decree, BAM is responsible for the

- further development of safety in technology and chemistry,
- implementation and evaluation of physical and chemical tests of materials and facilities, including the preparation of reference processes and reference materials,
- promotion of knowledge and technology transfer within the BAM's areas of work,
- cooperation in the development of statutory regulations, for example concerning the setting of safety standards and limits,
- advice to the Federal Government, industry, and national and international organisations in the fields of material technology and chemistry.

Five focus areas provide thematic platforms that structure the work. At the same time, they serve to make visible BAM's contribution to politically, socially and scientifically important topics. Within the focus area Energy the Radioactive waste Disposal is one specific area of expertise BAM is addresses for several decades. Major topics include safety evaluation and approval of all kinds of containments for transportation and storage of radioactive materials. Materials research and testing, component testing and up to full-scale container drop or fire testing are major competences as well as numerical simulation techniques to evaluate and demonstrate container safety.

The foreseen task BAM will contribute focuses on the integrity of spent nuclear fuel rods affected by thermo-mechanical conditions as well as fuel/cladding chemical interaction. BAM plans the numerical calculation of initiation fracture toughness for Zirlo in the initial elastic region or just shortly after passing this region in the ring compression test (RCT) on the basis of measured load-displacement curves, correlated observed distribution of hydrides, and postulated initial macroscopic cracks. As major outcome a fracture mechanics based failure criterion shall be developed. The gained knowledge base shall provide the basis for an extension to other and also irradiated cladding materials to evaluate fuel cladding integrity under mechanical loads during container operation and also under accidental loads.

Bundesanstalt für Geowissenschaften und Rohstoffe (BGR): WP HITEC, GAS, DONUT

The Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) is the national geoscientific authority providing advice to the German Federal Government in all geo-relevant questions. It is subordinate to the Federal Ministry for Economic Affairs and Energy (BMWi). Since more than 30 years BGR significantly contributes to all geoscientific tasks and undertakings to realize an underground final repository for radioactive waste.

At a constantly high qualitative and quantitative level about 100 BGR experts to perform this research and consultancy tasks. BGR has been advising the national commission on “Storage of High-level Radioactive Waste” since 2014. Due to their comprehensive research activities in the field of radioactive waste disposal, BGR has made numerous expert contributions since the first meeting of the commission, including lectures, data sheets, review articles and data collections. Topics included geoscientific criteria for repository projects in other countries, and easily understandable facts on e.g. claystone research.

BGR is represented in well-established international working groups (OECD/NEA) on potential host rock formations, informally known as the [Salt Club](#), the [Clay Club](#) and the [Crystalline Club](#).

The internal structure of the depository research in BGR is optimized for the upcoming tasks related to the Site Selection Act in Germany (StandAG) and comprise of e.g. providing geological maps or catalogues on the distribution of potential host rock formations (salt structures, claystone, crystalline rock formations) in Germany, geological-geotechnical exploration including the development of 3D-geological models, THM-rock and geotechnical barrier material characterization on laboratory and on in-situ scale, long-term safety (scenario development and analysis) and geotechnical safety analyses (THM numerical scenario studies).

The types of typical BGR research projects span from i) in-house-initiated, focused projects (e.g. updates/progress and synthesis reports of former studies), ii) initial research projects (methodological developments, feasibility studies, etc.), iii) projects assigned by federal institutions (BfS/BGE) related to explicit existing minesites (Asse II or Gorleben) or repositories (Konrad and Morsleben) in Germany or on international ground (Bure/FR, Aspö/SE, WIPP site/US, Beishan/CN, ect.), iv) mid- and long-term projects with relevant partners on a national level and v) international projects with high visibility (e.g. EU-project coordinator of PEBS (Performance of Engineered Barrier Systems), funding organization of DECOVALEX.org, Mont Terri consortium member since 1996). Stringent project and quality management systems with regular internal and external audits facilitate resource efficiency, strategic disposition and constrain the professional performance.

BGR will contribute to two work packages: a) The impact of elevated temperature ($> 100^{\circ}\text{C}$) on geochemical mineralogical properties of a suite of different bentonites (HITEC) and b) the impact and quantification of advective gas transport on the barrier integrity and barrier performance (GAS). In both these research areas BGR staff have significant share in the international knowledge development in the past decades (LOT, ABM1, ABM2, PEBS, ABM5 and DECOVALEX and Mont Terri Project).

In a third work package (DONUT) BGR aims at a guest status. The task focuses on the development and improvement of numerical methods and tools for the numerical modelling of coupled processes. Also here BGR staff has proven significant competence in numerous past and ongoing projects (PEBS, BEACON, DECOVALEX, etc.) and numerous publications.

Amphos 21 Consulting S.L. WP CORI

Amphos 21 (A21) is a private scientific and technical environmental consulting company with offices in Spain, Chile, Peru and France. Main activity fields are offered in the nuclear, mining, water resources and sustainability market sectors. The company was founded in 1994 and the nuclear services account for more than a 60% of the projects developed in Europe. The nuclear department gathers 30 professionals in the fields of chemistry, geochemistry, hydrology and IT development. A21 develop projects for most of the nuclear waste management organisations in Europe, focused on R&D activities in radioactive waste management, from the experimental and modelling studies of the behaviour of spent nuclear fuel and waste forms to the migration of radionuclides in the geosphere and performance assessment of deep and surface facilities for nuclear waste storage and deposition. A21 have worked in projects funded by the European Commission since 1994.

- **Link of the participant to the third party:** In 2018, KIT-INE and A21 signed a “Collaboration agreement on the field of management and disposal of Radioactive Waste”. The relationship between Amphos 21 and KIT-INE started in the 90’s and expands to different type of projects, EC and also private funded developments. The collaboration between KIT-INE and A21 has proven very successful and satisfactory for both parts. Last examples of close collaboration between both parties in EC projects have been CEBAMA, First-Nuclides, CROCK, Recosy and FUNMIG. Other types of collaborations have been through the Taslismán and Actinet instruments. Examples of collaboration not funded by the EC have led to the development of several Ph.D thesis, such as:

- Tasi, A. (2018) "Solubility, redox and sorption behaviour of plutonium in the presence of α -D-isosaccharinic acid and cement under reducing conditions". A21 subcontracted KIT-INE for the research project, which was funded by SKB (Sweden)
- Gonzalez-Siso, M.R. (2018). Determination of key master variables and radionuclide behaviour in the Swedish Final Repository environment
- Fernandes, T. (2017) Geochemical Behaviour of uranium and thorium in the waste of a uranium conversion facility.

Stages of personnel of A21 to KIT-INE and vice versa have been also accomplished through different collaboration and KIT-INE is part of the consortia for the development of the iCP tool and Image project managed by A21 (<https://image-modelling.net/project/view/1/iCP>)

An example of existing current collaboration contracts is the ThermAc3 (2017-2019) "Thermodynamics and speciation of actinides at elevated temperatures", extension of the initial contract dated 2015.

• **Tasks to be performed by the third party in WP3 - CORI :**

1. A21 is co-subtask leader in CORI, Subtask 3.
2. Task 3. Interaction of pure cement phases (CASH or CSH) with adipate and phthalate (characteristic of PUR and PVC degradation, resp.) and isosaccharinate (ISA, characteristic of cellulose degradation) in the presence and/or in the absence of Fe. A scientific development is foreseen using pure cement systems (CASH or CSH with variable C/S ratio) The work will follow a bottom-up approach:
 - Uptake of single organic molecules (adipate, phthalate or ISA) with CASH or CSH
 - Uptake of one organic, selected based on previous results, with CASH or CSH in the presence of iron.
3. Task 4. Interaction of Radionuclides (e.g. Ni and/or U) with pure cement phases (CASH or CSH) and organic ligands (adipate, phthalate and isosaccharinate). The bottom-up approach of the study will similar to that detailed in Task 3 and includes:
 - Uptake of selected RN by cementitious phases (CASH or CSH) in the absence of organic ligands (batch experiments with solid samples dispersed in cement synthetic water).
 - Uptake of selected RN by cementitious phases (CASH or CSH) in the presence of organic ligands (batch experiments with solid samples dispersed in cement synthetic water).

Third Party: PreussenElektra GmbH (PEL)

PreussenElektra is a wholly owned subsidiary of E.ON and has been operating Germany's largest fleet of commercial nuclear power stations. To its portfolio belong six nuclear power stations in the German states of Bavaria, Lower Saxony, and Schleswig-Holstein. Most of these plants were commissioned in the early 1980s. PEL owns minority shares in a further five plants. All of them will have been permanently shut down by 2022 and then await decommissioning. The safe operation of these facilities has been due to the continuous improvement and implementation of high safety standards, an extensive maintenance program and a highly-skilled workforce. One part of PEL's decommissioning activities is the qualification of suitable storage and transport casks for spent nuclear fuel and their subsequent loading and storage. PEL mainly uses the CASMO/SIMULATE toolset for reactor physics and source term calculations.

• **Link of the participant to the third party:**

PEL and KIT have a long history of research collaboration in the field of nuclear reactor safety and in particular a framework agreement entitled "Agreement for collaboration on the field of management and disposal of radioactive waste" has been put into place since February 2019.

• **Tasks to be performed by the third party:**

1. PEL contributes its industrial knowledge and experience about source term calculations for spent nuclear fuel and in particular its expertise regarding the requirements and techniques for nuclide vector determination for intermediate storage until final disposal.
2. PEL will be responsible for organizing the activities in subtask 2.4 of the main task "fuel properties characterization and related uncertainty analysis" and will be responsible for delivering the subtask's results. The objective is to standardize the analyses performed by the partners in order to

obtain consistent results from a large dataset of samples. This complements the activities of earlier subtasks which focus on developing recommendations for state-of-the-art calculations and are based on a relatively small dataset. In subtask 2.4 calculations with an industry-standard and an improved code will be done, and the statistical significance of the preceding method development and improvements will be demonstrated. PEL will develop with the partners a set of consistent input and calculation schemas to minimize modelling bias and merge results into a comprehensive report.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

25/ LEI

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

26/ MTA EK

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	<u>N</u>
Does the participant envisage that part of its work is performed by linked third parties	<u>Y</u>
The Linked Third Party, Social Organization for Radioecological Cleanliness (SORC), is a non-governmental organization created in 1993, aims to promote modernization of higher education, enhance the quality and relevance of higher education in the region. According to the aims the SORC would like to give the public the valuable and reliable information about the hazard on the radiations. The most well-known problems of the nuclear accidents (Chernobyl, Fukushima, etc.) but nowadays the NORM materials are in the focus too. Environmental impact and harm resulting from present and past industrial past activities is very complex and diverse according to the type of industry, raw material extraction and exploitation process and waste processing and handling and factors such as site local geology and hydrogeology. Instruments of SORC are primarily capable of measuring environmental samples (laboratory equipment) and Physical process modelling and simulations (GPU-CPU Server). The last 10 years SORC has developed several software, especially an atmospheric modelling software for Hungarian NPP. SORC is in close co-operation with other research groups, therefore it is possible to involve/carry out further numerical simulation. Link of the participant to the third party: MTA EK and SORC have developed the Hungarian National Nuclear Forensics Library. This library (software) dedicated for a comparative assessment of several characteristics with existing information could be used to identify or exclude possible origins of the nuclear materials. In addition, MTA EK and SORC are members of SUSTAINABLE ATOMIC ENERGY TECHNOLOGY PLATFORM (FAETP) in Hungary, it is a nuclear platform for nuclear research where they collaborate on the definition and development of research projects on nuclear technologies including aspects of the nuclear	

waste management. Tasks to be performed by the third party: WP Development and improvement of numerical methods and tools for modelling coupled processes (DONUT) into the Task 2: Numerical methods for high performance computing of coupled processes work will be developed by SORC team. SORC will develop modules with numerical algorithms adapted to the resolution of multiphysic coupled problem on GPU-CPU Server platforms, how is: Models designed to represent the development of discrete gas pathways in clays are likely to be too restricted in application for full scale performance assessment calculations, and the development of continuum models that would satisfy the needs of the latter are considered a priority. A large problem can usually be divided into smaller tasks that operate together in order to create a solution. One possible, effective solution for increasing the computational time can be the parallelization of the source codes. The GPU got a heavy parallel architecture, making the effective for arithmetic operations and calculations. The main plan to compare different programming modules (CUDA, OpenCL, OpenMP, OpenACC) and optimize a module for a cost effective and reliable numerical method. Tibor Kovacs, is responsible for DONUT WP as LTP.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	<u>N</u>
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	<u>N</u>
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	<u>N</u>

27/ NAGRA

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
• EPFL/LMS is a longtime research partner of Nagra in the field of THM coupled processes (laboratory, modelling). Collaboration has started in 2006; a multitude of PhD thesis have been accomplished, focussing on bentonite characterisation, gas transport in sand/bentonite and THM characterisation of indurated clays (Opalinus Clay and other Mesozoic clay formations). New experimental set-ups have been developed to characterise the suction behaviour of clay-rich material. The latest development is an advanced triaxial cell for gas permeability testing with highly accurate control of volumetric strains. The EPFL team has strong modelling capabilities; they have developed an elasto-plastic constitutive framework for modelling gas transport processes in clay-rich media. The modelling framework has been subjected to a comprehensive validation exercise in the context of SKB's EBS-Task Force (Task 7: "gas transport in bentonite"). • CIMNE and Nagra established comprehensive research collaborations 20 years ago. The collaboration started as part of an international project on gas transport in sand/bentonite mixtures at the Grimsel URL. Since then, Nagra has co-funded new experimental set-ups at CIMNE's geotechnical laboratories for investigating gas transport in bentonite and Opalinus Clay. Multiple publications in peer reviewed journals have been completed with emphasis on the deformation behaviour of clay-rich materials in response to gas pressures. On behalf of Nagra, CIMNE is currently performing a comprehensive laboratory programme on gas transport in bentonite in the context of SKB's EBS-Task Force. CIMNE participates in the validation exercise in the context of SKB's EBS-Task Force (Task 7: "gas transport in bentonite") with their own modelling framework. • ZHAW/ICP collaborates with Nagra for more than 10 years in the field of microstructural imaging of clay-rich materials. This includes pioneering work on pore connectivity of bentonite and Opalinus Clay	

(FiB nano-tomography, TEM, BiB, micro-CT) which has been published in peer reviewed journals. The ZHAW team has developed advanced image processing tools for upscaling the microstructural information, aimed at linking the micro-scale to the scale of laboratory testing with core samples. The upscaling techniques have been validated in the context of the EBS-Task Force (Task 7: "gas transport in bentonite").

- INSTITUTE of GEOLOGICAL SCIENCES of the UNIVERSITY of BERNE has been collaborating with Nagra for more than thirty years. The Rock Water Interaction group (RWI) of the institute of Geological Sciences group has acquired expertise not only in the framework of Nagra's projects (e.g. Wellenberg, Projekt Opalinuston, Mont Terri and Grimsel URL's) but also contributed in various ways to international projects (EU-projects and for Nagra's sister organisations). The wide range of expertise by RWI includes but is not limited to: porewater analyses of clayrocks and bentonite materials, transport properties of clay rocks and bentonite materials, mineralogical and petrographical investigations and the evolution of interfaces of engineered and natural barriers. This also includes an in depth understanding of interface processes between steel and bentonite or cement and bentonite under repository conditions.

Involvement of the Nagra LTPs in the EURAD :

- WP GAS: Laboratory experiments in support of Tasks 2.1 and 2.2 (gas-induced damage evolution/self-sealing) and modelling in support of Task 2.3 shall be performed through EPFL and CIMNE.
- WP GAS: Microstructural analyses of damage evolution and self-sealing processes using advanced 3-D imaging techniques in support of Tasks 2.1 and 2.2 (gas-induced damage evolution/self-sealing) shall be performed through ZHAW. The intended activities include also the processing/upscaling of the microstructural data, which will feed in Task 2.3.

WP ACED: The University of Berne will contribute to the ACED work package, with an experimental part and a modelling part. The experiment investigates the interaction between a Fe(II) solution and smectite, by using chemical and isotope analysis on the solution and spectroscopic analysis for the solid phases. The modelling part will build on the former experiment and previous experiences. A reactive transport model will be developed to analyse the long-term evolution of Fe-bentonite interaction under repository relevant conditions.

Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

28/ NCSR D

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
The linked third party is DMT GmbH & Co. KG, acronym DMT who is expert in mining, exploitation, radiation protection, waste management. DMT has approx. 700 employees. 65 are working in the field of disposal facilities for radioactive waste. NCSR D is linked to DMT by a MoU for cooperation on a cost-free basis, each party is only responsible for its own costs. The cooperation concerns the future planning of the disposal of the Greek radioactive waste and for planning the decommissioning and dismantling of components and systems of GRR-1 at the NCSR D on the one hand and for the planning of disposal options of radioactive waste in countries with small amounts of radioactive waste in general. Main tasks that will be performed by DMT are within WP9 ROUTES - Task 5 "RWM solutions for small amounts of waste" and Task 6 "Shared solutions in European countries in Waste Management Routes" of	

EURAD-1. DMT (LTP) will take over the management of Task5 and give information about disposal options appropriate for SIMS like the use of old mines, tunnels, bunkers, caverns, deep shafts and boreholes (some 100 m). Expertise in mining as well as treatment and disposal of radioactive waste are only present at DMT. Former investigations for general solutions for countries generating only small amounts of radioactive waste were already performed by DMT in cooperation with NCSR.D. Furthermore, DMT will collect the necessary information for the work in Task5 from the other Tasks of the WP. In WP9 Task 6 DMT will contribute by describing examples of sharing facilities in Germany as well as by providing feedback. DMT will share the information from the work in this Task with NCSR.D.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

29/ NES

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

30/ NJF

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

31/ NRG

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

14a of the General Model Grant Agreement)?	

32/ ONDRAF

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
ULiège The Civil Engineering Department of University of Liège (ULiège) is internationally recognized for its expertise in multi-physical and multi-scale modelling in geomechanics. It has participated to several EC projects in the field of geomechanics applied to the geological disposal of radioactive waste, such as TIMODAZ, FORGE and BEACON. Link to third-party: memorandum of understanding on collaboration and exchange of information on research in geomechanics, including but not limited to research related to the geological disposal of radioactive waste. Tasks: ULiège will model gas injections experiments performed on Boom Clay and COx in WP6 (GAS), to support the interpretation of these experiments and the identification of key parameters for gas transport in these natural materials. In that context, ULiège will develop innovative tools for multi-scale representation of gas – porous media interactions in clay materials and transport along interfaces. ULiège will also support WP7 (HITEC), participating in benchmark exercises on the modelling of in situ heater experiments in different clay rocks. In that context, the interface element approach developed by ULiège will be upgraded to make it possible to represent time-dependant sealing processes. Improving the understanding of the complex mechanisms involved in gas transport in clays (e.g. such as the development of discrete, unstable pathways controlled by the mechanical behaviour of the porous media) and the thermo-hydro-mechanical couplings, combined with sealing processes, is important to determine how the effects of these complex mechanisms can be bound and, in turn, to justify the use of simpler and robust descriptions for evaluation purposes. In addition, ULiège will co-organize the joint WP6-WP7 (GAS-HITEC) training activities on multi-physical couplings in geomechanics applied to geological waste disposal. EURIDICE Link to third-party: EURIDICE is an Economic Interest Grouping set by ONDRAF/NIRAS and SCK•CEN for the management and operation of The Belgian Underground Research Laboratory HADES. EURIDICE and/or its scientific staff have participated to several EC projects in the field of geomechanics applied to the geological disposal of radioactive waste, such as CLIPEX, SELFRAC (as coordinator), TIMODAZ (as coordinator) and FORGE. Tasks: As operator of the HADES URL, EURIDICE will provide experimental data to WP7 (HITEC) from the large scale in situ heater test PRACLAY. These experimental data will be used to support the benchmarking exercise. EURIDICE will also support EURAD by providing state-of-the-art knowledge on the geomechanical behaviour of Boom Clay.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

33/ POSIVA

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y

Envirocase Oy is a R&D consultancy company working with spent fuel disposal and safety case projects internationally. Envirocase do work for UMAN Subtask 3.1 – Types of uncertainties relevant to the safety analysis and the work is related to the safety case and description of knowledge quality assessment methodology. The person doing the work is former Posiva staff member having a good understanding of the safety case related tasks in spent fuel disposal.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

34/ PSI

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
EMPA is the Swiss Federal Laboratories for Materials Science and Technology. EMPA and PSI belong are two Swiss biggest research institutes. The Concrete and Construction Chemistry Laboratory focuses on fundamental research, application-oriented research and production development within the field of cementitious materials, with the aim of improving their sustainability. By studying alternative binder systems, concrete of improved durability and high-performance concrete, we aim at reducing the consumption of energy and raw materials and the CO₂-emissions during the life cycle of concrete structures. Laboratory for waste management at PSI and the Concrete and Construction Chemistry Laboratory at EMPA have long standing collaborative research agreement in the area of cement degradation, cement-waste interaction and radionuclides retention by cement minerals. Concrete and Construction Chemistry Laboratory at EMPA is the leading expert in thermodynamic modelling and experimental studies of cement hydration and cement interaction with environment. EMPA participate in WP CORI. Within the Task 3 (Organics-Cement-Interactions) EMPA will investigate the sorption of low molecular weight organics on the main phases present in hydrated cements: C-S-H (high and low Ca/Si C-S-H), AFm-phases and ettringite.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

35/ PURAM

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N

Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

36/ RATEN

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

37/ RWM

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

38/ SCK•CEN

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

39/ SKB

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
Uppsala University, Department of Physics and Astronomy Uppsala University (UU) is a public university founded in 1477. In WP8 for Spent Fuel characterization and evolution until disposal, Uppsala University Department of physics and astronomy, applied nuclear physics, are contributing to three tasks in the work package:	

1) In subtask 1.1, UU will perform the scientific and technical coordination of the SFC work package. 2) In subtask 2.2, UU will contribute to the activities by developing improved analysis procedures for calorimetric measurements; analyse the data and describing the results together with detailed fuel histories, which are required for the validation of the theoretical calculations. 3) In subtask 2.4, The main contribution of UU is to choose regression techniques and perform a multivariate regression analysis between the fuel history parameters and the experimental observables. UU will also assist PEL in establishing well-founded uncertainties for the SNF source-terms. Link to Third Party: Framework agreement and ordering of research tasks on nuclear fuel issues. SKB and Uppsala University have a long research relationship. In this case with the Department of physics and astronomy, applied nuclear physics the research is regarding on nuclear fuel diagnostics. The two latest agreements we have with the Department of physics and astronomy, applied nuclear physics are attached. They are in Swedish, and confidential information is hidden. Please don't hesitate to contact us if you need anything else proving the link between the two organisations.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

40/ SSTC NRS

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

41 STUBA

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

42/ SÚRAO

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N

Does the participant envisage that part of its work is performed by linked third parties	Y
1. The Institute of Geonics AS CR, v.v.i. (IGN) The Institute of Geonics AS CR, v.v.i. (IGN) which is based in Ostrava, Czech Republic, is one of a number of public research institutions that operate under the umbrella of the Czech Academy of Sciences. The IGN was founded in 1982 with a major focus on engineering applications in the field of geosciences. The research team of the Department of Applied Mathematics and Computer Science has, for many years, been involved in the development and implementation of innovative numerical methods for the simulation of processes occurring within geomaterials and the geological environment. More recently, the Institute has been working intensively on the research of methods for the estimation of uncertainty in modelling. The team is a partner of the National Supercomputing Centre in Ostrava with which it is currently working on a project oriented towards developing high performance, massively parallelisable computing methods. Linked third party (LTP) connection to the beneficiary: Long-term cooperation with SÚRAO, which includes the participation of a team in the international DECOVALEX (Development of Coupled Models and their Validation against Experiments) project since 2008, is supported by a research cooperation agreement (SO2018-095) that was signed in 2018. Tasks to be performed by the LTP: WP DONUT - Development and Improvement of Numerical Methods and Tools for the Modelling of Coupled Processes. The IGN team will contribute to the development of robust and efficient, parallelizable numerical methods for the simulation of hydro-mechanical and thermo-hydro-mechanical (THM) processes in natural and bentonite DGR barriers. The newly-developed methods will be tested on suitable benchmark problems related to the performance-safety analysis of the future Czech DGR. The IGN team will also contribute to the Monte-Carlo methods via a suitable variance reduction technique (Multi-level Monte-Carlo methods for issues concerning poromechanics), a stochastic collocation method and response surface methods. Moreover, IGN research will also focus on sensitivity analysis and inverse identification problems, focusing specifically on the Bayesian inversion technique with the use of surrogate models. The developed uncertainty quantification/reduction methods will be tested on models for the analysis of coupled processes relevant to underground nuclear waste disposal. 2. ÚJV Řež, a.s. The principle mission of ÚJV Řež, a.s. (Nuclear Research Institute, NRI, hereinafter referred to as UJV) is to remain the pre-eminent technical-engineering company in terms of contributing to the development of a long-term sustainable power supply in the Czech Republic and to make up a significant player with respect to European research in the field of nuclear energy. The Waste Disposal Department at UJV focuses primarily on supporting SÚRAO in the development of the long-term deep geological repository R&D programme. Its activities include the conducting of laboratory and field experiments for the quantification of migration and geochemical processes (sorption, diffusion) and laboratory experiments for the quantification of the degradation rates of spent fuel, waste forms and engineered barriers (disposal container materials, backfill and buffer materials). Moreover, the environmental safety performance and risk analysis of geological disposal systems (behaviour, spread of radionuclides and toxic substances in the near- and far-fields of disposal facilities and their environmental impacts) also make up important elements of the research programme of the department. The department is equipped with UV/Vis-spectroscopy, beta and gamma-spectroscopy and AAS etc. equipment and enjoys the support of the UJV's certified central laboratory (ICP-MS, DTA, alpha spectroscopy, DTA, HPLC etc.). LTP connection to the beneficiary: UJV and SÚRAO have enjoyed fruitful cooperation with concern to both national and international projects concerning radioactive waste management and the repository development programme since SÚRAO's establishment by the Atomic Act which was adopted in 1996. In 2017, UJV and SÚRAO signed cooperation agreement No. SO2017-105 focusing on various fields in the area of radioactive waste management and disposal. Tasks to be performed by the LTP: WP ACED – the Assessment of the Chemical Evolution of ILW and HLW Disposal Cells. The main contribution involves the combination and detailed evaluation of corrosion experiments under defined system (interface of steel, corrosion products and saturated compacted bentonite) and geochemical modelling of this interface. WP HITEC – the Influence of Temperature on Clay-based Material Behaviour. The study of changes in	

the properties of bentonite due to thermal loading (mineralogy with respect to changes of expandable structures of clay minerals, cation exchange capacity, specific surface, re-hydration - retention curves) and the provision of support for the CTU with respect particularly to analytical measurements.

WP GAS – the Mechanistic Understanding of Gas Transport in Clay-based Materials. The performance of laboratory experiments and the study of the migration (advection) of hydrogen through bentonite using experience obtained from previous projects (FORGE, Czech projects); the experiments are based on the detection of the lower pressure limit at which hydrogen breakthrough occurs in bentonite. The experiments will provide support for experiments conducted at the CTU.

WP CORI - Cement-Organics-Radionuclide-Interactions. The study of the degradation of concrete organic additives (superplasticisers) and ion-exchange resins via radiolysis (in an irradiation chamber) and hydrolysis in an alkaline environment and the consequent analytical evaluation of degradation products. Migration studies of the influence of degradation products of organics on cementitious materials – sorption, diffusion, leaching; the verification and description of the fixation of ion exchange resins in cement matrices; changes in the physical and mechanical properties of cement matrices due to the degradation of organics via irradiation and hydrolysis; studies of the migration of organics in cementitious materials influenced by iron corrosion products. The migration of selected tracers and their complexes with concrete additives and the degradation products of organics and the migration of selected tracers fixed on ion-exchange resins and their degradation products (e.g. Ni, U) in CEM I.

WP DONUT - Development/improvement of numerical methods and tools for the modelling of coupled processes. The UJV contributions will focus on the delivery of extensive pre-processed site-characterisation data, including the description and interpretation thereof in close connection with the FUTURE WP. A joint programme has been designed with concern to developments surrounding the mathematical representation of uncertain parameters applied for coupled processes involving cooperation between UJV, GRS, JUELICH and HZDR on the conducting of a complex uncertainty treatment and sensitivity analysis based on coordinated data collection, uncertainty quantification and the testing of sensitivity analysis methods applied in geochemical applications.

WP FUTURE - Fundamental Understanding of Radionuclide Mobility. The analysis of the connected pore network and surface topography of fractured crystalline rock samples and mineral infills followed by batch type and flow-through sorption experiments utilising the reference pore water of the specific host rock. UJV will focus on the preparation and characterisation of samples with respect to pore structure, batch sorption experiments (Eu, Ba, Sr, Se, I) and through-diffusion tests (HTO, I, Ba/Eu, U) with crystalline rock samples. The WP envisages extensive cooperation with HZDR and Helsinki university.

3. Technical University of Liberec (TUL)

The Technical University of Liberec (TUL), which was founded in 1953, is a regional public university offering an extensive range of technical and humanities subjects. Two departments are involved in the project: The Centre of Nano-materials, Advanced Technologies and Innovations (established as part of an EU regional operational programme) and the Faculty of Mechatronics and Interdisciplinary Engineering Studies. The specialised fields of the two teams include computer science research and numerical simulation in the field of geosciences. The teams have extensive experience of code comparison and benchmarking related to nuclear waste disposal (coordinated by SÚRAO) and the theory and implementation of numerical methods in the context of national research support programmes. The team also operates the “Charon” cluster of 400 cores in 20 nodes (introduced in 2017) as a part of the Czech MetaCentrum partnership.

LTP connection to the beneficiary:

The link between the participant and the third party is based on joint research work that has been underway via e.g. the DECOVALEX project (on the model development and testing of coupled processes and the processing of data on groundwater flow and the transport of tracers) since 2008 and the GEOSTAB project (on methodologies concerning the stability of underground constructions including SW for compiling 3D records of geological massifs) since 2011. An assessment of past cooperation with a view to subsequent cooperation was incorporated into research cooperation agreement No. SO 2018 – 091 of 9 November 2018.

Tasks to be performed by the LTP:

WP DONUT - Development and Improvement of Numerical Methods and Tools for the Modelling of Coupled Processes. As part of the project the TUL plans to develop and implement numerical approaches related to multi-dimensional domain modelling (fracture-continuum) comprising e.g. processes within

intersections, coupling frameworks, the XFEM method and hybrid parallelism. The TUL will apply the multi-dimensional model concept in relation to data from different spatial scales using hydraulic/tracer field data. As part of the uncertainty analysis work, it is planned that the multilevel Monte-Carlo method will be applied to the various model problems, resulting to the effective approximation of generalised moments followed by the approximation of CDF from generalised moments. Finally, the TUL will contribute to benchmarking and the evaluation of the Flow123d simulation code including uncertainty analysis tools.

4. Czech Technical University in Prague (CTU)

The Czech Technical University in Prague (CTU), a public university established in 1707, is one of the largest and oldest technical universities in Europe. The CTU currently has eight faculties (Civil Engineering, Mechanical Engineering, Electrical Engineering, Nuclear Science and Physical Engineering, Architecture, Transportation Sciences, Biomedical Engineering and Information Technology) and a student population of around 18,000. The university offers a wide variety of study programmes and hosts a number of leading research groups. Research groups from the Faculty of Nuclear Sciences and Civil Engineering will participate in the project.

LTP connection to the beneficiary:

The CTU enjoys long-standing cooperation with SÚRAO involving the conducting of a large number of joint research projects (e.g. DOPAS, BEACON, CEBAMA). Indeed, the CTU makes up one of SÚRAO's leading long-term research providers. The CTU and SÚRAO signed the latest framework research cooperation agreement (SO2018-096) on 2 February 2019, which establishes the will of the parties concerned to cooperate in research concerning the future Czech DGR.

Tasks to be performed by the LTP:

WP CORI - Cement-Organics-Radionuclide-Interactions. In close cooperation with UJV Řež, a. s., the CTU will study the degradation of cementitious materials, concrete organic additives and ion-exchange resins with regard to their mutual interaction and transport/retention properties. The research will consist of an analysis of cementitious samples originating from radiolytic degradation and the hydrolysis of the materials, and will include the identification and quantification of organics, organics-cement and organics-iron species and the influence of organics-Fe/organics-cement species on RN transport and cement degradation. Long-term experience of the modelling of geochemistry and diffusion transport in the PHREEQC3 environment will facilitate the subsequent experimental data fitting process.

WP DONUT – the Development/improvement of Numerical Methods and Tools for the Modelling of Coupled Processes. Attention will be devoted to numerical modelling and simulation with concern to thermo-hydro-mechanics and will include modelling issues based on material constitutive laws (CU) as well as HPC issues related to parallelism based on domain decomposition.

WP GAS – the Mechanistic Understanding of Gas Transport in Clay-based materials. The CTU will perform laboratory experiments and study the migration (advection) of gases through bentonite using experience obtained from previous projects (FORGE, CZ projects). A long-term experiment involving slow gas injection and including a series of repeated fracturing (gas breakthrough) tests and the resealing of the bentonite barrier (re-saturation and a permeability check) is planned.

WP HITEC – the Influence of Temperature on Clay-based Material Behaviour. The main objective of the CTU is to characterise and model the thermo-mechanical behaviour of bentonite at temperatures in excess of 100°C. The CTU will perform the analysis of materials exposed to high temperatures, measure the various parameters at high temperatures and perform the laboratory experiments. The laboratory data will provide input material for the construction of a mathematical model as part of the work package. Along with its various research responsibilities, the CTU will coordinate Task 3 and provide assistance with the preparation of a training workshop.

WP SFC – Spent Fuel Characterisation. The CTU enjoys extensive experience with the determination of the radiation source term during fuel depletion and the consequent decay period. The CTU will study the sensitivity of this source term to realistic levels of impurities in the composition of materials and the importance of structural materials with respect to the overall SNF source term.

WP KM – Training/Mobility. The CTU will assist in the preparation and conducting of training courses. The CTU is able to offer courses involving the research reactor and other laboratories as well as the Josef Underground Laboratory.

5. Charles University (CU)

The Charles University (CU) – is the oldest university in Central Europe. Established in 1348, and with 17

faculties, it is the largest and most respected university in the Czech Republic and also enjoys a high ranking internationally. SÚRAO is involved in the DONUT and HITEC WPs with the CU's College of Natural Sciences (Department of Engineering Geology). The university's main representative in the WPs, Dr. David Mašín, gained his professional experience at a number of leading universities in the field and has based his research at the University of Innsbruck; Imperial College, London; City University, London; Université Joseph Fourier, Grenoble; the University of Dresden; the University of Karlsruhe and the University of New South Wales, Sydney. The subject of the mechanical evolution of bentonite makes up the principal theme of the joint Horizon 2020 project commissioned in 2016 under the acronym BEACON and conducted in cooperation with SÚRAO.

LTP connection to the beneficiary:

Long-term cooperation with SÚRAO, which includes the participation of a team in the international BEACON project (Bentonite mechanical evolution, Horizon 2020, Proposal number: 745942) since 2015, is supported by an agreement on research cooperation signed on 5 April 2018 (SO 2018-094).

Tasks to be performed by the LTP:

WP DONUT, Task 2 – particular attention will be devoted to numerical modelling and simulation with respect to Thermo-Hydro-Mechanics (THM) including modelling issues based on material constitutive laws. The HITEC WP, Task 3 - Subtask 3.1: the CU will focus on the post-mortem analysis of small-scale laboratory experiments performed by the CTU. The CU will investigate swelling under constant load test conditions and conduct oedometric load-unload tests and water retention tests on heat-treated BCV bentonite. Subtask 3.2: the CU will study the BCV material at 100 °C and 150 °C in specialised cells and conduct 2 swelling pressure tests with suction control, 2 swelling under constant load tests with suction control and 1 oedometric load-unload test. Subtask 3.3: the CU will further develop and validate a hypoplastic model for bentonite at high temperature and will conduct simulations of experiments conducted by the CTU.

Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

43/ SURO

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

44/ TNO

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N

and 12 of the General Model Grant Agreement)	
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

45/ TS Enercon

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	<u>N</u>
Does the participant envisage that part of its work is performed by linked third parties	<u>N</u>
Does the participant envisage that part of its work is to be performed through financial support to third parties	<u>N</u>
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	<u>N</u>
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	<u>N</u>

46/ TUS

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

47/ UCY

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

48/ UH

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
JyU (University of Jyväskylä), a linked third party to UH will utilize X-ray techniques to obtain detailed spatial and temporal information on wetting and hydromechanic behaviour of small-scale bentonite	

samples at elevated temperatures. The experiments will be carried out as a joint effort with GTK. The data obtained will be organized in an open database to support related modelling and model validation carried out in Task 3 (Subtask 3.2). The legal link between UH and JyU is based on Finnish Radiation Safety Research Program and Consortium (Cores). The Finnish Government Resolution on Comprehensive Reform of State Research Institutes and Research Funding took place in September 2013.

GTK (Geological Survey of Finland), which is linked 3rd party (legal link) to UH, and GTK will be participating in Task 3, Subtask 3.2. for X-ray tomography. This is to be able to utilise the laboratory capacity and expertise at GTK for the project. The legal link between UH and GTK is based on the Cooperative agreement on shared laboratory facilities (The agreement from signed 2013).

TUT (Tampere University of Technology), which is linked 3rd party to UH, will participate in Task 4 (Tools and methods to quantify/derive uncertainties induce by coupled processes) of WP DONUT (Development and Improvement Of NUMerical methods and Tools for modelling coupled processes). The role of TUT will be to develop metamodels for uncertainty quantification related to tools and models developed in DONUT. The legal link between UH and TUT is based on Finnish Radiation Safety Research Program and Consortium (Cores). The Finnish Government Resolution on Comprehensive Reform of State Research Institutes and Research Funding took place in September 2013.'

Aalto University, which is linked 3rd party to UH, will participate in Task WP DONUT using the developed THMC coupled Finite Element Code (Abed & Sołowski 2017, 2018). In this project, the Aalto group intends to model the processes related to hydration of bentonite barrier in the nuclear waste storage. In Aalto they will simulate a repository scale problem (i.e. 'generic repository'), as defined early in the subtask by the EURAD participants. The legal link between UH and Aalto is based on Finnish Radiation Safety Research Program and Consortium (Cores). The Finnish Government Resolution on Comprehensive Reform of State Research Institutes and Research Funding took place in September 2013.'

Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

49/ UKRI-BGS

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

50/ VTT

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y

1. Short description of LTP

Galson Sciences Ltd (GSL) is an international environmental safety and radioactive waste research and consultancy company, specialising in radioactive waste management and disposal, nuclear decommissioning and nuclear safety studies, risk and impact assessment, risk management and communication, and geoscience studies. GSL implements national R&D programmes on behalf of the national waste management organisation (WMO) and the waste producers responsible for radioactive waste management. For example, in the UK GSL holds framework contracts to implement national R&D with RWM and LLWR Ltd (waste disposal) and with the NDA for estate-wide R&D (decommissioning and predisposal waste management on behalf of all of the NDA's Site Licence Companies). GSL also implements R&D directly for WMOs in other countries and for international organisations.

2. Description of link between VTT and GSL

GSL has built up a close collaboration with VTT Technical Research Centre of Finland (amongst others) over many years via collaborative R&D in all of the above-noted areas, and this collaboration is documented in a series of legally binding Memoranda of Understanding (MoUs) and contracting agreements. The legal agreement under which work in EURAD would be carried out is the **attached MoU** signed September 2018, which covers the entire radioactive waste management field. VTT and GSL also have a working relation on earlier cooperative EC-funded projects, most recently Euratom projects DOPAS, Modern2020 and THERAMIN.

Examples of recent collaboration outside of EURAD that illustrate the scope of recent collaboration include the following:

- Project for RWM on durability of concrete containers for radioactive waste.
- Project for RWM on radionuclide migration parameter values and laboratory techniques.
- Project for RWM on approaches to backfilling, sealing and closure of geological disposal facilities.

An example of an existing public contracting arrangement is the consortium led by GSL with VTT participation, to support the UK's Nuclear Decommissioning Authority for "Integrated Waste Management and Site Decommissioning and Remediation." See <https://www.gov.uk/government/news/12-million-contracts-support-nuclear-decommissioning-research>.

3. Involvement of GSL per Work Package (WP)

GSL is involved in ROUTES and UMAN. The work to be done (as per the EURAD proposal) is as follows:

ROUTES – WP2 - Contribute to identification and classification of challenging wastes and pre-disposal routes for these wastes; WP4 - (co)Lead development of report on identification of waste acceptance criteria (WAC), and development of WAC where wastes exist, but disposal facilities do not; WP6 – contribute to identification of shared predisposal waste management solutions across Europe, including identification of case studies and prospects.

UMAN – WP2 - Lead review of general strategies, approaches and tools for managing uncertainties.

Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

51/ VUJE

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N

Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

5. Ethics and Security

5.1. Ethics

Ethics issues are addressed in work package 14.

5.2. Security

Not applicable

ESTIMATED BUDGET FOR THE ACTION

	Estimated eligible ¹ costs (per budget category)										EU contribution			Additional information		
	A. Direct personnel costs				B. Direct costs of subcontracting	<i>[C. Direct costs of fin. support]</i>	D. Other direct costs		E. Indirect costs ²	Total costs	Reimbursement rate %	Maximum EU contribution ³	Maximum grant amount ⁴	Information for indirect costs	Information for auditors	Other information:
	A.1 Employees (or equivalent)		A.4 SME owners without salary				D.1 Travel	D.5 Costs of internally invoiced goods and services						Estimated costs of in-kind contributions not used on premises	Declaration of costs under Point D.4	Estimated costs of beneficiaries/ linked third parties not receiving funding/ international partners
A.2 Natural persons under direct contract		A.5 Beneficiaries that are natural persons without salary		D.2 Equipment												
A.3 Seconded persons				D.3 Other goods and services												
<i>[A.6 Personnel for providing access to research infrastructure]</i>				<i>[D.4 Costs of large research infrastructure]</i>												
Form of costs ⁶	Actual	Unit ⁷	Unit ⁸		Actual	Actual	Actual	Unit ⁹	Flat-rate ¹⁰							
									25%							
	a	Total b	No hours	Total c	d	<i>[e]</i>	f	Total g	h = 0,25 x (a +b+c+f+g + <i>[i1]</i> ¹³ + <i>[i2]</i> ¹³ -n)	j = a+b+c+d + <i>[e]</i> +f+g+h + <i>[i1]</i> + <i>[i2]</i>	k	l	m	n	Yes/No	
1. ANDRA	15 303 866.30	0.00	0.00	0.00	250 000.00	0.00	592 000.00	0.00	3 973 966.58	20 119 832.88	55.00	11 065 908.08	10 868 103.29	0.00	No	n/a
- BRGM	908 922.13	0.00	0.00	0.00	0.00	0.00	157 000.00	0.00	266 480.53	1 332 402.66	55.00	732 821.46	732 821.46	0.00	No	n/a
Total beneficiary	16 212 788.43	0.00			250 000.00	0.00	749 000.00	0.00	4 240 447.11	21 452 235.54		11 798 729.54	11 600 924.75	n/a	n/a	0.00
2. ARAO	5 103.07	0.00	0.00	0.00	0.00	0.00	5 000.00	0.00	2 525.77	12 628.84	55.00	6 945.86	6 945.86	0.00	No	n/a
3. BEL V	163 603.00	0.00	0.00	0.00	0.00	0.00	85 672.00	0.00	62 318.75	311 593.75	55.00	171 376.56	171 376.56	0.00	No	n/a
4. BGE	546 425.00	0.00	0.00	0.00	0.00	0.00	49 000.00	0.00	148 856.25	744 281.25	55.00	409 354.69	409 354.69	0.00	No	n/a
5. CEA	869 933.22	0.00	0.00	0.00	0.00	0.00	237 618.00	0.00	276 887.81	1 384 439.03	55.00	761 441.47	761 441.47	0.00	No	n/a
- EDF	446 300.00	0.00	0.00	0.00	0.00	0.00	53 700.00	0.00	125 000.00	625 000.00	55.00	343 750.00	343 750.00	0.00	No	n/a
- Orano	88 760.00	0.00	0.00	0.00	0.00	0.00	9 000.00	0.00	24 440.00	122 200.00	55.00	67 210.00	67 210.00	0.00	No	n/a
Total beneficiary	1 404 993.22	0.00			0.00	0.00	300 318.00	0.00	426 327.81	2 131 639.03		1 172 401.47	1 172 401.47	n/a	n/a	0.00
6. CIEMAT	1 564 205.24	0.00	0.00	0.00	0.00	0.00	243 251.00	0.00	451 864.06	2 259 320.30	55.00	1 242 626.17	1 242 626.17	0.00	No	n/a
- UPM	194 448.00	0.00	0.00	0.00	0.00	0.00	44 557.60	0.00	59 751.40	298 757.00	55.00	164 316.35	164 316.35	0.00	No	n/a
- UAM	115 000.00	0.00	0.00	0.00	0.00	0.00	43 200.00	0.00	39 550.00	197 750.00	55.00	108 762.50	108 762.50	0.00	No	n/a
- UPC	359 775.00	0.00	0.00	0.00	0.00	0.00	17 000.00	0.00	94 193.75	470 968.75	55.00	259 032.81	259 032.81	0.00	No	n/a
- CSIC	108 929.65	0.00	0.00	0.00	0.00	0.00	7 000.00	0.00	28 982.41	144 912.06	55.00	79 701.63	79 701.63	0.00	No	n/a
- IDOM	90 000.00	0.00	0.00	0.00	0.00	0.00	5 000.00	0.00	23 750.00	118 750.00	55.00	65 312.50	65 312.50	0.00	No	n/a
Total beneficiary	2 432 357.89	0.00			0.00	0.00	360 008.60	0.00	698 091.62	3 490 458.11		1 919 751.96	1 919 751.96	n/a	n/a	0.00
7. ChRDI	9 000.00	0.00	0.00	0.00	0.00	0.00	5 000.00	0.00	3 500.00	17 500.00	55.00	9 625.00	9 625.00	0.00	No	n/a
- KIPT	27 000.00	0.00	0.00	0.00	0.00	0.00	5 000.00	0.00	8 000.00	40 000.00	55.00	22 000.00	22 000.00	0.00	No	n/a
- SHGNASU	34 000.00	0.00	0.00	0.00	0.00	0.00	6 000.00	0.00	10 000.00	50 000.00	55.00	27 500.00	27 500.00	0.00	No	n/a
Total beneficiary	70 000.00	0.00	0.00	0.00	0.00	0.00	16 000.00	0.00	21 500.00	107 500.00		59 125.00	59 125.00	n/a	n/a	0.00
8. CNRS	1 524 726.05	0.00	0.00	0.00	0.00	0.00	673 660.10	0.00	549 596.54	2 747 982.69	55.00	1 511 390.48	1 511 390.48	0.00	No	n/a
- IMT Atlantique	214 046.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	53 511.54	267 557.69	55.00	147 156.73	147 156.73	0.00	No	n/a
- UGrenoble	281 900.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	70 475.00	352 375.00	55.00	193 806.25	193 806.25	0.00	No	n/a
- ULille	193 440.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48 360.00	241 800.00	55.00	132 990.00	132 990.00	0.00	No	n/a
- ULorraine	342 999.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	85 749.85	428 749.25	55.00	235 812.09	235 812.09	0.00	No	n/a
- UMontpellier	68 970.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17 242.60	86 213.00	55.00	47 417.15	47 417.15	0.00	No	n/a
- UNice	60 500.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15 125.00	75 625.00	55.00	41 593.75	41 593.75	0.00	No	n/a
- UOrléans	79 000.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19 750.00	98 750.00	55.00	54 312.50	54 312.50	0.00	No	n/a
- UPoitiers	249 868.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	62 467.00	312 335.00	55.00	171 784.25	171 784.25	0.00	No	n/a
Total beneficiary	3 015 450.00	0.00			0.00	0.00	673 660.10	0.00	922 277.53	4 611 387.63		2 536 263.20	2 536 263.20	n/a	n/a	0.00
9. COVRA	246 615.75	0.00	0.00	0.00	0.00	0.00	52 600.00	0.00	74 803.94	374 019.69	55.00	205 710.83	205 710.83	0.00	No	n/a
- TU Delft	144 489.50	0.00	0.00	0.00	0.00	0.00	11 000.00	0.00	38 872.38	194 361.88	55.00	106 899.03	106 899.03	0.00	No	n/a

ESTIMATED BUDGET FOR THE ACTION

	Estimated eligible ¹ costs (per budget category)									EU contribution			Additional information			
	A. Direct personnel costs			B. Direct costs of subcontracting	<i>[C. Direct costs of fin. support]</i>	D. Other direct costs		E. Indirect costs ²	Total costs	Reimbursement rate %	Maximum EU contribution ³	Maximum grant amount ⁴	Information for indirect costs	Information for auditors	Other information:	
	A.1 Employees (or equivalent)		A.4 SME owners without salary				D.1 Travel	D.5 Costs of internally invoiced goods and services					Estimated costs of in-kind contributions not used on premises	Declaration of costs under Point D.4	Estimated costs of beneficiaries/ linked third parties not receiving funding/ international partners	
Form of costs ⁶	Actual	Unit ⁷	Unit ⁸		Actual	Actual	Actual	Unit ⁹	Flat-rate ¹⁰							
									25%							
	a	Total b	No hours	Total c	d	<i>[e]</i>	f	Total g	$h = 0,25 \times (a + b + c + f + g + [i1]^{13} + [i2]^{13} - n)$	$j = a + b + c + d + [e] + f + g + h + [i1] + [i2]$	k	l	m	n	Yes/No	
Total beneficiary	391 105.25	0.00			0.00	0.00	63 600.00	0.00	113 676.32	568 381.57		312 609.86	312 609.86	n/a	n/a	0.00
10. FTMC	83 032.00	0.00	0.00	0.00	0.00	0.00	33 000.00	0.00	29 008.00	145 040.00	55.00	79 772.00	79 772.00	0.00	No	n/a
11. CV REZ	36 000.00	0.00	0.00	0.00	0.00	0.00	41 500.00	0.00	19 375.00	96 875.00	55.00	53 281.25	53 281.25	0.00	No	n/a
12. Dekom	17 400.00	0.00	0.00	0.00	0.00	0.00	8 500.00	0.00	6 475.00	32 375.00	55.00	17 806.25	17 806.25	0.00	No	n/a
13. EEAE	12 360.00	0.00	0.00	0.00	0.00	0.00	8 000.00	0.00	5 090.00	25 450.00	55.00	13 997.50	13 997.50	0.00	No	n/a
14. ENRESA	97 628.50	0.00	0.00	0.00	438 602.50	0.00	42 500.00	0.00	35 032.13	613 763.13	55.00	337 569.72	337 569.72	0.00	No	n/a
15. JUELICH	620 784.70	0.00	0.00	0.00	0.00	0.00	94 242.60	0.00	178 756.83	893 784.13	55.00	491 581.27	491 581.27	0.00	No	n/a
- HZDR	786 887.00	0.00	0.00	0.00	0.00	0.00	71 738.00	0.00	214 656.25	1 073 281.25	55.00	590 304.69	590 304.69	0.00	No	n/a
- UFZ	305 940.80	0.00	0.00	0.00	0.00	0.00	43 000.00	0.00	87 235.20	436 176.00	55.00	239 896.80	239 896.80	0.00	No	n/a
Total beneficiary	1 713 612.50	0.00			0.00	0.00	208 980.60	0.00	480 648.28	2 403 241.38		1 321 782.76	1 321 782.76	n/a	n/a	0.00
16. GRS	415 845.18	0.00	0.00	0.00	0.00	0.00	47 000.00	0.00	115 711.30	578 556.48	55.00	318 206.06	318 206.06	0.00	No	n/a
17. IAE	4 840.00	0.00	0.00	0.00	0.00	0.00	5 500.00	0.00	2 585.00	12 925.00	55.00	7 108.75	7 108.75	0.00	No	n/a
18. INCT	16 920.00	0.00	0.00	0.00	0.00	0.00	8 000.00	0.00	6 230.00	31 150.00	55.00	17 132.50	17 132.50	0.00	No	n/a
19. IRSN	649 724.00	0.00	0.00	0.00	0.00	0.00	150 500.00	0.00	200 056.00	1 000 280.00	55.00	550 154.00	550 154.00	0.00	No	n/a
- MINES ParisTech	157 200.00	0.00	0.00	0.00	0.00	0.00	13 000.00	0.00	42 550.00	212 750.00	55.00	117 012.50	117 012.50	0.00	No	n/a
- MUTADIS	196 679.00	0.00	0.00	0.00	0.00	0.00	21 500.00	0.00	54 544.75	272 723.75	55.00	149 998.06	149 998.06	0.00	No	n/a
- NTW	159 845.00	0.00	0.00	0.00	0.00	0.00	114 500.00	0.00	68 586.25	342 931.25	55.00	188 612.19	188 612.19	0.00	No	n/a
Total beneficiary	1 163 448.00	0.00	0.00	0.00	0.00	0.00	299 500.00	0.00	365 737.00	1 828 685.00		1 005 776.75	1 005 776.75	n/a	n/a	0.00
20. IST	30 636.00	0.00	0.00	0.00	0.00	0.00	7 000.00	0.00	9 409.00	47 045.00	55.00	25 874.75	25 874.75	0.00	No	n/a
21. IST ID	24 049.30	0.00	0.00	0.00	0.00	0.00	11 000.00	0.00	8 762.32	43 811.62	55.00	24 096.39	24 096.39	0.00	No	n/a
22. JSI	288 915.00	0.00	0.00	0.00	0.00	0.00	84 500.00	0.00	93 353.75	466 768.75	55.00	256 722.81	256 722.81	0.00	No	n/a
- EIMV	155 290.00	0.00	0.00	0.00	0.00	0.00	64 900.00	0.00	55 047.50	275 237.50	55.00	151 380.63	151 380.63	0.00	No	n/a
- ZAG	160 000.00	0.00	0.00	0.00	0.00	0.00	16 500.00	0.00	44 125.00	220 625.00	55.00	121 343.75	121 343.75	0.00	No	n/a
Total beneficiary	604 205.00	0.00			0.00	0.00	165 900.00	0.00	192 526.25	962 631.25		529 447.19	529 447.19	n/a	n/a	0.00
23. JRC	0.00	784 032.89	0.00	0.00	0.00	0.00	278 630.93	0.00	265 665.96	1 328 329.78	55.00	730 581.38	471 150.51	0.00	No	n/a
24. KIT	573 750.00	0.00	0.00	0.00	0.00	0.00	66 950.00	0.00	160 175.00	800 875.00	55.00	440 481.25	440 481.25	0.00	No	n/a
- Uni Potsdam	80 000.00	0.00	0.00	0.00	0.00	0.00	5 000.00	0.00	21 250.00	106 250.00	55.00	58 437.50	58 437.50	0.00	No	n/a
- Uni Clausthal	33 000.00	0.00	0.00	0.00	0.00	0.00	5 500.00	0.00	9 625.00	48 125.00	55.00	26 468.75	26 468.75	0.00	No	n/a
- Uni Mainz	264 600.00	0.00	0.00	0.00	0.00	0.00	33 000.00	0.00	74 400.00	372 000.00	55.00	204 600.00	204 600.00	0.00	No	n/a
- BAM	173 190.00	0.00	0.00	0.00	0.00	0.00	5 000.00	0.00	44 547.50	222 737.50	55.00	122 505.63	122 505.63	0.00	No	n/a
- BGR	128 590.00	0.00	0.00	0.00	0.00	0.00	18 500.00	0.00	36 772.50	183 862.50	55.00	101 124.38	101 124.38	0.00	No	n/a
- AMPHOS 21	128 400.00	0.00	0.00	0.00	0.00	0.00	55 500.00	0.00	45 975.00	229 875.00	55.00	126 431.25	126 431.25	0.00	No	n/a
- PEL	27 000.00	0.00	0.00	0.00	0.00	0.00	5 000.00	0.00	8 000.00	40 000.00	55.00	22 000.00	22 000.00	0.00	No	n/a

ESTIMATED BUDGET FOR THE ACTION

	Estimated eligible ¹ costs (per budget category)									EU contribution			Additional information			
	A. Direct personnel costs			B. Direct costs of subcontracting	[C. Direct costs of fin. support]	D. Other direct costs		E. Indirect costs ²	Total costs	Reimbursement rate %	Maximum EU contribution ³	Maximum grant amount ⁴	Information for indirect costs	Information for auditors	Other information:	
	A.1 Employees (or equivalent)		A.4 SME owners without salary				D.1 Travel	D.5 Costs of internally invoiced goods and services						Estimated costs of in-kind contributions not used on premises	Declaration of costs under Point D.4	Estimated costs of beneficiaries/ linked third parties not receiving funding/ international partners
A.2 Natural persons under direct contract		A.5 Beneficiaries that are natural persons without salary				D.2 Equipment										
A.3 Seconded persons						D.3 Other goods and services										
[A.6 Personnel for providing access to research infrastructure]						[D.4 Costs of large research infrastructure]										
Form of costs ⁶	Actual	Unit ⁷	Unit ⁸		Actual	Actual	Actual	Unit ⁹	Flat-rate ¹⁰							
									25%							
	a	Total b	No hours	Total c	d	[e]	f	Total g	h = 0,25 x (a +b+c+f+g +[i1] ¹³ + [i2] ¹³ -n)	j = a+b+c+d +[e]/+f+g+h +[i1]/+[i2]	k	l	m	n	Yes/No	
Total beneficiary	1 408 530.00	0.00	0.00	0.00	0.00	0.00	194 450.00	0.00	400 745.00	2 003 725.00		1 102 048.76	1 102 048.76	n/a	n/a	0.00
25. LEI	224 700.00	0.00	0.00	0.00	0.00	0.00	39 500.00	0.00	66 050.00	330 250.00	55.00	181 637.50	181 637.50	0.00	No	n/a
26. MTA EK	194 000.00	0.00	0.00	0.00	0.00	0.00	51 000.00	0.00	61 250.00	306 250.00	55.00	168 437.50	168 437.50	0.00	No	n/a
- SORC	24 000.00	0.00	0.00	0.00	0.00	0.00	19 000.00	0.00	10 750.00	53 750.00	55.00	29 562.50	29 562.50	0.00	No	n/a
Total beneficiary	218 000.00	0.00			0.00	0.00	70 000.00	0.00	72 000.00	360 000.00		198 000.00	198 000.00	n/a	n/a	0.00
27. NAGRA	395 866.67	0.00	0.00	0.00	0.00	0.00	44 300.00	0.00	110 041.67	550 208.34	55.00	302 614.59	302 614.59	0.00	No	n/a
- CIMNE	153 000.00	0.00	0.00	0.00	0.00	0.00	26 000.00	0.00	44 750.00	223 750.00	55.00	123 062.50	123 062.50	0.00	No	n/a
- EPFL	181 999.40	0.00	0.00	0.00	0.00	0.00	19 000.00	0.00	50 249.85	251 249.25	55.00	138 187.09	138 187.09	0.00	No	n/a
- UBERN	299 600.00	0.00	0.00	0.00	0.00	0.00	24 700.00	0.00	81 075.00	405 375.00	55.00	222 956.25	222 956.25	0.00	No	n/a
- ZHAW	96 999.60	0.00	0.00	0.00	0.00	0.00	15 000.00	0.00	27 999.90	139 999.50	55.00	76 999.73	76 999.73	0.00	No	n/a
Total beneficiary	1 127 465.67	0.00	0.00	0.00	0.00	0.00	129 000.00	0.00	314 116.42	1 570 582.09		863 820.16	863 820.16	n/a	n/a	0.00
28. NCSR	22 005.00	0.00	0.00	0.00	0.00	0.00	7 000.00	0.00	7 251.25	36 256.25	55.00	19 940.94	19 940.94	0.00	No	n/a
- DMT	80 220.00	0.00	0.00	0.00	0.00	0.00	13 000.00	0.00	23 305.00	116 525.00	55.00	64 088.75	64 088.75	0.00	No	n/a
Total beneficiary	102 225.00	0.00			0.00	0.00	20 000.00	0.00	30 556.25	152 781.25		84 029.69	84 029.69	n/a	n/a	0.00
29. NES	51 459.67	0.00	0.00	0.00	0.00	0.00	8 000.00	0.00	14 864.92	74 324.59	55.00	40 878.52	40 878.52	0.00	No	n/a
30. NJF	3 214.10	0.00	0.00	0.00	0.00	0.00	5 000.00	0.00	2 053.52	10 267.62	55.00	5 647.19	5 647.19	0.00	No	n/a
31. NRG	318 794.25	0.00	0.00	0.00	0.00	0.00	35 500.00	0.00	88 573.56	442 867.81	55.00	243 577.30	243 577.30	0.00	No	n/a
32. ONDRAF/ NIRAS	220 224.49	0.00	0.00	0.00	0.00	0.00	34 500.00	0.00	63 681.12	318 405.61	55.00	175 123.09	175 123.09	0.00	No	n/a
- ULiège	457 300.00	0.00	0.00	0.00	0.00	0.00	16 000.00	0.00	118 325.00	591 625.00	55.00	325 393.75	325 393.75	0.00	No	n/a
- EURIDICE	56 893.87	0.00	0.00	0.00	0.00	0.00	29 800.00	0.00	21 673.47	108 367.34	55.00	59 602.04	59 602.04	0.00	No	n/a
Total beneficiary	734 418.36	0.00			0.00	0.00	80 300.00	0.00	203 679.59	1 018 397.95		560 118.88	560 118.88	n/a	n/a	0.00
33. POSIVA	15 000.00	0.00	0.00	0.00	0.00	0.00	8 500.00	0.00	5 875.00	29 375.00	55.00	16 156.25	16 156.25	0.00	No	n/a
- Envirocase	15 888.00	0.00	0.00	0.00	0.00	0.00	5 500.00	0.00	5 347.00	26 735.00	55.00	14 704.25	14 704.25	0.00	No	n/a
Total beneficiary	30 888.00	0.00	0.00	0.00	0.00	0.00	14 000.00	0.00	11 222.00	56 110.00		30 860.50	30 860.50	n/a	n/a	0.00
34. PSI	0.00	1 625 069.60	0.00	0.00	0.00	0.00	128 891.50	0.00	438 490.28	2 192 451.38	55.00	1 205 848.26	1 205 848.26	0.00	No	n/a
- EMPA	99 000.00	0.00	0.00	0.00	0.00	0.00	22 000.00	0.00	30 250.00	151 250.00	55.00	83 187.50	83 187.50	0.00	No	n/a
Total beneficiary	99 000.00	1 625 069.60			0.00	0.00	150 891.50	0.00	468 740.28	2 343 701.38		1 289 035.76	1 289 035.76	n/a	n/a	0.00
35. PURAM	79 800.00	0.00	0.00	0.00	0.00	0.00	12 000.00	0.00	22 950.00	114 750.00	55.00	63 112.50	63 112.50	0.00	No	n/a
36. RATEN	108 328.00	0.00	0.00	0.00	0.00	0.00	57 000.00	0.00	41 332.00	206 660.00	55.00	113 663.00	113 663.00	0.00	No	n/a
37. RWM	183 807.10	0.00	0.00	0.00	0.00	0.00	44 000.00	0.00	56 951.78	284 758.88	55.00	156 617.38	156 617.38	0.00	No	n/a
38. SCK•CEN	1 415 154.61	0.00	0.00	0.00	0.00	0.00	296 145.00	0.00	427 824.90	2 139 124.51	55.00	1 176 518.48	1 176 518.48	0.00	No	n/a
39. SKB	80 550.00	0.00	0.00	0.00	0.00	0.00	19 000.00	0.00	24 887.50	124 437.50	55.00	68 440.63	68 440.63	0.00	No	n/a
- UU	272 833.40	0.00	0.00	0.00	0.00	0.00	37 000.00	0.00	77 458.35	387 291.75	55.00	213 010.46	213 010.46	0.00	No	n/a

ESTIMATED BUDGET FOR THE ACTION

	Estimated eligible ¹ costs (per budget category)									EU contribution			Additional information			
	A. Direct personnel costs			B. Direct costs of subcontracting	<i>[C. Direct costs of fin. support]</i>	D. Other direct costs		E. Indirect costs ²	Total costs	Reimbursement rate %	Maximum EU contribution ³	Maximum grant amount ⁴	Information for indirect costs	Information for auditors	Other information:	
	A.1 Employees (or equivalent)	A.4 SME owners without salary				D.1 Travel	D.5 Costs of internally invoiced goods and services						Estimated costs of in-kind contributions not used on premises	Declaration of costs under Point D.4	Estimated costs of beneficiaries/ linked third parties not receiving funding/ international partners	
A.2 Natural persons under direct contract	A.5 Beneficiaries that are natural persons without salary				D.2 Equipment											
A.3 Seconded persons					D.3 Other goods and services											
<i>[A.6 Personnel for providing access to research infrastructure]</i>					<i>[D.4 Costs of large research infrastructure]</i>											
Form of costs ⁶	Actual	Unit ⁷	Unit ⁸		Actual	Actual	Actual	Unit ⁹	Flat-rate ¹⁰							
									25%							
	a	Total b	No hours	Total c	d	<i>[e]</i>	f	Total g	h = 0,25 x (a +b+c+f+g + <i>[i1]</i> ¹³ + <i>[i2]</i> ¹³ -n)	j = a+b+c+d + <i>[e]</i> +f+g+h + <i>[i1]</i> + <i>[i2]</i>	k	l	m	n	Yes/No	
Total beneficiary	353 383.40	0.00			0.00	0.00	56 000.00	0.00	102 345.85	511 729.25		281 451.09	281 451.09	n/a	n/a	0.00
40. SSTC NRS	115 435.00	0.00	0.00	0.00	0.00	0.00	47 000.00	0.00	40 608.75	203 043.75	55.00	111 674.06	111 674.06	0.00	No	n/a
41. STUBA	17 538.00	0.00	0.00	0.00	0.00	0.00	12 500.00	0.00	7 509.50	37 547.50	55.00	20 651.13	20 651.13	0.00	No	n/a
42. SÚRAO	211 035.00	0.00	0.00	0.00	0.00	0.00	74 000.00	0.00	71 258.75	356 293.75	55.00	195 961.56	195 961.56	0.00	No	n/a
- IGN	111 588.00	0.00	0.00	0.00	0.00	0.00	8 500.00	0.00	30 022.00	150 110.00	55.00	82 560.50	82 560.50	0.00	No	n/a
- CU	123 700.00	0.00	0.00	0.00	0.00	0.00	31 800.00	0.00	38 875.00	194 375.00	55.00	106 906.25	106 906.25	0.00	No	n/a
- CTU	546 644.34	0.00	0.00	0.00	0.00	0.00	122 575.00	0.00	167 304.84	836 524.18	55.00	460 088.30	460 088.30	0.00	No	n/a
- ÚJV	305 633.15	0.00	0.00	0.00	0.00	0.00	150 480.00	0.00	114 028.29	570 141.44	55.00	313 577.79	313 577.79	0.00	No	n/a
- TUL	111 150.00	0.00	0.00	0.00	0.00	0.00	12 700.00	0.00	30 962.50	154 812.50	55.00	85 146.88	85 146.88	0.00	No	n/a
Total beneficiary	1 409 750.49	0.00			0.00	0.00	400 055.00	0.00	452 451.38	2 262 256.87		1 244 241.28	1 244 241.28	n/a	n/a	0.00
43. SURO	121 729.00	0.00	0.00	0.00	0.00	0.00	30 500.00	0.00	38 057.25	190 286.25	55.00	104 657.44	104 657.44	0.00	No	n/a
44. TNO	89 600.00	0.00	0.00	0.00	0.00	0.00	22 800.00	0.00	28 100.00	140 500.00	55.00	77 275.00	77 275.00	0.00	No	n/a
45. TS Enercon	83 396.95	0.00	0.00	0.00	0.00	0.00	12 750.00	0.00	24 036.74	120 183.69	55.00	66 101.03	66 101.03	0.00	No	n/a
46. TUS	147 416.17	0.00	0.00	0.00	0.00	0.00	38 483.40	0.00	46 474.89	232 374.46	55.00	127 805.95	127 805.95	0.00	No	n/a
47. UCyprus	19 192.46	0.00	0.00	0.00	0.00	0.00	10 500.00	0.00	7 423.11	37 115.57	55.00	20 413.56	20 413.56	0.00	No	n/a
48. UHelsinki	0.00	205 000.00	0.00	0.00	0.00	0.00	17 600.00	0.00	55 650.00	278 250.00	55.00	153 037.50	153 037.50	0.00	No	n/a
- Aalto	32 850.00	0.00	0.00	0.00	0.00	0.00	5 000.00	0.00	9 462.50	47 312.50	55.00	26 021.88	26 021.88	0.00	No	n/a
- TUT	116 000.00	0.00	0.00	0.00	0.00	0.00	8 000.00	0.00	31 000.00	155 000.00	55.00	85 250.00	85 250.00	0.00	No	n/a
- JYU	122 200.00	0.00	0.00	0.00	0.00	0.00	25 000.00	0.00	36 800.00	184 000.00	55.00	101 200.00	101 200.00	0.00	No	n/a
- GTK	42 500.00	0.00	0.00	0.00	0.00	0.00	39 000.00	0.00	20 375.00	101 875.00	55.00	56 031.25	56 031.25	0.00	No	n/a
Total beneficiary	313 550.00	205 000.00			0.00	0.00	94 600.00	0.00	153 287.50	766 437.50		421 540.63	421 540.63	n/a	n/a	0.00
49. UKRI	1 060 314.47	0.00	0.00	0.00	0.00	0.00	260 884.08	0.00	330 299.64	1 651 498.19	55.00	908 324.00	908 324.00	0.00	No	n/a
50. VTT	0.00	527 168.50	0.00	0.00	0.00	0.00	187 442.01	0.00	178 652.63	893 263.14	55.00	491 294.73	491 294.73	0.00	Yes	n/a
- GSL	127 980.00	0.00	0.00	0.00	0.00	0.00	10 500.00	0.00	34 620.00	173 100.00	55.00	95 205.00	95 205.00	0.00	No	n/a
Total beneficiary	127 980.00	527 168.50	0.00	0.00	0.00	0.00	197 942.01	0.00	213 272.63	1 066 363.14		586 499.73	586 499.73	n/a	n/a	0.00
51. VUJE	6 700.00	0.00	0.00	0.00	0.00	0.00	5 000.00	0.00	2 925.00	14 625.00	55.00	8 043.75	8 043.75	0.00	No	n/a
Total consortium	38 433 573.04	3 141 270.99		0.00	688 602.50	0.00	5 812 071.22	0.00	11 846 728.86	59 922 246.61		32 957 235.66	32 500 000.00			0.00

¹ See Article 6 for the eligibility conditions.

² Indirect costs already covered by an operating grant (received under any EU or Euratom funding programme; see Article 6.5.(b)) are ineligible under the GA. Therefore, a beneficiary/linked third party that receives an operating grant during the action's duration cannot declare indirect costs for the year(s)/reporting period(s) covered by the operating grant, unless it can demonstrate that the operating grant does not cover any costs of the action (see Article 6.2.E).

³ This is the theoretical amount of EU contribution that the system calculates automatically (by multiplying all the budgeted costs by the reimbursement rate). This theoretical amount is capped by the 'maximum grant amount' (that the Commission decided to grant for the action) (see Article 5.1).

⁴ The 'maximum grant amount' is the maximum grant amount decided by the Commission. It normally corresponds to the requested grant, but may be lower.

⁵ Depending on its type, this specific cost category will or will not cover indirect costs. Specific unit costs that include indirect costs are: costs for energy efficiency measures in buildings, access costs for providing trans-national access to research infrastructure and costs for clinical studies.

⁶ See Article 5 for the forms of costs.

⁷ Unit : hours worked on the action; costs per unit (hourly rate) : calculated according to the beneficiary's usual accounting practice.

ESTIMATED BUDGET FOR THE ACTION

⁸ See Annex 2a 'Additional information on the estimated budget' for the details (costs per hour (hourly rate)).

⁹ Unit and costs per unit : calculated according to the beneficiary's usual accounting practices.

¹⁰ Flat rate : 25% of eligible direct costs, from which are excluded: direct costs of subcontracting, costs of in-kind contributions not used on premises, direct costs of financial support, and unit costs declared under budget category F if they include indirect costs (see Article 6.2.E).

¹¹ See Annex 2a 'Additional information on the estimated budget' for the details (units, costs per unit).

¹² See Annex 2a 'Additional information on the estimated budget' for the details (units, costs per unit, estimated number of units, etc).

¹³ Only specific unit costs that do not include indirect costs.

¹⁴ See Article 9 for beneficiaries not receiving funding.

¹⁵ Only for linked third parties that receive funding.

ANNEX 2a

ADDITIONAL INFORMATION ON THE ESTIMATED BUDGET

- Instructions and footnotes in blue will not appear in the text generated by the IT system (since they are internal instructions only).
- For options [in square brackets]: the applicable option will be chosen by the IT system. Options not chosen will automatically not appear.
- For fields in [grey in square brackets] (even if they are part of an option as specified in the previous item): IT system will enter the appropriate data.

 **Transitory period:** Until SyGMA fully supports Annex 2a, you must prepare it manually (using this template by choosing and deleting the options/entering the appropriate data).
For the 'unit cost tables': either fill them out manually or use currently existing tables from Annex 1 or the proposal.
The document can then be uploaded in SyGMA and attached to the grant agreement.

Unit cost for SME owners/natural beneficiaries without salary

1. Costs for a [SME owner]/[beneficiary that is a natural person] not receiving a salary

Units: hours worked on the action

Amount per unit ('hourly rate'): calculated according to the following formula:

{the monthly living allowance for researchers in MSCA-IF actions / 143 hours}
multiplied by
{country-specific correction coefficient of the country where the beneficiary is established}

The monthly living allowance and the country-specific correction coefficients are set out in the Work Programme (section 3 MSCA) in force at the time of the call:

- for calls *before* Work Programme 2018-2020:
 - for the monthly living allowance: **EUR 4 650**
 - for the country-specific correction coefficients: see Work Programme 2014-2015 and Work Programme 2016-2017 (available on the [Participant Portal Reference Documents](#) page)
- for calls *under* Work Programme 2018-2020:
 - for the monthly living allowance: **EUR 4 880**
 - for the country-specific correction coefficients: see Work Programme 2018-2020 (available on the [Participant Portal Reference Documents](#) page)

[additional OPTION for beneficiaries/linked third parties that have opted to use the unit cost (in the proposal/with an amendment): For the following beneficiaries/linked third parties, the amounts per unit (hourly rate) are fixed as follows:

- beneficiary/linked third party [short name]: EUR [insert amount]
- beneficiary/linked third party [short name]: EUR [insert amount]
- [same for other beneficiaries/linked third parties, if necessary]]

Estimated number of units: see Annex 2

Energy efficiency measures unit cost

[OPTION if specific unit cost applicable to the grant: 2. Costs for energy efficiency measures in buildings

Unit: m² of eligible 'conditioned' (i.e. built or refurbished) floor area

Amount per unit*: see (for each beneficiary/linked third party and BEST table) the 'unit cost table' attached

* Amount calculated as follows:
{EUR 0.1 x estimated total kWh saved per m² per year x 10}

Estimated number of units: see (for each beneficiary/linked third party and BEST table) the 'unit cost table' attached

Unit cost table (energy efficiency measures unit cost)¹

Short name beneficiary/linked third party	BEST No	Cost Amount per unit	Estimated No of units	Total unit cost (cost per unit x estimated no of units)

Clinical studies unit cost

[OPTION if specific unit cost is applicable to the grant: 3. Costs for clinical studies

Units: patients/subjects that participate in the clinical study

Amount per unit*: see (for each sequence (if any), clinical study and beneficiary/linked third party) the 'unit cost table' attached

Estimated number of units: see (for each clinical study and beneficiary/linked third party) the 'unit cost table' attached

* Amount calculated, for the cost components of each task, as follows:

For personnel costs:

For personnel costs of doctors: 'average hourly cost for doctors', i.e.:

{certified or auditable total personnel costs for doctors for year N-1
{1720 * number of full-time-equivalent for doctors for year N-1}
multiplied by
estimated number of hours to be worked by doctors for the task (per participant))}

For personnel costs of other medical personnel: 'average hourly cost for other medical personnel', i.e.:

{certified or auditable total personnel costs for other medical personnel for year N-1
{1720 * number of full-time-equivalent for other medical personnel for year N-1}
multiplied by
estimated number of hours to be worked by other medical personnel for the task (per participant))}

For personnel costs of technical personnel: 'average hourly cost for technical personnel', i.e.:

{certified or auditable total personnel costs for technical personnel for year N-1
{1720 * number of full-time-equivalent for technical personnel for year N-1}
multiplied by

¹ Data from the 'building energy specification table (BEST)' that is part of the proposal and Annex 1.

estimated number of hours to be worked by technical personnel for the task (per participant))

‘total personnel costs’ means actual salaries + actual social security contributions + actual taxes and other costs included in the remuneration, provided they arise from national law or the employment contract/equivalent appointing act

For consumables:

For each cost item: ‘average price of the consumable’, i.e.:

$$\frac{\{\{\text{certified or auditable total costs of purchase of the consumable in year N-1}\}}{\text{total number of items purchased in year N-1}} \\ \text{multiplied by} \\ \text{estimated number of items to be used for the task (per participant)}\}$$

‘total costs of purchase of the consumable’ means total value of the supply contracts (including related duties, taxes and charges such as non-deductible VAT) concluded by the beneficiary for the consumable delivered in year N-1, provided the contracts were awarded according to the principle of best value- for-money and without any conflict of interests

For medical equipment:

For each cost item: ‘average cost of depreciation and directly related services per unit of use’, i.e.:

$$\frac{\{\{\text{certified or auditable total depreciation costs in year N-1} + \text{certified or auditable total costs of purchase of services in year N-1 for the category of equipment concerned}\}}{\text{total capacity in year N-1}} \\ \text{multiplied by} \\ \text{estimated number of units of use of the equipment for the task (per participant)}\}$$

‘total depreciation costs’ means total depreciation allowances as recorded in the beneficiary’s accounts of year N-1 for the category of equipment concerned, provided the equipment was purchased according to the principle of best value for money and without any conflict of interests + total costs of renting or leasing contracts (including related duties, taxes and charges such as non-deductible VAT) in year N-1 for the category of equipment concerned, provided they do not exceed the depreciation costs of similar equipment and do not include finance fees

For services:

For each cost item: ‘average cost of the service per study participant’, i.e.:

$$\frac{\{\{\text{certified or auditable total costs of purchase of the service in year N-1}\}}{\text{total number of patients or subjects included in the clinical studies for which the service was delivered in year N-1}} \\ \text{multiplied by} \\ \text{estimated number of units of use of the equipment for the task (per participant)}\}$$

‘total costs of purchase of the service’ means total value of the contracts concluded by the beneficiary (including related duties, taxes and charges such as non-deductible VAT) for the specific service delivered in year N-1 for the conduct of clinical studies, provided the contracts were awarded according to the principle of best value for money and without any conflict of interests

For indirect costs:

$$\{\{\{\text{cost component ‘personnel costs’} + \text{cost component ‘consumables’} + \text{cost component ‘medical equipment’}\}} \\ \text{minus} \\ \{\text{costs of in-kind contributions provided by third parties which are not used on the beneficiary’s premises} \\ + \text{costs of providing financial support to third parties (if any)}\}\} \\ \text{multiplied by} \\ 25\%\}$$

The estimation of the resources to be used must be done on the basis of the study protocol and must be the same for all beneficiaries/linked third parties/third parties involved.

The year N-1 to be used is the last closed financial year at the time of submission of the grant application.

Unit cost table: clinical studies unit cost²

Task, Direct cost categories	Resource per patient	Costs year N-1 Beneficiary 1 [short name]	Costs year N-1 Linked third party 1a [short name]	Costs year N-1 Beneficiary 2 [short name]	Costs year N-1 Linked third party 2a [short name]	Costs year N-1 Third party giving in-kind contributions 1 [short name]
Sequence No. 1						
Task No. 1 Blood sample						
(a) Personnel costs:						
- Doctors	n/a					
- Other Medical Personnel	Phlebotomy (nurse), 10 minutes	8,33 EUR	11,59 EUR	10,30 EUR	11,00 EUR	9,49 EUR
- Technical Personnel	Sample Processing (lab technician), 15 minutes	9,51 EUR	15,68 EUR	14,60 EUR	15,23 EUR	10,78 EUR
(b) Costs of consumables:	Syringe	XX EUR	XX EUR	XX EUR	XX EUR	XX EUR
	Cannula	XX EUR	XX EUR	XX EUR	XX EUR	XX EUR
	Blood container	XX EUR	XX EUR	XX EUR	XX EUR	XX EUR
(c) Costs of medical equipment:	Use of -80° deep freezer, 60 days	XX EUR	XX EUR	XX EUR	XX EUR	XX EUR
	Use of centrifuge, 15 minutes	XX EUR	XX EUR	XX EUR	XX EUR	XX EUR
(d) Costs of services	Cleaning of XXX	XX EUR	XX EUR	XX EUR	XX EUR	XX EUR
(e) Indirect costs (25% flat-rate)		XX EUR	XX EUR	XX EUR	XX EUR	XX EUR
Task No. 2						
...						
Amount per unit (unit cost sequence 1):		XX EUR	XX EUR	XX EUR	XX EUR	XX EUR
Sequence No. 2						
Task No. 1 XXX						
(a) Personnel costs:						
- Doctors	XXX	XX EUR	XX EUR	XX EUR	XX EUR	XX EUR
- Other Medical Personnel	XXX	XX EUR	XX EUR	XX EUR	XX EUR	XX EUR

² Same table as in proposal and Annex 1.

- Technical Personnel	XXX	XX EUR	XX EUR	XX EUR	XX EUR	XX EUR
(b) Costs of consumables:	XXX	XX EUR	XX EUR	XX EUR	XX EUR	XX EUR
	XXX	XX EUR	XX EUR	XX EUR	XX EUR	XX EUR
	XXX	XX EUR	XX EUR	XX EUR	XX EUR	XX EUR
(c) Costs of medical equipment:	XXX	XX EUR	XX EUR	XX EUR	XX EUR	XX EUR
	XXX	XX EUR	XX EUR	XX EUR	XX EUR	XX EUR
(d) Costs of services	XXX	XX EUR	XX EUR	XX EUR	XX EUR	XX EUR
(e) Indirect costs (25% flat-rate)		XX EUR	XX EUR	XX EUR	XX EUR	XX EUR
Task No. 2						
...						
Amount per unit (unit cost sequence 2):		XX EUR	XX EUR	XX EUR	XX EUR	XX EUR
...						
Amount per unit (unit cost entire study):		XX EUR	XX EUR	XX EUR	XX EUR	XX EUR

J

EJP Euratom Fusion unit costs

[OPTION if specific unit cost applicable to the grant: 4. Costs for mobility of personnel

Daily subsistence allowance

Units: days spent by the personnel on secondment

Amount per unit*: see (for each beneficiary/linked third party and secondment) the 'unit cost table' attached

* Amount calculated as follows:

{EUR 127.65

multiplied by

country-specific correction coefficient of the place of secondment}

Country-specific correction coefficients applied until 31 December 2015³:

Country/place	Coefficient (%)	Country/place	Coefficient (%)
Austria	106.4	Italy	104.2
Bulgaria	58.4	Italy Varese	93.4

³ For the 'estimated budget (Annex 2)': country coefficient for UK Culham (i.e. 112.5%) should be used. (⚠️ For the 'financial statements', the amount must be adjusted according to the actual place of secondment.) The country-specific coefficient is based on Regulation (EU) No [423/2014](#) of the European Parliament and of the Council of 16 April 2014 adjusting with effect from 1 July 2012 the remuneration and pensions of officials and other servants of the European Union and the correction coefficients applied thereto (OJ L 129, 30.04.2014, p. 12). Revised coefficients (based on 1 October 2015 values) will be applied as from 1 January 2016 through an amendment to the grant agreement.

Croatia	80.0	Latvia	77.6
Cyprus	84.1	Lithuania	71.5
Czech Rep.	80.6	Malta	83.3
Denmark	135.3	Netherlands	105.3
Estonia	77.6	Poland	74.2
Finland	122.1	Portugal	83.5
France	117.7	Romania	68.8
Germany	95.8	Slovakia	79.7
<i>Germany Bonn</i>	94.1	Slovenia	85.3
<i>Germany Karlsruhe</i>	93.8	Spain	97.1
<i>Germany Munich</i>	106.4	Sweden	131.9
		<i>Switzerland Geneva</i>	124.6
Greece	90.5	<i>Switzerland Berne</i>	123.3
Hungary	78.3		
Ireland	110.6	United Kingdom	147.8
		<i>UK Culham</i>	112.5

Country-specific correction coefficients as from 1 January 2016⁴:

Country/place	Coefficient (%)	Country/place	Coefficient (%)
Austria	105.9	Italy	99.4
Bulgaria	52.1	<i>Italy Varese</i>	92.2
Croatia	74.6	Latvia	74.2
Cyprus	77.3	Lithuania	69.0
Czech Rep.	73.4	Malta	84.5
Denmark	131.8	Netherlands	107.8
Estonia	78.0	Poland	71.8
Finland	119.7	Portugal	79.2
France	114.6	Romania	64.8
Germany	96.6	Slovakia	76.4
<i>Germany Bonn</i>	93.4	Slovenia	81.2
<i>Germany Karlsruhe</i>	93.8	Spain	90.2
<i>Germany Munich</i>	106.0	Sweden	127.9
Greece	79.9	<i>Switzerland</i>	142.4
Hungary	69.0		
Ireland	116.6	United Kingdom	166.9
		<i>UK Culham</i>	127.7

⁴ For the 'estimated budget (Annex 2)': country coefficient for UK Culham (i.e. 127.7%) should be used. (⚠️)
For the 'financial statements', the amount must be adjusted according to the actual place of secondment.)
The revised country coefficients are based on the 2015 update of the remuneration and pensions of the officials and other servants of the European Union and the correction coefficients applied thereto (OJ C 415, 15.12.2015, p.4). The revised coefficients were introduced into the EJP Euratom Fusion grant agreement through an amendment.

Estimated number of units: see (for each beneficiary/linked third party and secondment) the ‘unit cost table’ attached

Monthly subsistence allowance

Units: months spent by the personnel on secondment

Amount per unit*: see (for each beneficiary/linked third party and secondment) the ‘unit cost table’ attached

* Amount calculated as follows:

{[insert amount from the table below, depending on the distance between the place where the individual was working before the secondment and the place of secondment]}⁵:

Distance between place of employment and place of secondment (km)	Monthly allowance (EUR)
0 – 150	0
> 150	82.05
> 300	145.86
> 500	237.05
> 800	382.92
> 1 300	601.73
> 2 000	720.27

multiplied by
country-specific correction coefficient of the place of secondment}

For the country-specific correction coefficient, see above (daily subsistence allowance)⁶.

Estimated number of units: see (for each beneficiary/linked third party and secondment) the ‘unit cost table’ attached

Family allowance

Units: months spent on secondment

Amount per unit*: see (for each beneficiary/linked third party and secondment) the ‘unit cost table’ attached

* Amount calculated as follows:

{EUR 252.81 x number of dependent children⁷}

⁵ For the ‘estimated budget (Annex 2)’: the distance between the place of employment and UK Culham should be used. (⚠ For the ‘financial statements’, the amount must be adjusted according to the actual place of secondment.)

⁶ For the ‘estimated budget (Annex 2)’: the country coefficient for UK Culham (i.e. 112.5% until 31.12.2015 or 127.7% from 01.01.2016) should be used. (⚠ For the ‘financial statements’, the amount must be adjusted according to the actual place of secondment.)

⁷ For the ‘estimated budget (Annex 2)’: an average should be used. (⚠ For the ‘financial statements’, the number of children (and months) must be adjusted according to the actual family status at the moment the secondment starts.)

Estimated number of units: see (for each beneficiary/linked third party and secondment) the ‘unit cost table’ attached

Unit cost table (EJP Fusion mobility unit cost)

Short name beneficiary/linked third party	Secondment (name*, destination, duration**)	Type of unit cost	Unit	Amount per unit	Estimated No of units	Total unit cost (cost per unit x estimated no of units)
[insert short name of beneficiary/linked third party]	NN, UK Culham, 3 days	Daily subsistence allowance	days		3	
		Monthly subsistence allowance	months		0	
		Family allowance	months		0	
	NN, UK Culham, 3 months (= 90 days)	Daily subsistence allowance	days		90	
		Monthly subsistence allowance	months		3	
		Family allowance	months		3	
	NN, UK Culham, 8 months (= 240 days)	Daily subsistence allowance	days		240	
		Monthly subsistence allowance	months		8	
		Family allowance	months		8	
	NN, UK Culham, 20 days	Daily subsistence allowance	days		20	
		Monthly subsistence allowance	months		0	
		Family allowance	months		0	
	...					
[insert short name of beneficiary/linked third party]	NN, UK Culham, 25 months (= 750 days)	Daily subsistence allowance	days		750	
		Monthly subsistence allowance	months		25	
		Family allowance	months		25	
	NN, UK Culham, 15 days	Daily subsistence allowance	days		15	
		Monthly subsistence allowance	months		0	
		Family allowance	months		0	
	NN, UK Culham, 8 months (= 240 days)	Daily subsistence allowance	days		240	
		Monthly subsistence allowance	months		8	
		Family allowance	months		8	
	...					
...		Daily subsistence allowance	days			
		Monthly subsistence allowance	months			
		Family allowance	months			
		Daily subsistence allowance	days			
		Monthly subsistence allowance	months			
		Family allowance	months			
		Daily subsistence allowance	days			
		Monthly subsistence allowance	months			
		Family allowance	months			
		Daily subsistence allowance	days			
		Monthly subsistence allowance	months			
		Family allowance	months			
		Daily subsistence allowance	days			
		Monthly subsistence allowance	months			
		Family allowance	months			

* For the 'estimated budget': NN should be used. (For the 'financial statements', NN should be changed to the real name.)

** For the 'estimated budget': count 30 days per month. (For the 'financial statements', the number of days and months must be adapted according to the actual duration of the secondment — according to the calculation explained in the 'AGA – Annotated Grant Agreement' published on the [Participant Portal](#).)

[OPTION if specific unit cost applicable to the grant: 5. Costs for fellowships for researchers]

Living allowance

Units: months spent by the fellow on fellowship

Amount per unit*: see (for each beneficiary/linked third party and fellowship) the 'unit cost table' attached

* Amount calculated as follows:

{the monthly living allowance for researchers in MSCA-IF/MSCA-ITN actions multiplied by country-specific correction coefficient of [OPTION by default: the country in which the researcher is recruited][OPTION for IF-global fellowship: the country where the partner organisation hosting the researcher during a secondment is located (for the outgoing phase) and the country in which the researcher is recruited (for the return phase)]}

The monthly living allowance and the country-specific correction coefficients are set out in the Work Programme (section 3 MSCA) in force at the time of the call:

- for calls *before* Work Programme 2018-2020:
 - for the monthly living allowance:
 - IF: **EUR 4 650**
 - ITN: **EUR 3 110**
 - for the country-specific correction coefficients: see Work Programme 2014-2015 and Work Programme 2016-2017 (available on the [Participant Portal Reference Documents](#) page)
- for calls *under* Work Programme 2018-2020:
 - for the monthly living allowance:
 - IF: **EUR 4 880**
 - ITN: **EUR 3 270**
 - for the country-specific correction coefficients: see Work Programme 2018-2020 (available on the [Participant Portal Reference Documents](#) page).

Country-specific correction coefficient⁸:

Country	Coefficient	Country	Coefficient
Austria	104.8%	Italy	106.7%
Belgium	100.0%	Lithuania	73.1%
Bulgaria	71.5%	Luxembourg	100.0%
Cyprus	91.8%	Latvia	75.9%
Czech Republic	83.8%	Malta	89.6%
Germany	98.8%	Netherlands	104.3%
Denmark	135.3%	Poland	76.4%
Estonia	78.3%	Portugal	89.1%

⁸ For the 'estimated budget (Annex 2)': the country coefficient for Belgium (i.e. 100%) should be used. For the 'financial statements', the amount must be adjusted according to the actual country of fellowship. The country-specific coefficient is based on the Marie Skłodowska Curie country-specific coefficients (see Table 3 of the 2014-2015 [Main Work Programme — MSCA](#)).

Greece	92.7%	Romania	68.3%
Spain	97.6%	Sweden	111.7 %
Finland	116.6%	Slovenia	86.1%
France	111.0%	Slovakia	82.6%
Croatia	97.5%	United Kingdom	120.3%
Hungary	76.2%		
Ireland	113.5%	Switzerland	113.1%

Estimated number of units: see (for each beneficiary/linked third party and fellowship) the ‘unit cost table’ attached

Mobility allowance

Units: months spent by the fellow on fellowship

Amount per unit⁹: **EUR 600**

Estimated number of units: see (for each beneficiary/linked third party and fellowship) the ‘unit cost table’ attached

Family allowance

Units: months spent by the fellow on fellowship

Amount per unit¹⁰: **EUR 500**

Estimated number of units: see (for each beneficiary/linked third party and fellowship) the ‘unit cost table’ attached

Unit cost table (EJP Fusion fellowship unit cost)

Short name beneficiary/linked third party	Fellowship (name, type of fellow, destination, duration)	Type of unit cost	Amount per unit	Estimated No of units	Total unit cost (cost per unit x estimated no of units)
[insert short name of beneficiary/linked third party]	NN, early stage researcher, Belgium, 3 months	Living allowance	XX EUR	3	
		Mobility allowance	600	3	
		Family allowance	500	3	
	NN, early stage researcher, Belgium, 15 months	Living allowance	XX EUR	15	
		Mobility allowance	600	15	
		Family allowance	500	15	
	NN, experienced researcher, Belgium, 9 months	Living allowance	XX EUR	9	
		Mobility allowance	600	9	
		Family allowance	500	9	
	...				
[insert short name of beneficiary/linked third party]	NN, experienced researcher, Belgium, 20 months	Living allowance	XX EUR	20	
		Mobility allowance	600	20	
		Family allowance	500	20	

⁹ Same for all beneficiaries/linked third parties.

¹⁰ Same for all beneficiaries/linked third parties.

	NN, early stage researcher, Belgium, 8 months	Living allowance	XX EUR	8	
		Mobility allowance	600	8	
		Family allowance	500	8	
	NN, experience researcher, Belgium, 7 months	Living allowance	XX EUR	7	
		Mobility allowance	600	7	
		Family allowance	500	7	
...	...				
		Living allowance	XX EUR		
		Mobility allowance	600		
		Family allowance	500		
		Living allowance	XX EUR		
		Mobility allowance	600		
		Family allowance	500		
		Living allowance	XX EUR		
		Mobility allowance	600		
		Family allowance	500		

6. Access costs for research infrastructure

Units¹¹: see (for each beneficiary/linked third party and installation) the ‘unit cost table’ attached

Amount per unit^{*}: see (for each beneficiary/linked third party and installation) the ‘unit cost table’ attached

* Amount calculated as follows:

average annual total access cost to the installation (over past two years¹²)

average annual total quantity of access to the installation (over past two years¹³)

Estimated number of units: see (for each beneficiary/linked third party and installation) the ‘unit cost table’ attached

Unit cost table (EJP Fusion access to research infrastructure unit cost)

Short name beneficiary/linked third party	Short name infrastructure	Installation		Unit of access	Amount per unit	Estimated No of units	Total unit cost (cost per unit x estimated no of units)
		No	Short name				

J

¹¹ Unit of access (e.g. beam hours, weeks of access, sample analysis) fixed by the access provider in proposal.

¹² In exceptional and duly justified cases, the Commission/Agency may agree to a different reference period.

¹³ In exceptional and duly justified cases, the Commission/Agency may agree to a different reference period.

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

ARAO-AGENCIJA ZA RADIOAKTIVNE ODPADKE LJUBLJANA ZAVOD (ARAO), established in CELOVSKA C. 182, LJUBLJANA 1000, Slovenia, VAT number: SI32495854, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('2')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

BEL V (BEL V), established in RUE WALCOURT 148, BRUXELLES 1070, Belgium, VAT number: BE0892419202, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('3')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

BUNDES-GESELLSCHAFT FUR ENDLAGERUNGMBH (BGE) (BGE), established in ESCHENSTRASSE 55, PEINE 31224, Germany, VAT number: DE308282389, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('4')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES (CEA), established in RUE LEBLANC 25, PARIS 15 75015, France, VAT number: FR43775685019, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('5')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

CENTRO DE INVESTIGACIONES ENERGETICAS, MEDIOAMBIENTALES Y TECNOLOGICAS-CIEMAT (CIEMAT), established in Avenida Complutense 40, MADRID 28040, Spain, VAT number: ESQ2820002J, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('6')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

PUBLIC UNION CHORNOBYL RESEARCH AND DEVELOPMENT INSTITUTE (ChRDI), established in PECHERSKIY DISTRICT, STARONAVODNITSKA ST. 6B OFFICE 272, KYIV 01015, Ukraine, VAT number: UA403675526559, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('7')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS (CNRS), established in RUE MICHEL ANGE 3, PARIS 75794, France, VAT number: FR40180089013, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('8')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

CENTRALE ORGANISATIE VOOR RADIOACTIEF AFVAL NV (COVRA), established in SPANJEWEG 1 HAVEN 8601, NIEUWDORP ZLD 4455 TW, Netherlands, VAT number: NL008836309B01, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('9')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

VALSTYBINIS MOKSLINIŲ TYRIMŲ INSTITUTAS FIZINIŲ IR TECHNOLOGIJOS MOKSLŲ CENTRAS (FTMC), established in Savanorių 231, VILNIUS 02300, Lithuania, VAT number: LT100005300110, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('10')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Gintaras VALUŠIS with ECAS id nvalugin signed in the Participant Portal on 28/05/2019 at 11:54:44 (transaction id SigId-63049-AuBp4cFMEXxbfEtvJY1zXzTXso5iiP1ZGABrehzHAadkwqBPjhWtHzYGeYV0zuyXtDxip6AT3zTV6FN5OBxE77Bm-jpJZscgsw0Kv1vxGC5zvJV-YrN7pdicLORzjgBJ6BGzuE0VzsCAABRiED9SgCJD5e80)
Timestamp by third party at
Tue May 28 12:54:51 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

CENTRUM VYZKUMU REZ S.R.O. (CV REZ), established in HUSINEC-REZ 130, HUSINEC-REZ 250 68, Czech Republic, VAT number: CZ26722445, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('11')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Lukas VESELY with ECAS id nveseluk signed in the Participant Portal on 27/05/2019 at 14:18:15 (transaction id SigId-52780-wBJMSPNWqyyNzSViKqJhA3x75P0aBQPZ2VbdmvPxr46EWDfWJtqL0m1ZcKkKkVAOyDnM6S9u3SzhRi4qBMJPgK-jpJZscgsw0Kv1vxGC5zvJV-bSkOwG5GTTpR2DSF22olYOiDCOzY1Zg8pMbBIDIBy98). Timestamp by third party at Mon May 27 15:18:22 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

DANSK DEKOMMISSIONERING (Dekom), established in FREDERIKSBORGVEJ 399, Roskilde 4000, Denmark, VAT number: DK26144744, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('12')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Merete Soerensen with ECAS id n002p92t signed in the Participant Portal on 28/05/2019 at 07:43:42 (transaction id SigId-57977-wn63yRxqmNqoplXzMkobG3khL4M9GOiucEe8AAfSfhV039oUVJZ2AxIFHn9INyAoq1Ru5c6JCTXotL49JvdMzX-jpJZscgsw0Kv1vxGC5zvJV-dDvg6KseS1qPEYAic8vmP5eVzY7UgCxb9QAKBLsSMt4)
. Timestamp by third party at
Tue May 28 08:43:57 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

ELLINIKI EPITROPI ATOMIKIS ENERGEIAS (EEAE), established in NEAPOLEOS 4 PATRIARCHOU GRIGORIOU, AGHIA PARASKEVI 15310, Greece, VAT number: EL090085792, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('13')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

EMPRESA NACIONAL DE RESIDUOS RADIOACTIVOS S.A. (ENRESA), established in Calle Emilio Vargas 7, MADRID 28043, Spain, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('14')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Mariano NAVARRO SANTOS with ECAS id nnamiano
signed in the Participant Portal on 27/05/2019 at 10:15:58
(transaction id SigId-47643-
G0kAYwArSduDJ4pOjEYYPY0zsgzNZJwMHVgRgMtVzo5
nzR8rJcs5Xdl1JiwezN0endE8mgGdzMAAdKQA3weoVEzc8
-jpJZscgsw0Kv1vxGC5zvJV-
BQUFGNbSb9Ki7nRmDhkQgszYPjgxio0pjOZylD6PwTG).
Timestamp by third party at
Mon May 27 11:16:04 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

FORSCHUNGSZENTRUM JULICH GMBH (JUELICH), established in WILHELM JOHNEN STRASSE, JULICH 52428, Germany, VAT number: DE122624631, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('15')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

GESELLSCHAFT FUR ANLAGEN UND REAKTORSICHERHEIT (GRS) gGmbH (GRS), established in SCHWERTNERGASSE 1, KOLN 50667, Germany, VAT number: DE122792708, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('16')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

VALSTYBES IMONE IGNALINOS ATOMINE ELEKTRINE (IAE), established in ELEKTRINES G. 4, K47, DRUKSINIU, VISAGINAS 31152, Lithuania, VAT number: LT554500811, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('17')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

INSTYTUT CHEMII I TECHNIKI JADROWEJ (INCT), established in ul. Dorodna 16, WARSZAWA 03-195, Poland, VAT number: PL5250008330, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('18')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Andrzej CHMIELEWSKI with ECAS id nchmiand signed in the Participant Portal on 25/05/2019 at 19:52:41
(transaction id SigId-43647-oi03Hw3QYH4kN6LqMsf9qbR2RT7TISBAM7hygkaO0b3FBJJ8vwDcwzzpLcoA4sOUEgqzW9vNQCMp8QC5iyXnc0-jpJZscgsw0Kv1vxGC5zvJV-LJL0BpzwlGLC8szvZiUgfJPAMHXd7BXzbDIDK5MhYHzY)
. Timestamp by third party at
Sat May 25 20:52:46 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

INSTITUT DE RADIOPROTECTION ET DE SURETE NUCLEAIRE (IRSN), established in AV DE LA DIVISION LECLERC 31, FONTENAY AUX ROSES 92260, France, VAT number: FR68440546018, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('19')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

INSTITUTO SUPERIOR TECNICO (IST), established in AVENIDA ROVISCO PAIS 1, LISBOA 1049-001, Portugal, VAT number: PT501507930, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('20')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Arlindo OLIVEIRA with ECAS id nolivarI signed in the Participant Portal on 27/05/2019 at 19:26:34 (transaction id SigId-56857-euhLzRtglp3FzK49s0WAXJzbuUikJ3zSWUVbmAizW9ksbZzV85BT5eoPJcki6Xbv7Je5vhBh135PYaieZ1TK6coW-jpJZscgsw0Kv1vxGC5zvJV-CpUJ60cZgzT38eZXDfDLvFFA53a6cgsBiZKhbdVRjJP).
Timestamp by third party at
Mon May 27 20:26:45 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

ASSOCIACAO DO INSTITUTO SUPERIOR TECNICO PARA A INVESTIGACAO E DESENVOLVIMENTO (IST ID), established in AVENIDA ROVISCO PAIS 1, LISBOA 1049 001, Portugal, VAT number: PT509830072, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('21')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Arlindo OLIVEIRA with ECAS id nolivarl signed in the Participant Portal on 27/05/2019 at 19:27:40 (transaction id SigId-56860-fqCPfuzMhd6YvG7nIrTWrHWG5h1OWH5tzY6v7CjM7FP F9pgfGgKdojkVD0vqVRFYmmHbWNj3AQMKAJ1ysqt5Am-jpJZscgsw0Kv1vxGC5zvJV-0DZP1jikQ6yszevj5Ycj9fsAsZulY0VDMHPg6DJ4Gzbm).
Timestamp by third party at
Mon May 27 20:27:50 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

INSTITUT JOZEF STEFAN (JSI), established in Jamova 39, LJUBLJANA 1000, Slovenia, VAT number: SI55560822, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('22')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Jadran LENARČIČ with ECAS id nlenjada signed in the Participant Portal on 27/05/2019 at 07:41:54 (transaction id SigId-44863-IsczTude0Kv1zQjIQ8TyleH54MTktak95mJzYKnNEBSSIhtEYIQLcPY2msLqBYUMw41MhmlL3LSlcRTZ9w3ICZG-jpJZscgsw0Kv1vxGC5zvJV-3szVXGaU5w5TFjclMv6d0vuc9ZO3Lt7h7PxRzpK0QspG).
Timestamp by third party at
Mon May 27 08:42:07 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

KARLSRUHER INSTITUT FÜR TECHNOLOGIE (KIT), established in KAISERSTRASSE 12, KARLSRUHE 76131, Germany, VAT number: DE266749428, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('24')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

LIETUVOS ENERGETIKOS INSTITUTAS (LEI), established in Breslaujos g. 3, KAUNAS LT-44403, Lithuania, VAT number: LT119552113, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('25')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Sigitas RIMKEVIČIUS with ECAS id nrimksig signed in the Participant Portal on 27/05/2019 at 08:15:25 (transaction id SigId-45240-EtWaDneCMIzeetL3DyKzS17YuGvcZl1Te0bedSBjcdVPsi7jiPgqyHwwxfE0OEDzZueY4zLTPjwPU8Bdno360FS-jpJZscgsw0Kv1vxGC5zvJV-OdBehNEtYeqF2aXbE6x3UzziOeaTkm49YI4WmfBZlgSG)
. Timestamp by third party at
Mon May 27 09:15:33 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

MAGYAR TUDOMANYOS AKADEMIA ENERGIATUDOMANYI KUTATOKOZPONT (MTA EK), established in KONKOLY THEGE MIKLOS UT 29-33, Budapest 1121, Hungary, VAT number: HU 15327040, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('26')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Ákos HORVÁTH with ECAS id nhorvako signed in the Participant Portal on 24/05/2019 at 16:55:14 (transaction id SigId-42507-aXneiymumsZWet3fRvkOVByM6Yzy3lBvDBDEwJpgSKbAefxQK31CJtc3zHNNuOclUrzOhQAkkolFgddbElHmCGG-jpJZscgsw0Kv1vxGC5zvJV-KfJMgRACRnaDg12u6JbUf6T33R1R2b0jnKryjmtzqEH).
Timestamp by third party at
Fri May 24 17:55:21 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

NATIONALE GENOSSENSCHAFT FUER DIE LAGERUNG RADIOAKTIVER ABFAELLE (NAGRA), established in Hardstrasse 73, WETTINGEN 5430, Switzerland, VAT number: CH270953, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('27')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

NATIONAL CENTER FOR SCIENTIFIC RESEARCH "DEMOKRITOS" (NCSR), established in END OF PATRIARCHOU GRIGORIOU E AND 27 NEAPOLEOS STREET, AGIA PARASKEVI 15341, Greece, VAT number: EL090085651, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('28')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

NUCLEAR ENGINEERING SEIBERSDORF GMBH (NES), established in FORSCHUNGSZENTRUM, SEIBERSDORF 2444, Austria, VAT number: ATU57207427, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('29')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

NARODNY JADROVY FOND (NJF), established in MIEROVA 19, BRATISLAVA 821 05, Slovakia, VAT number: SK2022216988, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('30')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

NUCLEAR RESEARCH AND CONSULTANCY GROUP (NRG), established in WESTERDUINWEG 3, PETTEN 1755 LE, Netherlands, VAT number: NL807320316B01, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('31')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

NATIONALE INSTELLING VOOR RADIOACTIEF AFVAL EN VERRIJKTE SPLIJSTOFFEN (ONDRAF/NIRAS), established in KUNSTLAAN 14, SAINT-JOSSE-TEN-NOODE 1210, Belgium, VAT number: BE0222116241, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('32')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

POSIVA OY (POSIVA), established in OLKILUOTO, EURAJOKI 27160, Finland, VAT number: FI10292588, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('33')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

PAUL SCHERRER INSTITUT (PSI), established in FORSCHUNGSTRASSE 111, VILLIGEN PSI 5232, Switzerland, VAT number: CHE116133392MWST, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('34')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Irene WALTHERT with ECAS id nwalthir signed in the Participant Portal on 26/05/2019 at 04:44:20 (transaction id SigId-43674-56Bqr50kDhezyfOMrxn1AXV30idBPfzK3LOchpY1KvzHBI0bWOQXdaH9scqbQY8ID6HtcufjGtCywk3nmanQutmjJZscgsw0Kv1vxGC5zvJV-JTWU0zJuHuSIVTDKKaeNxJgsKj0g7VYbPqIMefcVAm).
Timestamp by third party at
Sun May 26 05:44:32 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

RADIOAKTIV HULLADEKOKAT KEZELO KOZHASZNU NONPROFIT KORLATOLT FELELOSSEGU TARSASAG (PURAM), established in PUSKAS TIVADAR UTCA 11, BUDAPEST 2040, Hungary, VAT number: HU18680188, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('35')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

REGIA AUTONOMA TEHNOLOGII PENTRU ENERGIA NUCLEARA - RATEN (RATEN), established in STRADA CAMPULUI 1, MIOVENI 115400, Romania, VAT number: RO32306920, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('36')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

RADIOACTIVE WASTE MANAGEMENT LIMITED (RWM), established in HERDUS HOUSE INGWELL DRIVE WESTLAKES SCIENCE AND TECHNOLOGY PARK MOOR ROW, CUMBRIA CA24 3HU, United Kingdom, VAT number: GB902183358, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('37')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Steve TURNER with ECAS id ntrnerst signed in the Participant Portal on 28/05/2019 at 09:36:16 (transaction id SigId-59926-MI900BV9wBJpkOkzXlmmZUUnQmiAuY37fzSjYsJuO53hH9DT017MWuT14ZooglgvskbizuH8kYWxczZM6pvOPda-jpJZscgsw0Kv1vxGC5zvJV-zRcx3k6BWSNXkTYn4Z0fQIHNEB7lvIG1AqxebgXTq1U).
Timestamp by third party at
Tue May 28 10:36:23 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

STUDIECENTRUM VOOR KERNENERGIE / CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE (SCK•CEN), established in AVENUE HERRMANN DEBROUX 40, BRUXELLES 1160, Belgium, VAT number: BE0406568867, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('38')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Eric VAN WALLE with ECAS id nwalleer signed in the Participant Portal on 27/05/2019 at 14:15:06 (transaction id SigId-52680-tNsX0iF8I3zlwSkNH0nmq0IOZ5HAExBrWwksdk0vN3sKd7SeHLUXJgcAmYy9TBLbcdEDyotmjKgAbu6kXFa538-jpJZscgsw0Kv1vxGC5zvJV-MvX5fi2mt89EyyWOF1p3rTzv492Dzd2YFY0wdebenwA0).
Timestamp by third party at
Mon May 27 15:15:19 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

SVENSK KARNBRANSLEHANTERING AKTIEBOLAG (SKB), established in BOX 3091, SOLNA 169 03, Sweden, VAT number: SE556175201401, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('39')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Eva Halldén with ECAS id n002duc6 signed in the Participant Portal on 27/05/2019 at 08:44:55 (transaction id SigId-45599-zRYKDHeVrxGBI2pyzu1zRmQXuGvmZuII7MbR2H0xznQ5kZTzmOG0UgqlfPgHKmQaPYGfbcqluuYcdGzPH7EbBs4W-jpJZscgsw0Kv1vxGC5zvJV-6qsQqsZ4K80qvFHXm0b5PY8psPxR1dKxgOFoIHMaH).
Timestamp by third party at
Mon May 27 09:45:03 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

STATE ENTERPRISE STATE SCIENTIFIC AND TECHNICAL CENTER FOR NUCLEAR AND RADIATION SAFETY (SSTC NRS), established in VASYLYA STUSA STREET 35 - 37, KYIV 03142, Ukraine, VAT number: UA142823326578, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('40')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

SLOVENSKA TECHNICKA UNIVERZITA V BRATISLAVE (STUBA), established in VAZOVOVA 5, BRATISLAVA 81243, Slovakia, VAT number: SK2020845255, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('41')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Miroslav FIKAR with ECAS id nfikarmi signed in the Participant Portal on 25/05/2019 at 05:52:07 (transaction id SigId-43500-rysvlg50u7rFmzZmNITOGu5dkn0SVccjOt8RB2GzzU3c8ZSuvlgXLqiQsgkZX8Hci5pTIOHxgZR049vi9QE9UIW-jpJZscgsw0Kv1vxGC5zvJV-i6v0oUAyZQ9ZOceXh1eaSpNEDbnzzHykC0PzmXXVlaMi). Timestamp by third party at Sat May 25 06:52:26 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

Radioactive Waste Repository Authority (SÚRAO), established in Dlazdena 6, Praha 110000, Czech Republic, VAT number: CZ-66000769, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('42')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

STATNI USTAV RADIACNI OCHRANY v.v.i. (SURO), established in BARTOSKOVA 28, Praha 14000, Czech Republic, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('43')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Zdeněk ROZLÍVKA with ECAS id nrozlzd signed in the Participant Portal on 27/05/2019 at 14:57:01 (transaction id SigId-53661-6zaNmQ3oxAzO3hS5qCJAxVxjzcdkVeP9b58qzsiwrlb6S4JDVuKHc6dzO5ZXtVmWQyTgZ9M6RYWMujJMTcHNu4-jpJZscgsw0Kv1vxGC5zvJV-uDQrzHPCn6CdzMuANIDVRWSjDdRqPGzp7RhWMwGsXU80). Timestamp by third party at Mon May 27 15:57:09 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK TNO (TNO), established in ANNA VAN BUERENPLEIN 1, DEN HAAG 2595 DA, Netherlands, VAT number: NL002875718B01, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('44')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

TS ENERCON MERNOKIRODA KFT (TS Enercon), established in CSALOGANY UTCA 23-33, BUDAPEST 1027, Hungary, VAT number: HU12165986, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('45')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

TECHNICAL UNIVERSITY OF SOFIA (TUS), established in Kliment Ohridsky Bd 8, SOFIA 1000, Bulgaria, VAT number: BG831917834, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('46')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Ivan KRALOV with ECAS id nkaloviv signed in the Participant Portal on 25/05/2019 at 08:30:16 (transaction id SigId-43513-wCzXda155HO7hJ4jtVXHVMmchqnC7ehBrm4RL06ljfJopLIFKweDcU2Gj5aTQ89aZzVScdO4lhQrjlrWwYzuOGm-jpJZscgsw0Kv1vxGC5zvJV-D88O4fvDtydlzJMOKuyV7dYg3CoEFwJqlEvYxYs4LNA).
Timestamp by third party at
Sat May 25 09:30:23 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

UNIVERSITY OF CYPRUS (UCyprus), established in KALLIPOLEOS STREET 75, NICOSIA 1678, Cyprus, VAT number: CY90001673W, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('47')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Marios DEMETRIADES with ECAS id ndmemari signed in the Participant Portal on 24/05/2019 at 18:13:28
(transaction id SigId-42980-0JQzOXX1bdWzfL5bqdgG4388kVzzuRDdTwrFGFLGuTY7iZsUcpXQ40grefHqTiDHge46kbUOWEbW3LDTEzO6rV-jpJZscgsw0Kv1vxGC5zvJV-nURzwIhLxpzsdMwgzsbRvSp4PltgdokK69wwEMdWB3rq)
. Timestamp by third party at
Fri May 24 19:13:35 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

HELSINGIN YLIOPISTO (UHelsinki), established in FABIANINKATU 33, HELSINGIN YLIOPISTO 00014, Finland, VAT number: FI03134717, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('48')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

heikki TENHU with ECAS id ntenhuhe signed in the Participant Portal on 27/05/2019 at 07:52:10 (transaction id SigId-44971-5MAYHbQvHe3Dc4zuZZhzkj642157t1ZpzSiLDei1K6BzlsZSZtf3CMYCMDfXT9RBDXAxpTYwbJE3Lkh1ZwlJK-jpJZscgsw0Kv1vxGC5zvJV-rXuNMs3n07xyZKKVhImDuBHEbulib3Sce2rNtzzGMwOG).
Timestamp by third party at
Mon May 27 08:52:17 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

UNITED KINGDOM RESEARCH AND INNOVATION (UKRI), established in POLARIS HOUSE NORTH STAR AVENUE, SWINDON SN2 1FL, United Kingdom, VAT number: GB287461957, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('49')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

Teknologian tutkimuskeskus VTT Oy (VTT), established in VUORIMIEHENTIE 3, Espoo 02150, Finland, VAT number: FI26473754, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('50')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary

Satu HELYNEN with ECAS id nhelynsa signed in the Participant Portal on 26/05/2019 at 19:33:32 (transaction id SigId-44037-D3B0f8aKwj162g1LD9HN7OzqfTJmXMWYUiqOLGnPeYA6HUJa09qYQjthzwNcONP54DztHjZPixu8a99tSKQ5rR0-jpJZscgsw0Kv1vxGC5zvJV-NiM1XLwIKHX2bpx2zXUyppmh5ibcv6tjpddepNnhav6X).
Timestamp by third party at
Sun May 26 20:33:44 CEST 2019

ANNEX 3

ACCESSION FORM FOR BENEFICIARIES

VUJE AS (VUJE), established in Okružna 5, TRNAVA 91864, Slovakia, VAT number: SK2020392539, ('the beneficiary'), represented for the purpose of signing this Accession Form by the undersigned,

hereby agrees

to become beneficiary No ('51')

in Grant Agreement No 847593 ('the Agreement')

between AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS **and** the European Union ('the EU'), represented by the European Commission ('the Commission'),

for the action entitled 'European Joint Programme on Radioactive Waste Management (EURAD)'.

and mandates

the coordinator to submit and sign in its name and on its behalf any **amendments** to the Agreement, in accordance with Article 55.

By signing this Accession Form, the beneficiary accepts the grant and agrees to implement it in accordance with the Agreement, with all the obligations and conditions it sets out.

SIGNATURE

For the beneficiary



EUROPEAN COMMISSION
Joint Research Centre (JRC)

Director



ANNEX 3b

ADMINISTRATIVE ARRANGEMENT WITH THE JOINT RESEARCH CENTRE (JRC) FOR A HORIZON 2020 FRAMEWORK PROGRAMME GRANT

This **Administrative Arrangement** is **between** the following parties:

on the one part,

DG Directorate-General for Research and Innovation

represented for the purposes of signature of this Arrangement by Patrick CHILD, the Acting Director,
Directorate-General for Research and Innovation,

and

on the other part,

the **Joint Research Centre (JRC)**, represented by the Director of the .

With this Administrative Arrangement, the **parties agree to consider the JRC as beneficiary in Grant Agreement No 847593** ('the Grant Agreement') **between** AGENCE NATIONALE POUR LA GESTION DES DECHETS RADIOACTIFS (ANDRA) **and** the European Union ('the EU'), represented by the European Commission ('the Commission'), **for the action “European Joint Programme on Radioactive Waste Management (EURAD)”**

The **JRC accepts the grant and agrees to implement the action**, as specified in Annex 1 to the Grant Agreement, under its own responsibility and in accordance with the Grant Agreement, with all the obligations and conditions it sets out.

The **parties agree** to the following **specific provisions** for the JRC:

- the JRC becomes part of the Grant Agreement not via an accession form but via an administrative arrangement (Preamble);
- the JRC is considered a 'beneficiary' (preamble);
- the periodic financial report must contain information on the amount of each interim payment and payment of the balance to be paid by the DG to the JRC (Article 20.3);

- the part of the pre-financing payment(s) related to the JRC is not paid to the coordinator, but kept by the DG for the JRC (Article 21.2).

In addition to these specificities, the **parties agree**:

1. Start of participation

The JRC will assume rights and obligations under the Grant Agreement with effect from the date of entry into force of the Grant Agreement.

2. Payments

Payments will be transferred according to the Commission's accounting rules on internal invoicing and will be made from the operational budget line of the DG to the Legal Entity File (LEF) number of the JRC, mentioning the Recovery Order (RO) number. The JRC will submit a debit note for each payment (including the pre-financing).

The DG will make the following payments (see Article 21 of the Grant Agreement) to the JRC:

- a **pre-financing payment** of EUR **94 230.10** (ninety four thousand two hundred and thirty EURO and ten eurocents), within 30 days from the submission of a debit note by the JRC after the signature of the Administrative Arrangement

The JRC agrees that the amount of EUR **23 557.53** (twenty three thousand five hundred and fifty seven EURO and fifty three eurocents), representing its contribution to the Guarantee Fund (see Article 21.2 of the Grant Agreement), is transferred in its name by the DG to the Guarantee Fund

- one or more **interim payments** (see Article 21.3 of the Grant Agreement)
- a **payment of the balance** (see Article 21.4 of the Grant Agreement).

3. Late-payment interest

No interest will be paid on delayed payments between the JRC and the DG.

4. Certificate on the financial statements and/or certificate on the methodology

The JRC Quality assurance and risk management unit will act as the competent public officer for providing the certificate pursuant to Articles 18.1.2 and 20.4 of the Grant Agreement.

5. Amendments

Any amendment to the Administrative Arrangement will be signed in the electronic exchange system (see Articles 52 and 55 of the Grant Agreement).

6. Interpretation

If the Grant Agreement conflicts with any provision of the Administrative Arrangement with regard to relations between the DG and the JRC, the latter will prevail.

7. Termination

If the Grant Agreement is terminated (see Article 50.1 or 50.3 of the Grant Agreement), this Administrative Arrangement will terminate automatically in parallel.

If the participation of the JRC is terminated (see Article 50.2 or 50.3 of the Grant Agreement), the Administrative Arrangement will be terminated under the conditions set out in the Grant Agreement — *mutatis mutandis*.

8. Entry into force

The Administrative Arrangement will enter into force on the day of signature by the JRC.

SIGNATURE
For the JRC

FINANCIAL STATEMENT FOR [BENEFICIARY [name]/ LINKED THIRD PARTY [name]] FOR REPORTING PERIOD [reporting period]

	Eligible ¹ costs (per budget category)													Receipts	EU contribution			Additional information	
	A. Direct personnel costs			B. Direct costs of subcontracting	[C. Direct costs of fin. support]	D. Other direct costs			E. Indirect costs ²	[F. Costs of ...]		Total costs	Receipts	Reimburse ment rate %	Maximum EU contribution ³	Requested EU contribution	Information for indirect costs :		
	A.1 Employees (or equivalent)	A.4 SME owners without salary		[C.1 Financial support]	D.1 Travel	[D.4 Costs of large research infrastructure]	D.5 Costs of internally invoiced goods and services		[F.1 Costs of ...]	[F.2 Costs of ...]		Receipts of the action, to be reported in the last reporting period, according to Article 5.3.3					Costs of in-kind contributions not used on premises		
	A.2 Natural persons under direct contract	A.5 Beneficiaries that are natural persons without salary		[C.2 Prizes]	D.2 Equipment														
A.3 Seconded persons					D.3 Other goods and services														
	[A.6 Personnel for providing access to research infrastructure]																		
Form of costs ⁴	Actual	Unit	Unit		Actual	Actual	Actual	Actual	Unit	Flat-rate ⁵		Unit	[Unit][Lump sum]						
										25%									
	a	Total b	No hours	Total c	d	[e]	f	[g]	Total h	i=0,25 x (a+b+c+f+[g] + h+ [j 1] ⁶ +[j2] ⁶ -p)	No units	Total [j1]	Total [j2]	k = a+b+c+d+[e] +f+ [g] +h+ i + [j1] +[j2]	l	m	n	o	p
[short name beneficiary/linked third party]																			

The beneficiary/linked third party hereby confirms that:
The information provided is complete, reliable and true.
The costs declared are eligible (see Article 6).
The costs can be substantiated by adequate records and supporting documentation that will be produced upon request or in the context of checks, reviews, audits and investigations (see Articles 17, 18 and 22).
For the last reporting period: that all the receipts have been declared (see Article 5.3.3).

❗ Please declare all eligible costs, even if they exceed the amounts indicated in the estimated budget (see Annex 2). Only amounts that were declared in your individual financial statements can be taken into account lateron, in order to replace other costs that are found to be ineligible.

¹ See Article 6 for the eligibility conditions
² The indirect costs claimed must be free of any amounts covered by an operating grant (received under any EU or Euratom funding programme; see Article 6.2.E). If you have received an operating grant during this reporting period, you cannot claim indirect costs unless you can demonstrate that the operating grant does not cover any costs of the action.
³ This is the *theoretical* amount of EU contribution that the system calculates automatically (by multiplying the reimbursement rate by the total costs declared). The amount you request (in the column 'requested EU contribution') may be less,
⁴ See Article 5 for the forms of costs
⁵ Flat rate : 25% of eligible direct costs, from which are excluded: direct costs of subcontracting, costs of in-kind contributions not used on premises, direct costs of financial support, and unit costs declared under budget category F if they include indirect costs (see Article 6.2.E)
⁶ Only specific unit costs that do not include indirect costs

ANNEX 5

MODEL FOR THE CERTIFICATE ON THE FINANCIAL STATEMENTS

- For options [*in italics in square brackets*]: choose the applicable option. Options not chosen should be deleted.
- For fields in [grey in square brackets]: enter the appropriate data

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TERMS OF REFERENCE FOR AN INDEPENDENT REPORT OF FACTUAL FINDINGS ON COSTS DECLARED UNDER A GRANT AGREEMENT FINANCED UNDER THE HORIZON 2020 RESEARCH FRAMEWORK PROGRAMME

INDEPENDENT REPORT OF FACTUAL FINDINGS ON COSTS DECLARED UNDER A GRANT AGREEMENT FINANCED UNDER THE HORIZON 2020 RESEARCH FRAMEWORK PROGRAMME

Terms of Reference for an Independent Report of Factual Findings on costs declared under a Grant Agreement financed under the Horizon 2020 Research and Innovation Framework Programme

This document sets out the ‘**Terms of Reference (ToR)**’ under which

[OPTION 1: [insert name of the beneficiary] (*‘the Beneficiary’*)] [OPTION 2: [insert name of the linked third party] (*‘the Linked Third Party’*), third party linked to the Beneficiary [insert name of the beneficiary] (*‘the Beneficiary’*)]

agrees to engage

[insert legal name of the auditor] (*‘the Auditor’*)

to produce an independent report of factual findings (*‘the Report’*) concerning the Financial Statement(s)¹ drawn up by the [Beneficiary] [Linked Third Party] for the Horizon 2020 grant agreement [insert number of the grant agreement, title of the action, acronym and duration from/to] (*‘the Agreement’*), and

to issue a Certificate on the Financial Statements’ (*‘CFS’*) referred to in Article 20.4 of the Agreement based on the compulsory reporting template stipulated by the Commission.

The Agreement has been concluded under the Horizon 2020 Research and Innovation Framework Programme (H2020) between the Beneficiary and [OPTION 1: *the European Union, represented by the European Commission (‘the Commission’)*][OPTION 2: *the European Atomic Energy Community (Euratom,) represented by the European Commission (‘the Commission’)*][OPTION 3: *the [Research Executive Agency (REA)] [European Research Council Executive Agency (ERCEA)] [Innovation and Networks Executive Agency (INEA)] [Executive Agency for Small and Medium-sized Enterprises (EASME)] (‘the Agency’), under the powers delegated by the European Commission (‘the Commission’).*]

The [Commission] [Agency] is mentioned as a signatory of the Agreement with the Beneficiary only. The [European Union][Euratom][Agency] is not a party to this engagement.

1.1 Subject of the engagement

The coordinator must submit to the [Commission][Agency] the final report within 60 days following the end of the last reporting period which should include, amongst other documents, a CFS for each beneficiary and for each linked third party that requests a total contribution of EUR 325 000 or more, as reimbursement of actual costs and unit costs calculated on the basis of its usual cost accounting practices (see Article 20.4 of the Agreement). The CFS must cover all reporting periods of the beneficiary or linked third party indicated above.

The Beneficiary must submit to the coordinator the CFS for itself and for its linked third party(ies), if the CFS must be included in the final report according to Article 20.4 of the Agreement.

The CFS is composed of two separate documents:

- The Terms of Reference (*‘the ToR’*) to be signed by the [Beneficiary] [Linked Third Party] and the Auditor;

¹ By which costs under the Agreement are declared (see template ‘Model Financial Statements’ in Annex 4 to the Grant Agreement).

- The Auditor's Independent Report of Factual Findings ('the Report') to be issued on the Auditor's letterhead, dated, stamped and signed by the Auditor (or the competent public officer) which includes the agreed-upon procedures ('the Procedures') to be performed by the Auditor, and the standard factual findings ('the Findings') to be confirmed by the Auditor.

If the CFS must be included in the final report according to Article 20.4 of the Agreement, the request for payment of the balance relating to the Agreement cannot be made without the CFS. However, the payment for reimbursement of costs covered by the CFS does not preclude the Commission [Agency,] the European Anti-Fraud Office and the European Court of Auditors from carrying out checks, reviews, audits and investigations in accordance with Article 22 of the Agreement.

1.2 Responsibilities

The [Beneficiary] [Linked Third Party]:

- must draw up the Financial Statement(s) for the action financed by the Agreement in compliance with the obligations under the Agreement. The Financial Statement(s) must be drawn up according to the [Beneficiary's] [Linked Third Party's] accounting and book-keeping system and the underlying accounts and records;
- must send the Financial Statement(s) to the Auditor;
- is responsible and liable for the accuracy of the Financial Statement(s);
- is responsible for the completeness and accuracy of the information provided to enable the Auditor to carry out the Procedures. It must provide the Auditor with a written representation letter supporting these statements. The written representation letter must state the period covered by the statements and must be dated;
- accepts that the Auditor cannot carry out the Procedures unless it is given full access to the [Beneficiary's] [Linked Third Party's] staff and accounting as well as any other relevant records and documentation.

The Auditor:

- [Option 1 by default: is qualified to carry out statutory audits of accounting documents in accordance with Directive 2006/43/EC of the European Parliament and of the Council of 17 May 2006 on statutory audits of annual accounts and consolidated accounts, amending Council Directives 78/660/EEC and 83/349/EEC and repealing Council Directive 84/253/EEC or similar national regulations].
- [Option 2 if the Beneficiary or Linked Third Party has an independent Public Officer: is a competent and independent Public Officer for which the relevant national authorities have established the legal capacity to audit the Beneficiary].
- [Option 3 if the Beneficiary or Linked Third Party is an international organisation: is an [internal] [external] auditor in accordance with the internal financial regulations and procedures of the international organisation].

The Auditor:

- must be independent from the Beneficiary [and the Linked Third Party], in particular, it must not have been involved in preparing the [Beneficiary's] [Linked Third Party's] Financial Statement(s);
- must plan work so that the Procedures may be carried out and the Findings may be assessed;
- must adhere to the Procedures laid down and the compulsory report format;
- must carry out the engagement in accordance with this ToR;
- must document matters which are important to support the Report;
- must base its Report on the evidence gathered;
- must submit the Report to the [Beneficiary] [Linked Third Party].

The Commission sets out the Procedures to be carried out by the Auditor. The Auditor is not responsible for their suitability or pertinence. As this engagement is not an assurance engagement, the Auditor does not provide an audit opinion or a statement of assurance.

1.3 Applicable Standards

The Auditor must comply with these Terms of Reference and with²:

- the International Standard on Related Services ('ISRS') 4400 *Engagements to perform Agreed-upon Procedures regarding Financial Information* as issued by the International Auditing and Assurance Standards Board (IAASB);
- the *Code of Ethics for Professional Accountants* issued by the International Ethics Standards Board for Accountants (IESBA). Although ISRS 4400 states that independence is not a requirement for engagements to carry out agreed-upon procedures, the [Commission]/[Agency] requires that the Auditor also complies with the Code's independence requirements.

The Auditor's Report must state that there is no conflict of interests in establishing this Report between the Auditor and the Beneficiary *[and the Linked Third Party]*, and must specify - if the service is invoiced - the total fee paid to the Auditor for providing the Report.

1.4 Reporting

The Report must be written in the language of the Agreement (see Article 20.7).

Under Article 22 of the Agreement, the Commission[, the Agency], the European Anti-Fraud Office and the Court of Auditors have the right to audit any work that is carried out under the action and for which costs are declared from [the European Union] [Euratom] budget. This includes work related to this engagement. The Auditor must provide access to all working papers (e.g. recalculation of hourly rates, verification of the time declared for the action) related to this assignment if the Commission [, the Agency], the European Anti-Fraud Office or the European Court of Auditors requests them.

1.5 Timing

The Report must be provided by [dd Month yyyy].

1.6 Other terms

[The [Beneficiary] [Linked Third Party] and the Auditor can use this section to agree other specific terms, such as the Auditor's fees, liability, applicable law, etc. Those specific terms must not contradict the terms specified above.]

[legal name of the Auditor]	[legal name of the [Beneficiary]/[Linked Third Party]]
[name & function of authorised representative]	[name & function of authorised representative]
[dd Month yyyy]	[dd Month yyyy]
Signature of the Auditor	Signature of the [Beneficiary]/[Linked Third Party]

² Supreme Audit Institutions applying INTOSAI-standards may carry out the Procedures according to the corresponding International Standards of Supreme Audit Institutions and code of ethics issued by INTOSAI instead of the International Standard on Related Services ('ISRS') 4400 and the Code of Ethics for Professional Accountants issued by the IAASB and the IESBA.

**Independent Report of Factual Findings on costs declared
under Horizon 2020 Research and Innovation Framework Programme**

(To be printed on the Auditor's letterhead)

To
[name of contact person(s)], [Position]
[[Beneficiary's] [Linked Third Party's] name]
[Address]
[dd Month yyyy]

Dear [Name of contact person(s)],

As agreed under the terms of reference dated [dd Month yyyy]

with [OPTION 1: [insert name of the beneficiary] ('the Beneficiary')] [OPTION 2: [insert name of the linked third party] ('the Linked Third Party'), third party linked to the Beneficiary [insert name of the beneficiary] ('the Beneficiary')],

we

[name of the auditor] ('the Auditor'),
established at
[full address/city/state/province/country],
represented by
[name and function of an authorised representative],

have carried out the procedures agreed with you regarding the costs declared in the Financial Statement(s)³ of the [Beneficiary] [Linked Third Party] concerning the grant agreement [insert grant agreement reference: number, title of the action and acronym] ('the Agreement'),

with a total cost declared of
[total amount] EUR,

and a total of actual costs and unit costs calculated in accordance with the [Beneficiary's] [Linked Third Party's] usual cost accounting practices' declared of

[sum of total actual costs and total direct personnel costs declared as unit costs calculated in accordance with the [Beneficiary's] [Linked Third Party's] usual cost accounting practices] EUR

and **hereby provide our Independent Report of Factual Findings ('the Report')** using the compulsory report format agreed with you.

The Report

Our engagement was carried out in accordance with the terms of reference ('the ToR') appended to this Report. The Report includes the agreed-upon procedures ('the Procedures') carried out and the standard factual findings ('the Findings') examined.

³ By which the Beneficiary declares costs under the Agreement (see template 'Model Financial Statement' in Annex 4 to the Agreement).

The Procedures were carried out solely to assist the [Commission] [Agency] in evaluating whether the [Beneficiary's] [Linked Third Party's] costs in the accompanying Financial Statement(s) were declared in accordance with the Agreement. The [Commission] [Agency] draws its own conclusions from the Report and any additional information it may require.

The scope of the Procedures was defined by the Commission. Therefore, the Auditor is not responsible for their suitability or pertinence. Since the Procedures carried out constitute neither an audit nor a review made in accordance with International Standards on Auditing or International Standards on Review Engagements, the Auditor does not give a statement of assurance on the Financial Statements.

Had the Auditor carried out additional procedures or an audit of the [Beneficiary's] [Linked Third Party's] Financial Statements in accordance with International Standards on Auditing or International Standards on Review Engagements, other matters might have come to its attention and would have been included in the Report.

Not applicable Findings

We examined the Financial Statement(s) stated above and considered the following Findings not applicable:

Explanation (to be removed from the Report):

If a Finding was not applicable, it must be marked as 'N.A.' ('Not applicable') in the corresponding row on the right-hand column of the table and means that the Finding did not have to be corroborated by the Auditor and the related Procedure(s) did not have to be carried out.

The reasons of the non-application of a certain Finding must be obvious i.e.

- i) if no cost was declared under a certain category then the related Finding(s) and Procedure(s) are not applicable;*
- ii) if the condition set to apply certain Procedure(s) are not met the related Finding(s) and those Procedure(s) are not applicable. For instance, for 'beneficiaries with accounts established in a currency other than euro' the Procedure and Finding related to 'beneficiaries with accounts established in euro' are not applicable. Similarly, if no additional remuneration is paid, the related Finding(s) and Procedure(s) for additional remuneration are not applicable.*

List here all Findings considered not applicable for the present engagement and explain the reasons of the non-applicability.

....

Exceptions

Apart from the exceptions listed below, the [Beneficiary] [Linked Third Party] provided the Auditor all the documentation and accounting information needed by the Auditor to carry out the requested Procedures and evaluate the Findings.

Explanation (to be removed from the Report):

- If the Auditor was not able to successfully complete a procedure requested, it must be marked as 'E' ('Exception') in the corresponding row on the right-hand column of the table. The reason such as the inability to reconcile key information or the unavailability of data that prevents the Auditor from carrying out the Procedure must be indicated below.*
- If the Auditor cannot corroborate a standard finding after having carried out the corresponding procedure, it must also be marked as 'E' ('Exception') and, where possible, the reasons why the Finding was not fulfilled and its possible impact must be explained here below.*

List here any exceptions and add any information on the cause and possible consequences of each exception, if known. If the exception is quantifiable, include the corresponding amount.

....

Example (to be removed from the Report):

1. *The Beneficiary was unable to substantiate the Finding number 1 on ... because*
2. *Finding number 30 was not fulfilled because the methodology used by the Beneficiary to calculate unit costs was different from the one approved by the Commission. The differences were as follows: ...*
3. *After carrying out the agreed procedures to confirm the Finding number 31, the Auditor found a difference of _____ EUR. The difference can be explained by ...*

Further Remarks

In addition to reporting on the results of the specific procedures carried out, the Auditor would like to make the following general remarks:

Example (to be removed from the Report):

1. *Regarding Finding number 8 the conditions for additional remuneration were considered as fulfilled because ...*
2. *In order to be able to confirm the Finding number 15 we carried out the following additional procedures:*

Use of this Report

This Report may be used only for the purpose described in the above objective. It was prepared solely for the confidential use of the [Beneficiary] [Linked Third Party] and the [Commission] [Agency], and only to be submitted to the [Commission] [Agency] in connection with the requirements set out in Article 20.4 of the Agreement. The Report may not be used by the [Beneficiary] [Linked Third Party] or by the [Commission] [Agency] for any other purpose, nor may it be distributed to any other parties. The [Commission] [Agency] may only disclose the Report to authorised parties, in particular to the European Anti-Fraud Office (OLAF) and the European Court of Auditors.

This Report relates only to the Financial Statement(s) submitted to the [Commission] [Agency] by the [Beneficiary] [Linked Third Party] for the Agreement. Therefore, it does not extend to any other of the [Beneficiary's] [Linked Third Party's] Financial Statement(s).

There was no conflict of interest⁴ between the Auditor and the Beneficiary [and Linked Third Party] in establishing this Report. The total fee paid to the Auditor for providing the Report was EUR [] (including EUR [] of deductible VAT).

We look forward to discussing our Report with you and would be pleased to provide any further information or assistance.

[legal name of the Auditor]

[name and function of an authorised representative]

[dd Month yyyy]

Signature of the Auditor

⁴ A conflict of interest arises when the Auditor's objectivity to establish the certificate is compromised in fact or in appearance when the Auditor for instance:

- was involved in the preparation of the Financial Statements;
- stands to benefit directly should the certificate be accepted;
- has a close relationship with any person representing the beneficiary;
- is a director, trustee or partner of the beneficiary; or
- is in any other situation that compromises his or her independence or ability to establish the certificate impartially.

Agreed-upon procedures to be performed and standard factual findings to be confirmed by the Auditor

The European Commission reserves the right to i) provide the auditor with additional guidance regarding the procedures to be followed or the facts to be ascertained and the way in which to present them (this may include sample coverage and findings) or to ii) change the procedures, by notifying the Beneficiary in writing. The procedures carried out by the auditor to confirm the standard factual finding are listed in the table below.

If this certificate relates to a Linked Third Party, any reference here below to ‘the Beneficiary’ is to be considered as a reference to ‘the Linked Third Party’.

The ‘result’ column has three different options: ‘C’, ‘E’ and ‘N.A.’:

- ‘C’ stands for ‘confirmed’ and means that the auditor can confirm the ‘standard factual finding’ and, therefore, there is no exception to be reported.
- ‘E’ stands for ‘exception’ and means that the Auditor carried out the procedures but cannot confirm the ‘standard factual finding’, or that the Auditor was not able to carry out a specific procedure (e.g. because it was impossible to reconcile key information or data were unavailable),
- ‘N.A.’ stands for ‘not applicable’ and means that the Finding did not have to be examined by the Auditor and the related Procedure(s) did not have to be carried out. The reasons of the non-application of a certain Finding must be obvious i.e. i) if no cost was declared under a certain category then the related Finding(s) and Procedure(s) are not applicable; ii) if the condition set to apply certain Procedure(s) are not met then the related Finding(s) and Procedure(s) are not applicable. For instance, for ‘beneficiaries with accounts established in a currency other than the euro’ the Procedure related to ‘beneficiaries with accounts established in euro’ is not applicable. Similarly, if no additional remuneration is paid, the related Finding(s) and Procedure(s) for additional remuneration are not applicable.

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
A	ACTUAL PERSONNEL COSTS AND UNIT COSTS CALCULATED BY THE BENEFICIARY IN ACCORDANCE WITH ITS USUAL COST ACCOUNTING PRACTICE		
	The Auditor draws a sample of persons whose costs were declared in the Financial Statement(s) to carry out the procedures indicated in the consecutive points of this section A. <i>(The sample should be selected randomly so that it is representative. Full coverage is required if there are fewer than 10 people (including employees, natural persons working under a direct contract and personnel seconded by a third party), otherwise the sample should have a minimum of 10 people, or 10% of the total, whichever number is the highest)</i> The Auditor sampled [] people out of the total of [] people.		

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
A.1	PERSONNEL COSTS <u>For the persons included in the sample and working under an employment contract or equivalent act (general procedures for individual actual personnel costs and personnel costs declared as unit costs)</u> To confirm standard factual findings 1-5 listed in the next column, the Auditor reviewed following information/documents provided by the Beneficiary: ○ a list of the persons included in the sample indicating the period(s) during which they worked for the action, their position (classification or category) and type of contract; ○ the payslips of the employees included in the sample; ○ reconciliation of the personnel costs declared in the Financial Statement(s) with the accounting system (project accounting and general ledger) and payroll system; ○ information concerning the employment status and employment conditions of personnel included in the sample, in particular their employment contracts or equivalent; ○ the Beneficiary's usual policy regarding payroll matters (e.g. salary policy, overtime policy, variable pay); ○ applicable national law on taxes, labour and social security and ○ any other document that supports the personnel costs declared. The Auditor also verified the eligibility of all components of the retribution (see Article 6 GA) and recalculated the personnel costs for employees included in the sample.	1) The employees were i) directly hired by the Beneficiary in accordance with its national legislation, ii) under the Beneficiary's sole technical supervision and responsibility and iii) remunerated in accordance with the Beneficiary's usual practices.	
		2) Personnel costs were recorded in the Beneficiary's accounts/payroll system.	
		3) Costs were adequately supported and reconciled with the accounts and payroll records.	
		4) Personnel costs did not contain any ineligible elements.	
		5) There were no discrepancies between the personnel costs charged to the action and the costs recalculated by the Auditor.	
	<i>Further procedures if 'additional remuneration' is paid</i> To confirm standard factual findings 6-9 listed in the next column, the Auditor: ○ reviewed relevant documents provided by the Beneficiary (legal form, legal/statutory	6) The Beneficiary paying "additional remuneration" was a non-profit legal entity.	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	obligations, the Beneficiary's usual policy on additional remuneration, criteria used for its calculation, the Beneficiary's usual remuneration practice for projects funded under national funding schemes...); recalculated the amount of additional remuneration eligible for the action based on the supporting documents received (full-time or part-time work, exclusive or non-exclusive dedication to the action, usual remuneration paid for projects funded by national schemes) to arrive at the applicable FTE/year and pro-rata rate (see data collected in the course of carrying out the procedures under A.2 'Productive hours' and A.4 'Time recording system'). <i>'ADDITIONAL REMUNERATION' MEANS ANY PART OF THE REMUNERATION WHICH EXCEEDS WHAT THE PERSON WOULD BE PAID FOR TIME WORKED IN PROJECTS FUNDED BY NATIONAL SCHEMES.</i> <i>IF ANY PART OF THE REMUNERATION PAID TO THE EMPLOYEE QUALIFIES AS "ADDITIONAL REMUNERATION" AND IS ELIGIBLE UNDER THE PROVISIONS OF ARTICLE 6.2.A.1, THIS CAN BE CHARGED AS ELIGIBLE COST TO THE ACTION UP TO THE FOLLOWING AMOUNT:</i> (A) <i>IF THE PERSON WORKS FULL TIME AND EXCLUSIVELY ON THE ACTION DURING THE FULL YEAR: UP TO EUR 8 000/YEAR;</i> (B) <i>IF THE PERSON WORKS EXCLUSIVELY ON THE ACTION BUT NOT FULL-TIME OR NOT FOR THE FULL YEAR: UP TO THE CORRESPONDING PRO-RATA AMOUNT OF EUR 8 000, OR</i> (C) <i>IF THE PERSON DOES NOT WORK EXCLUSIVELY ON THE ACTION: UP TO A PRO-RATA AMOUNT CALCULATED IN ACCORDANCE TO ARTICLE 6.2.A.1.</i>	7) The amount of additional remuneration paid corresponded to the Beneficiary's usual remuneration practices and was consistently paid whenever the same kind of work or expertise was required.	
		8) The criteria used to calculate the additional remuneration were objective and generally applied by the Beneficiary regardless of the source of funding used.	
		9) The amount of additional remuneration included in the personnel costs charged to the action was capped at EUR 8,000 per FTE/year (up to the equivalent pro-rata amount if the person did not work on the action full-time during the year or did not work exclusively on the action).	
	<i>Additional procedures in case "unit costs calculated by the Beneficiary in accordance with its usual cost accounting practices" is applied:</i> Apart from carrying out the procedures indicated above to confirm standard factual findings 1-5 and, if applicable, also 6-9, the Auditor carried out following procedures to confirm standard	10) The personnel costs included in the Financial Statement were calculated in accordance with the Beneficiary's usual cost accounting practice. This methodology was consistently	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	factual findings 10-13 listed in the next column: - obtained a description of the Beneficiary's usual cost accounting practice to calculate unit costs; - reviewed whether the Beneficiary's usual cost accounting practice was applied for the Financial Statements subject of the present CFS; - verified the employees included in the sample were charged under the correct category (in accordance with the criteria used by the Beneficiary to establish personnel categories) by reviewing the contract/HR-record or analytical accounting records; - verified that there is no difference between the total amount of personnel costs used in calculating the cost per unit and the total amount of personnel costs recorded in the statutory accounts; - verified whether actual personnel costs were adjusted on the basis of budgeted or estimated elements and, if so, verified whether those elements used are actually relevant for the calculation, objective and supported by documents.	used in all H2020 actions.	
		11) The employees were charged under the correct category.	
		12) Total personnel costs used in calculating the unit costs were consistent with the expenses recorded in the statutory accounts.	
		13) Any estimated or budgeted element used by the Beneficiary in its unit-cost calculation were relevant for calculating personnel costs and corresponded to objective and verifiable information.	
	<u>For natural persons included in the sample and working with the Beneficiary under a direct contract other than an employment contract, such as consultants (no subcontractors).</u> To confirm standard factual findings 14-17 listed in the next column the Auditor reviewed following information/documents provided by the Beneficiary: - the contracts, especially the cost, contract duration, work description, place of work, ownership of the results and reporting obligations to the Beneficiary; - the employment conditions of staff in the same category to compare costs and; - any other document that supports the costs declared and its registration (e.g. invoices, accounting records, etc.).	14) The natural persons worked under conditions similar to those of an employee, in particular regarding the way the work is organised, the tasks that are performed and the premises where they are performed.	
		15) The results of work carried out belong to the Beneficiary, or, if not, the Beneficiary has obtained all necessary rights to fulfil its obligations as if those	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
		results were generated by itself.	
		16) Their costs were not significantly different from those for staff who performed similar tasks under an employment contract with the Beneficiary.	
		17) The costs were supported by audit evidence and registered in the accounts.	
	<u>For personnel seconded by a third party and included in the sample (not subcontractors)</u> To confirm standard factual findings 18-21 listed in the next column, the Auditor reviewed following information/documents provided by the Beneficiary: ○ their secondment contract(s) notably regarding costs, duration, work description, place of work and ownership of the results; ○ if there is reimbursement by the Beneficiary to the third party for the resource made available (in-kind contribution against payment): any documentation that supports the costs declared (e.g. contract, invoice, bank payment, and proof of registration in its accounting/payroll, etc.) and reconciliation of the Financial Statement(s) with the accounting system (project accounting and general ledger) as well as any proof that the amount invoiced by the third party did not include any profit; ○ if there is no reimbursement by the Beneficiary to the third party for the resource made available (in-kind contribution free of charge): a proof of the actual cost borne by the Third Party for the resource made available free of charge to the Beneficiary such as a statement of costs incurred by the Third Party and proof of the registration in the Third Party's accounting/payroll;	18) Seconded personnel reported to the Beneficiary and worked on the Beneficiary's premises (unless otherwise agreed with the Beneficiary).	
		19) The results of work carried out belong to the Beneficiary, or, if not, the Beneficiary has obtained all necessary rights to fulfil its obligations as if those results were generated by itself..	
		<i>If personnel is seconded against payment:</i> 20) The costs declared were supported with documentation and recorded in the	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	any other document that supports the costs declared (e.g. invoices, etc.).	Beneficiary's accounts. The third party did not include any profit.	
		<i>If personnel is seconded free of charge:</i> 21) The costs declared did not exceed the third party's cost as recorded in the accounts of the third party and were supported with documentation.	
A.2	PRODUCTIVE HOURS To confirm standard factual findings 22-27 listed in the next column, the Auditor reviewed relevant documents, especially national legislation, labour agreements and contracts and time records of the persons included in the sample, to verify that: - the annual productive hours applied were calculated in accordance with one of the methods described below, - the full-time equivalent (FTEs) ratios for employees not working full-time were correctly calculated. If the Beneficiary applied method B, the auditor verified that the correctness in which the total number of hours worked was calculated and that the contracts specified the annual workable hours. If the Beneficiary applied method C, the auditor verified that the 'annual productive hours' applied when calculating the hourly rate were equivalent to at least 90 % of the 'standard annual workable hours'. The Auditor can only do this if the calculation of the standard annual workable	22) The Beneficiary applied method [choose one option and delete the others] [A: 1720 hours] [B: the 'total number of hours worked'] [C: 'standard annual productive hours' used correspond to usual accounting practices]	
		23) Productive hours were calculated annually.	
		24) For employees not working full-time the full-time equivalent (FTE) ratio was correctly applied.	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	hours can be supported by records, such as national legislation, labour agreements, and contracts. <i>BENEFICIARY'S PRODUCTIVE HOURS' FOR PERSONS WORKING FULL TIME SHALL BE ONE OF THE FOLLOWING METHODS:</i> <i>A. 1720 ANNUAL PRODUCTIVE HOURS (PRO-RATA FOR PERSONS NOT WORKING FULL-TIME)</i> <i>B. THE TOTAL NUMBER OF HOURS WORKED BY THE PERSON FOR THE BENEFICIARY IN THE YEAR (THIS METHOD IS ALSO REFERRED TO AS 'TOTAL NUMBER OF HOURS WORKED' IN THE NEXT COLUMN). THE CALCULATION OF THE TOTAL NUMBER OF HOURS WORKED WAS DONE AS FOLLOWS: ANNUAL WORKABLE HOURS OF THE PERSON ACCORDING TO THE EMPLOYMENT CONTRACT, APPLICABLE LABOUR AGREEMENT OR NATIONAL LAW PLUS OVERTIME WORKED MINUS ABSENCES (SUCH AS SICK LEAVE OR SPECIAL LEAVE).</i> <i>C. THE STANDARD NUMBER OF ANNUAL HOURS GENERALLY APPLIED BY THE BENEFICIARY FOR ITS PERSONNEL IN ACCORDANCE WITH ITS USUAL COST ACCOUNTING PRACTICES (THIS METHOD IS ALSO REFERRED TO AS 'STANDARD ANNUAL PRODUCTIVE HOURS' IN THE NEXT COLUMN). THIS NUMBER MUST BE AT LEAST 90% OF THE STANDARD ANNUAL WORKABLE HOURS.</i> <i>'ANNUAL WORKABLE HOURS' MEANS THE PERIOD DURING WHICH THE PERSONNEL MUST BE WORKING, AT THE EMPLOYER'S DISPOSAL AND CARRYING OUT HIS/HER ACTIVITY OR DUTIES UNDER THE EMPLOYMENT CONTRACT, APPLICABLE COLLECTIVE LABOUR AGREEMENT OR NATIONAL WORKING TIME LEGISLATION.</i>	<i>If the Beneficiary applied method B.</i> 25) The calculation of the number of 'annual workable hours', overtime and absences was verifiable based on the documents provided by the Beneficiary. 25.1) The Beneficiary calculates the hourly rates per full financial year following procedure A.3 (method B is not allowed for beneficiaries calculating hourly rates per month). <i>If the Beneficiary applied method C.</i> 26) The calculation of the number of 'standard annual workable hours' was verifiable based on the documents provided by the Beneficiary.	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
		27) The 'annual productive hours' used for calculating the hourly rate were consistent with the usual cost accounting practices of the Beneficiary and were equivalent to at least 90 % of the 'annual workable hours'.	
A.3	HOURLY PERSONNEL RATES <u>I) For unit costs calculated in accordance to the Beneficiary's usual cost accounting practice (unit costs):</u> If the Beneficiary has a "Certificate on Methodology to calculate unit costs " (CoMUC) approved by the Commission, the Beneficiary provides the Auditor with a description of the approved methodology and the Commission's letter of acceptance. The Auditor verified that the Beneficiary has indeed used the methodology approved. If so, no further verification is necessary. If the Beneficiary does not have a "Certificate on Methodology" (CoMUC) approved by the Commission, or if the methodology approved was not applied, then the Auditor: ○ reviewed the documentation provided by the Beneficiary, including manuals and internal guidelines that explain how to calculate hourly rates; ○ recalculated the unit costs (hourly rates) of staff included in the sample following the results of the procedures carried out in A.1 and A.2. <u>II) For individual hourly rates:</u> The Auditor: ○ reviewed the documentation provided by the Beneficiary, including manuals and internal guidelines that explain how to calculate hourly rates;	28) The Beneficiary applied [<i>choose one option and delete the other</i>]: [Option I: "Unit costs (hourly rates) were calculated in accordance with the Beneficiary's usual cost accounting practices"] [Option II: Individual hourly rates were applied] <i>For option I concerning unit costs and if the Beneficiary applies the methodology approved by the Commission (CoMUC):</i> 29) The Beneficiary used the Commission-approved methodology to calculate hourly rates. It corresponded to the organisation's usual cost accounting practices and was applied consistently for all	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	- recalculated the hourly rates of staff included in the sample (recalculation of all hourly rates if the Beneficiary uses annual rates, recalculation of three months selected randomly for every year and person if the Beneficiary uses monthly rates) following the results of the procedures carried out in A.1 and A.2; (only in case of monthly rates) confirmed that the time spent on parental leave is not deducted, and that, if parts of the basic remuneration are generated over a period longer than a month, the Beneficiary has included only the share which is generated in the month.	activities irrespective of the source of funding.	
	<u>“UNIT COSTS CALCULATED BY THE BENEFICIARY IN ACCORDANCE WITH ITS USUAL COST ACCOUNTING PRACTICES”:</u> <i>IT IS CALCULATED BY DIVIDING THE TOTAL AMOUNT OF PERSONNEL COSTS OF THE CATEGORY TO WHICH THE EMPLOYEE BELONGS VERIFIED IN LINE WITH PROCEDURE A.1 BY THE NUMBER OF FTE AND THE ANNUAL TOTAL PRODUCTIVE HOURS OF THE SAME CATEGORY CALCULATED BY THE BENEFICIARY IN ACCORDANCE WITH PROCEDURE A.2.</i> <u>HOURLY RATE FOR INDIVIDUAL ACTUAL PERSONAL COSTS:</u> <i>IT IS CALCULATED FOLLOWING ONE OF THE TWO OPTIONS BELOW:</i> <i>A) [OPTION BY DEFAULT] BY DIVIDING THE ACTUAL ANNUAL AMOUNT OF PERSONNEL COSTS OF AN EMPLOYEE VERIFIED IN LINE WITH PROCEDURE A.1 BY THE NUMBER OF ANNUAL PRODUCTIVE HOURS VERIFIED IN LINE WITH PROCEDURE A.2 (FULL FINANCIAL YEAR HOURLY RATE);</i> <i>B) BY DIVIDING THE ACTUAL MONTHLY AMOUNT OF PERSONNEL COSTS OF AN EMPLOYEE VERIFIED IN LINE WITH PROCEDURE A.1 BY 1/12 OF THE NUMBER OF ANNUAL PRODUCTIVE HOURS VERIFIED IN LINE WITH PROCEDURE A.2.(MONTHLY HOURLY RATE).</i>	<i>For option I concerning unit costs and if the Beneficiary applies a methodology not approved by the Commission:</i> 30) The unit costs re-calculated by the Auditor were the same as the rates applied by the Beneficiary.	
		<i>For option II concerning individual hourly rates:</i> 31) The individual rates re-calculated by the Auditor were the same as the rates applied by the Beneficiary. 31.1) The Beneficiary used only one option (per full financial year or per month) throughout each financial year examined. 31.2) The hourly rates do not include additional remuneration.	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
A.4	TIME RECORDING SYSTEM To verify that the time recording system ensures the fulfilment of all minimum requirements and that the hours declared for the action were correct, accurate and properly authorised and supported by documentation, the Auditor made the following checks for the persons included in the sample that declare time as worked for the action on the basis of time records: ○ description of the time recording system provided by the Beneficiary (registration, authorisation, processing in the HR-system); ○ its actual implementation; ○ time records were signed at least monthly by the employees (on paper or electronically) and authorised by the project manager or another manager; ○ the hours declared were worked within the project period; ○ there were no hours declared as worked for the action if HR-records showed absence due to holidays or sickness (further cross-checks with travels are carried out in B.1 below) ; ○ the hours charged to the action matched those in the time recording system.	32) All persons recorded their time dedicated to the action on a daily/ weekly/ monthly basis using a paper/computer-based system. <i>(delete the answers that are not applicable)</i>	
		33) Their time-records were authorised at least monthly by the project manager or other superior.	
		34) Hours declared were worked within the project period and were consistent with the presences/absences recorded in HR-records.	
		35) There were no discrepancies between the number of hours charged to the action and the number of hours recorded.	
	<i>ONLY THE HOURS WORKED ON THE ACTION CAN BE CHARGED. ALL WORKING TIME TO BE CHARGED SHOULD BE RECORDED THROUGHOUT THE DURATION OF THE PROJECT, ADEQUATELY SUPPORTED BY EVIDENCE OF THEIR REALITY AND RELIABILITY (SEE SPECIFIC PROVISIONS BELOW FOR PERSONS WORKING EXCLUSIVELY FOR THE ACTION WITHOUT TIME RECORDS).</i> <u>If the persons are working exclusively for the action and without time records</u> For the persons selected that worked exclusively for the action without time records, the Auditor verified evidence available demonstrating that they were in reality exclusively dedicated to the action and that the Beneficiary signed a declaration confirming that they have worked exclusively for the action.	36) The exclusive dedication is supported by a declaration signed by the Beneficiary and by any other evidence gathered.	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
B	COSTS OF SUBCONTRACTING		
B.1	The Auditor obtained the detail/breakdown of subcontracting costs and sampled cost items selected randomly (full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest). To confirm standard factual findings 37-41 listed in the next column, the Auditor reviewed the following for the items included in the sample: ○ the use of subcontractors was foreseen in Annex 1; ○ subcontracting costs were declared in the subcontracting category of the Financial Statement; ○ supporting documents on the selection and award procedure were followed; ○ the Beneficiary ensured best value for money (key elements to appreciate the respect of this principle are the award of the subcontract to the bid offering best price-quality ratio, under conditions of transparency and equal treatment. In case an existing framework contract was used the Beneficiary ensured it was established on the basis of the principle of best value for money under conditions of transparency and equal treatment). In particular, i. if the Beneficiary acted as a contracting authority within the meaning of Directive 2004/18/EC (or 2014/24/EU) or of Directive 2004/17/EC (or 2014/25/EU), the Auditor verified that the applicable national law on public procurement was followed and that the subcontracting complied with the Terms and Conditions of the Agreement. ii. if the Beneficiary did not fall under the above-mentioned category the Auditor verified that the Beneficiary followed their usual procurement rules and respected the Terms and Conditions of the Agreement..	37) The use of claimed subcontracting costs was foreseen in Annex 1 and costs were declared in the Financial Statements under the subcontracting category. 38) There were documents of requests to different providers, different offers and assessment of the offers before selection of the provider in line with internal procedures and procurement rules. Subcontracts were awarded in accordance with the principle of best value for money. <i>(When different offers were not collected the Auditor explains the reasons provided by the Beneficiary under the caption “Exceptions” of the Report. The Commission will analyse this information to evaluate whether these costs might be accepted as eligible)</i> 39) The subcontracts were not awarded to other Beneficiaries	

Ref	Procedures	Standard factual finding	Result (C / E / N.A.)
	For the items included in the sample the Auditor also verified that: - the subcontracts were not awarded to other Beneficiaries in the consortium; - there were signed agreements between the Beneficiary and the subcontractor; - there was evidence that the services were provided by subcontractor;	of the consortium.	
		40) All subcontracts were supported by signed agreements between the Beneficiary and the subcontractor.	
		41) There was evidence that the services were provided by the subcontractors.	
C	COSTS OF PROVIDING FINANCIAL SUPPORT TO THIRD PARTIES		
C.1	The Auditor obtained the detail/breakdown of the costs of providing financial support to third parties and sampled [] cost items selected randomly <i>(full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest).</i> The Auditor verified that the following minimum conditions were met: a) the maximum amount of financial support for each third party did not exceed EUR 60 000, unless explicitly mentioned in Annex 1; b) the financial support to third parties was agreed in Annex 1 of the Agreement and the other provisions on financial support to third parties included in Annex 1 were respected.	42) All minimum conditions were met	

D	OTHER ACTUAL DIRECT COSTS		
D.1	COSTS OF TRAVEL AND RELATED SUBSISTENCE ALLOWANCES The Auditor sampled [] cost items selected randomly (<i>full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is the highest</i>). The Auditor inspected the sample and verified that: ○ travel and subsistence costs were consistent with the Beneficiary's usual policy for travel. In this context, the Beneficiary provided evidence of its normal policy for travel costs (e.g. use of first class tickets, reimbursement by the Beneficiary on the basis of actual costs, a lump sum or per diem) to enable the Auditor to compare the travel costs charged with this policy; ○ travel costs are correctly identified and allocated to the action (e.g. trips are directly linked to the action) by reviewing relevant supporting documents such as minutes of meetings, workshops or conferences, their registration in the correct project account, their consistency with time records or with the dates/duration of the workshop/conference; ○ no ineligible costs or excessive or reckless expenditure was declared (see Article 6.5 MGA).	43) Costs were incurred, approved and reimbursed in line with the Beneficiary's usual policy for travels.	
		44) There was a link between the trip and the action.	
		45) The supporting documents were consistent with each other regarding subject of the trip, dates, duration and reconciled with time records and accounting.	
		46) No ineligible costs or excessive or reckless expenditure was declared.	
D.2	DEPRECIATION COSTS FOR EQUIPMENT, INFRASTRUCTURE OR OTHER ASSETS The Auditor sampled [] cost items selected randomly (<i>full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is the highest</i>). For “equipment, infrastructure or other assets” [from now on called “asset(s)”] selected in the sample the Auditor verified that: ○ the assets were acquired in conformity with the Beneficiary's internal guidelines and procedures;	47) Procurement rules, principles and guides were followed.	
		48) There was a link between the grant agreement and the asset charged to the action.	
		49) The asset charged to the action was traceable to the accounting records and the underlying documents.	

	○ they were correctly allocated to the action (with supporting documents such as delivery note invoice or any other proof demonstrating the link to the action) ○ they were entered in the accounting system; ○ the extent to which the assets were used for the action (as a percentage) was supported by reliable documentation (e.g. usage overview table); The Auditor recalculated the depreciation costs and verified that they were in line with the applicable rules in the Beneficiary's country and with the Beneficiary's usual accounting policy (e.g. depreciation calculated on the acquisition value). The Auditor verified that no ineligible costs such as deductible VAT, exchange rate losses, excessive or reckless expenditure were declared (see Article 6.5 GA).	50) The depreciation method used to charge the asset to the action was in line with the applicable rules of the Beneficiary's country and the Beneficiary's usual accounting policy.	
		51) The amount charged corresponded to the actual usage for the action.	
		52) No ineligible costs or excessive or reckless expenditure were declared.	
D.3	COSTS OF OTHER GOODS AND SERVICES The Auditor sampled [] cost items selected randomly (<i>full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest</i>). For the purchase of goods, works or services included in the sample the Auditor verified that: ○ the contracts did not cover tasks described in Annex 1; ○ they were correctly identified, allocated to the proper action, entered in the accounting system (traceable to underlying documents such as purchase orders, invoices and accounting); ○ the goods were not placed in the inventory of durable equipment; ○ the costs charged to the action were accounted in line with the Beneficiary's usual accounting practices; ○ no ineligible costs or excessive or reckless expenditure were declared (see Article 6 GA). In addition, the Auditor verified that these goods and services were acquired in conformity with	53) Contracts for works or services did not cover tasks described in Annex 1.	
		54) Costs were allocated to the correct action and the goods were not placed in the inventory of durable equipment.	
		55) The costs were charged in line with the Beneficiary's accounting policy and were adequately supported.	
		56) No ineligible costs or excessive or reckless expenditure were declared. For internal invoices/charges only the cost element was charged, without any mark-ups.	

	the Beneficiary's internal guidelines and procedures, in particular: ○ if Beneficiary acted as a contracting authority within the meaning of Directive 2004/18/EC (or 2014/24/EU) or of Directive 2004/17/EC (or 2014/25/EU), the Auditor verified that the applicable national law on public procurement was followed and that the procurement contract complied with the Terms and Conditions of the Agreement. ○ if the Beneficiary did not fall into the category above, the Auditor verified that the Beneficiary followed their usual procurement rules and respected the Terms and Conditions of the Agreement. For the items included in the sample the Auditor also verified that: ○ the Beneficiary ensured best value for money (key elements to appreciate the respect of this principle are the award of the contract to the bid offering best price-quality ratio, under conditions of transparency and equal treatment. In case an existing framework contract was used the Auditor also verified that the Beneficiary ensured it was established on the basis of the principle of best value for money under conditions of transparency and equal treatment); <i>SUCH GOODS AND SERVICES INCLUDE, FOR INSTANCE, CONSUMABLES AND SUPPLIES, DISSEMINATION (INCLUDING OPEN ACCESS), PROTECTION OF RESULTS, SPECIFIC EVALUATION OF THE ACTION IF IT IS REQUIRED BY THE AGREEMENT, CERTIFICATES ON THE FINANCIAL STATEMENTS IF THEY ARE REQUIRED BY THE AGREEMENT AND CERTIFICATES ON THE METHODOLOGY, TRANSLATIONS, REPRODUCTION.</i>	57) Procurement rules, principles and guides were followed. There were documents of requests to different providers, different offers and assessment of the offers before selection of the provider in line with internal procedures and procurement rules. The purchases were made in accordance with the principle of best value for money. <i>(When different offers were not collected the Auditor explains the reasons provided by the Beneficiary under the caption “Exceptions” of the Report. The Commission will analyse this information to evaluate whether these costs might be accepted as eligible)</i>	
D.4	AGGREGATED CAPITALISED AND OPERATING COSTS OF RESEARCH INFRASTRUCTURE The Auditor ensured the existence of a positive ex-ante assessment (issued by the EC Services) of the cost accounting methodology of the Beneficiary allowing it to apply the guidelines on direct costing for large research infrastructures in Horizon 2020.	58) The costs declared as direct costs for Large Research Infrastructures (in the appropriate line of the Financial Statement) comply with the methodology described in the positive ex-ante assessment report.	

	<i>In the cases that a positive ex-ante assessment has been issued (see the standard factual findings 58-59 on the next column),</i> The Auditor ensured that the beneficiary has applied consistently the methodology that is explained and approved in the positive ex ante assessment; <i>In the cases that a positive ex-ante assessment has NOT been issued (see the standard factual findings 60 on the next column),</i> The Auditor verified that no costs of Large Research Infrastructure have been charged as direct costs in any costs category; <i>In the cases that a draft ex-ante assessment report has been issued with recommendation for further changes (see the standard factual findings 60 on the next column),</i> The Auditor followed the same procedure as above (when a positive ex-ante assessment has NOT yet been issued) and paid particular attention (testing reinforced) to the cost items for which the draft ex-ante assessment either rejected the inclusion as direct costs for Large Research Infrastructures or issued recommendations.	59) Any difference between the methodology applied and the one positively assessed was extensively described and adjusted accordingly.	
		60) The direct costs declared were free from any indirect costs items related to the Large Research Infrastructure.	
D.5	Costs of internally invoiced goods and services The Auditor sampled cost items selected randomly (full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest). To confirm standard factual findings 61-65 listed in the next column, the Auditor: - obtained a description of the Beneficiary's usual cost accounting practice to calculate costs of internally invoiced goods and services (unit costs); - reviewed whether the Beneficiary's usual cost accounting practice was applied for the Financial Statements subject of the present CFS; - ensured that the methodology to calculate unit costs is being used in a consistent manner, based on objective criteria, regardless of the source of funding; - verified that any ineligible items or any costs claimed under other budget categories, in particular indirect costs, have not been taken into account when calculating the costs of	61) The costs of internally invoiced goods and services included in the Financial Statement were calculated in accordance with the Beneficiary's usual cost accounting practice.	
		62) The cost accounting practices used to calculate the costs of internally invoiced goods and services were applied by the Beneficiary in a consistent manner based on objective criteria regardless of the source of funding.	
		63) The unit cost is calculated using the actual costs for the good or service recorded in the Beneficiary's accounts, excluding any ineligible cost or costs included in other	

	internally invoiced goods and services (see Article 6 GA); - o verified whether actual costs of internally invoiced goods and services were adjusted on the basis of budgeted or estimated elements and, if so, verified whether those elements used are actually relevant for the calculation, and correspond to objective and verifiable information. - o verified that any costs of items which are not directly linked to the production of the invoiced goods or service (e.g. supporting services like cleaning, general accountancy, administrative support, etc. not directly used for production of the good or service) have not been taken into account when calculating the costs of internally invoiced goods and services. - o verified that any costs of items used for calculating the costs internally invoiced goods and services are supported by audit evidence and registered in the accounts.	budget categories.	
		64) The unit cost excludes any costs of items which are not directly linked to the production of the invoiced goods or service.	
		65) The costs items used for calculating the actual costs of internally invoiced goods and services were relevant, reasonable and correspond to objective and verifiable information.	
E	USE OF EXCHANGE RATES		
E.1	<u>a) For Beneficiaries with accounts established in a currency other than euros</u> The Auditor sampled [] cost items selected randomly and verified that the exchange rates used for converting other currencies into euros were in accordance with the following rules established in the Agreement (full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest): <i>COSTS RECORDED IN THE ACCOUNTS IN A CURRENCY OTHER THAN EURO SHALL BE CONVERTED INTO EURO AT THE AVERAGE OF THE DAILY EXCHANGE RATES PUBLISHED IN THE C SERIES OF OFFICIAL JOURNAL OF THE EUROPEAN UNION (https://www.ecb.int/stats/exchange/eurofxref/html/index.en.html), DETERMINED OVER THE CORRESPONDING REPORTING PERIOD.</i> <i>IF NO DAILY EURO EXCHANGE RATE IS PUBLISHED IN THE OFFICIAL JOURNAL OF THE EUROPEAN UNION FOR THE CURRENCY IN QUESTION, CONVERSION SHALL BE MADE AT THE AVERAGE OF THE MONTHLY ACCOUNTING RATES ESTABLISHED BY THE COMMISSION AND PUBLISHED ON ITS WEBSITE (http://ec.europa.eu/budget/contracts_grants/info_contracts/inforeuro/inforeuro_en.cfm),</i>	66) The exchange rates used to convert other currencies into Euros were in accordance with the rules established of the Grant Agreement and there was no difference in the final figures.	

	DETERMINED OVER THE CORRESPONDING REPORTING PERIOD.		
	b) For Beneficiaries with accounts established in euros The Auditor sampled [] cost items selected randomly and verified that the exchange rates used for converting other currencies into euros were in accordance with the following rules established in the Agreement (full coverage is required if there are fewer than 10 items, otherwise the sample should have a minimum of 10 item, or 10% of the total, whichever number is highest): <i>COSTS INCURRED IN ANOTHER CURRENCY SHALL BE CONVERTED INTO EURO BY APPLYING THE BENEFICIARY'S USUAL ACCOUNTING PRACTICES.</i>	67) The Beneficiary applied its usual accounting practices.	

[legal name of the audit firm]

[name and function of an authorised representative]

[dd Month yyyy]

<Signature of the Auditor>

ANNEX 6

MODEL FOR THE CERTIFICATE ON THE METHODOLOGY

- For options [*in italics in square brackets*]: choose the applicable option. Options not chosen should be deleted.
- For fields in [grey in square brackets]: enter the appropriate data.

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TERMS OF REFERENCE FOR AN AUDIT ENGAGEMENT FOR A METHODOLOGY CERTIFICATE IN CONNECTION WITH ONE OR MORE GRANT AGREEMENTS FINANCED UNDER THE HORIZON 2020 RESEARCH AND INNOVATION FRAMEWORK PROGRAMME

INDEPENDENT REPORT OF FACTUAL FINDINGS ON THE METHODOLOGY CONCERNING GRANT AGREEMENTS FINANCED UNDER THE HORIZON 2020 RESEARCH AND INNOVATION FRAMEWORK PROGRAMME

**Terms of reference for an audit engagement for a methodology certificate
in connection with one or more grant agreements financed
under the Horizon 2020 Research and Innovation Framework Programme**

This document sets out the ‘**Terms of Reference (ToR)**’ under which

[OPTION 1: [insert name of the beneficiary] (*‘the Beneficiary’*)] [OPTION 2: [insert name of the linked third party] (*‘the Linked Third Party’*), third party linked to the Beneficiary [insert name of the beneficiary] (*‘the Beneficiary’*)]

agrees to engage

[insert legal name of the auditor] (*‘the Auditor’*)

to produce an independent report of factual findings (*‘the Report’*) concerning the [Beneficiary’s] [Linked Third Party’s] usual accounting practices for calculating and claiming direct personnel costs declared as unit costs (*‘the Methodology’*) in connection with grant agreements financed under the Horizon 2020 Research and Innovation Framework Programme.

The procedures to be carried out for the assessment of the methodology will be based on the grant agreement(s) detailed below:

[title and number of the grant agreement(s)] (*‘the Agreement(s)’*)

The Agreement(s) has(have) been concluded between the Beneficiary and [OPTION 1: *the European Union, represented by the European Commission (‘the Commission’)*][OPTION 2: *the European Atomic Energy Community (Euratom,) represented by the European Commission (‘the Commission’)*][OPTION 3: *the [Research Executive Agency (REA)] [European Research Council Executive Agency (ERCEA)] [Innovation and Networks Executive Agency (INEA)] [Executive Agency for Small and Medium-sized Enterprises (EASME)] (‘the Agency’), under the powers delegated by the European Commission (‘the Commission’).*].

The [Commission] [Agency] is mentioned as a signatory of the Agreement with the Beneficiary only. The [European Union] [Euratom] [Agency] is not a party to this engagement.

1.1 Subject of the engagement

According to Article 18.1.2 of the Agreement, beneficiaries [and linked third parties] that declare direct personnel costs as unit costs calculated in accordance with their usual cost accounting practices may submit to the [Commission] [Agency], for approval, a certificate on the methodology (*‘CoMUC’*) stating that there are adequate records and documentation to prove that their cost accounting practices used comply with the conditions set out in Point A of Article 6.2.

The subject of this engagement is the CoMUC which is composed of two separate documents:

- the Terms of Reference (*‘the ToR’*) to be signed by the [Beneficiary] [Linked Third Party] and the Auditor;
- the Auditor’s Independent Report of Factual Findings (*‘the Report’*) issued on the Auditor’s letterhead, dated, stamped and signed by the Auditor which includes; the standard statements (*‘the Statements’*) evaluated and signed by the [Beneficiary] [Linked Third Party], the agreed-upon procedures (*‘the Procedures’*) performed by the Auditor and the standard factual findings

(‘the Findings’) assessed by the Auditor. The Statements, Procedures and Findings are summarised in the table that forms part of the Report.

The information provided through the Statements, the Procedures and the Findings will enable the Commission to draw conclusions regarding the existence of the *[Beneficiary’s] [Linked Third Party’s]* usual cost accounting practice and its suitability to ensure that direct personnel costs claimed on that basis comply with the provisions of the Agreement. The Commission draws its own conclusions from the Report and any additional information it may require.

1.2 Responsibilities

The parties to this agreement are the *[Beneficiary] [Linked Third Party]* and the Auditor.

The *[Beneficiary] [Linked Third Party]*:

- is responsible for preparing financial statements for the Agreement(s) (‘the Financial Statements’) in compliance with those Agreements;
- is responsible for providing the Financial Statement(s) to the Auditor and enabling the Auditor to reconcile them with the *[Beneficiary’s] [Linked Third Party’s]* accounting and bookkeeping system and the underlying accounts and records. The Financial Statement(s) will be used as a basis for the procedures which the Auditor will carry out under this ToR;
- is responsible for its Methodology and liable for the accuracy of the Financial Statement(s);
- is responsible for endorsing or refuting the Statements indicated under the heading ‘Statements to be made by the Beneficiary/ Linked Third Party’ in the first column of the table that forms part of the Report;
- must provide the Auditor with a signed and dated representation letter;
- accepts that the ability of the Auditor to carry out the Procedures effectively depends upon the *[Beneficiary] [Linked Third Party]* providing full and free access to the *[Beneficiary’s] [Linked Third Party’s]* staff and to its accounting and other relevant records.

The Auditor:

- *[Option 1 by default: is qualified to carry out statutory audits of accounting documents in accordance with Directive 2006/43/EC of the European Parliament and of the Council of 17 May 2006 on statutory audits of annual accounts and consolidated accounts, amending Council Directives 78/660/EEC and 83/349/EEC and repealing Council Directive 84/253/EEC or similar national regulations].*
- *[Option 2 if the Beneficiary or Linked Third Party has an independent Public Officer: is a competent and independent Public Officer for which the relevant national authorities have established the legal capacity to audit the Beneficiary].*
- *[Option 3 if the Beneficiary or Linked Third Party is an international organisation: is an [internal] [external] auditor in accordance with the internal financial regulations and procedures of the international organisation].*

The Auditor:

- must be independent from the Beneficiary *[and the Linked Third Party]*, in particular, it must not have been involved in preparing the Beneficiary’s *[and Linked Third Party’s]* Financial Statement(s);
- must plan work so that the Procedures may be carried out and the Findings may be assessed;
- must adhere to the Procedures laid down and the compulsory report format;
- must carry out the engagement in accordance with these ToR;
- must document matters which are important to support the Report;
- must base its Report on the evidence gathered;
- must submit the Report to the *[Beneficiary] [Linked Third Party]*.

The Commission sets out the Procedures to be carried out and the Findings to be endorsed by the Auditor. The Auditor is not responsible for their suitability or pertinence. As this engagement is not an assurance engagement the Auditor does not provide an audit opinion or a statement of assurance.

1.3 Applicable Standards

The Auditor must comply with these Terms of Reference and with¹:

- the International Standard on Related Services ('ISRS') 4400 *Engagements to perform Agreed-upon Procedures regarding Financial Information* as issued by the International Auditing and Assurance Standards Board (IAASB);
- the *Code of Ethics for Professional Accountants* issued by the International Ethics Standards Board for Accountants (IESBA). Although ISRS 4400 states that independence is not a requirement for engagements to carry out agreed-upon procedures, the Commission requires that the Auditor also complies with the Code's independence requirements.

The Auditor's Report must state that there was no conflict of interests in establishing this Report between the Auditor and the Beneficiary *[and the Linked Third Party]* that could have a bearing on the Report, and must specify – if the service is invoiced - the total fee paid to the Auditor for providing the Report.

1.4 Reporting

The Report must be written in the language of the Agreement (see Article 20.7 of the Agreement).

Under Article 22 of the Agreement, the Commission, *[the Agency]*, the European Anti-Fraud Office and the Court of Auditors have the right to audit any work that is carried out under the action and for which costs are declared from *[the European Union]* *[Euratom]* budget. This includes work related to this engagement. The Auditor must provide access to all working papers related to this assignment if the Commission¹, *the Agency*, the European Anti-Fraud Office or the European Court of Auditors requests them.

1.5 Timing

The Report must be provided by [dd Month yyyy].

1.6 Other Terms

[The [Beneficiary] [Linked Third Party] and the Auditor can use this section to agree other specific terms, such as the Auditor's fees, liability, applicable law, etc. Those specific terms must not contradict the terms specified above.]

[legal name of the Auditor]
[name & title of authorised representative]
[dd Month yyyy]
Signature of the Auditor

[legal name of the [Beneficiary] [Linked Third Party]]
[name & title of authorised representative]
[dd Month yyyy]
Signature of the *[Beneficiary] [Linked Third Party]*

¹ Supreme Audit Institutions applying INTOSAI-standards may carry out the Procedures according to the corresponding International Standards of Supreme Audit Institutions and code of ethics issued by INTOSAI instead of the International Standard on Related Services ('ISRS') 4400 and the Code of Ethics for Professional Accountants issued by the IAASB and the IESBA.

Independent report of factual findings on the methodology concerning grant agreements financed under the Horizon 2020 Research and Innovation Framework Programme

(To be printed on letterhead paper of the auditor)

To

[name of contact person(s)], [Position]
[[Beneficiary's] [Linked Third Party's] name]
[Address]
[dd Month yyyy]

Dear [Name of contact person(s)],

As agreed under the terms of reference dated [dd Month yyyy]

with [OPTION 1: [insert name of the beneficiary] ('the Beneficiary')] [OPTION 2: [insert name of the linked third party] ('the Linked Third Party'), third party linked to the Beneficiary [insert name of the beneficiary] ('the Beneficiary')],

we

[name of the auditor] ('the Auditor'),

established at

[full address/city/state/province/country],

represented by

[name and function of an authorised representative],

have carried out the agreed-upon procedures ('the Procedures') and provide hereby our Independent Report of Factual Findings ('the Report'), concerning the [Beneficiary's] [Linked Third Party's] usual accounting practices for calculating and declaring direct personnel costs declared as unit costs ('the Methodology').

You requested certain procedures to be carried out in connection with the grant(s)

[title and number of the grant agreement(s)] ('the Agreement(s)').

The Report

Our engagement was carried out in accordance with the terms of reference ('the ToR') appended to this Report. The Report includes: the standard statements ('the Statements') made by the [Beneficiary] [Linked Third Party], the agreed-upon procedures ('the Procedures') carried out and the standard factual findings ('the Findings') confirmed by us.

The engagement involved carrying out the Procedures and assessing the Findings and the documentation requested appended to this Report, the results of which the Commission uses to draw conclusions regarding the acceptability of the Methodology applied by the [Beneficiary] [Linked Third Party].

The Report covers the methodology used from [dd Month yyyy]. In the event that the [Beneficiary] [Linked Third Party] changes this methodology, the Report will not be applicable to any Financial Statement¹ submitted thereafter.

The scope of the Procedures and the definition of the standard statements and findings were determined solely by the Commission. Therefore, the Auditor is not responsible for their suitability or pertinence.

Since the Procedures carried out constitute neither an audit nor a review made in accordance with International Standards on Auditing or International Standards on Review Engagements, we do not give a statement of assurance on the costs declared on the basis of the [Beneficiary's] [Linked Third Party's] Methodology. Had we carried out additional procedures or had we performed an audit or review in accordance with these standards, other matters might have come to its attention and would have been included in the Report.

Exceptions

Apart from the exceptions listed below, the [Beneficiary] [Linked Third Party] agreed with the standard Statements and provided the Auditor all the documentation and accounting information needed by the Auditor to carry out the requested Procedures and corroborate the standard Findings.

List here any exception and add any information on the cause and possible consequences of each exception, if known. If the exception is quantifiable, also indicate the corresponding amount.

.....

Explanation of possible exceptions in the form of examples (to be removed from the Report):

- i. the [Beneficiary] [Linked Third Party] did not agree with the standard Statement number ... because...;
- ii. the Auditor could not carry out the procedure ... established because (e.g. due to the inability to reconcile key information or the unavailability or inconsistency of data);
- iii. the Auditor could not confirm or corroborate the standard Finding number ... because

Remarks

We would like to add the following remarks relevant for the proper understanding of the Methodology applied by the [Beneficiary] [Linked Third Party] or the results reported:

Example (to be removed from the Report):

Regarding the methodology applied to calculate hourly rates ...

Regarding standard Finding 15 it has to be noted that ...

The [Beneficiary] [Linked Third Party] explained the deviation from the benchmark statement XXIV concerning time recording for personnel with no exclusive dedication to the action in the following manner:

...

Annexes

Please provide the following documents to the auditor and annex them to the report when submitting this CoMUC to the Commission:

¹ Financial Statement in this context refers solely to Annex 4 of the Agreement by which the Beneficiary declares costs under the Agreement.

1. Brief description of the methodology for calculating personnel costs, productive hours and hourly rates;
2. Brief description of the time recording system in place;
3. An example of the time records used by the [Beneficiary] [Linked Third Party];
4. Description of any budgeted or estimated elements applied, together with an explanation as to why they are relevant for calculating the personnel costs and how they are based on objective and verifiable information;
5. A summary sheet with the hourly rate for direct personnel declared by the [Beneficiary] [Linked Third Party] and recalculated by the Auditor for each staff member included in the sample (the names do not need to be reported);
6. A comparative table summarising for each person selected in the sample a) the time claimed by the [Beneficiary] [Linked Third Party] in the Financial Statement(s) and b) the time according to the time record verified by the Auditor;
7. A copy of the letter of representation provided to the Auditor.

Use of this Report

This Report has been drawn up solely for the purpose given under Point 1.1 Reasons for the engagement.

The Report:

- is confidential and is intended to be submitted to the Commission by the [Beneficiary] [Linked Third Party] in connection with Article 18.1.2 of the Agreement;
- may not be used by the [Beneficiary] [Linked Third Party] or by the Commission for any other purpose, nor distributed to any other parties;
- may be disclosed by the Commission only to authorised parties, in particular the European Anti-Fraud Office (OLAF) and the European Court of Auditors.
- relates only to the usual cost accounting practices specified above and does not constitute a report on the Financial Statements of the [Beneficiary] [Linked Third Party].

No conflict of interest² exists between the Auditor and the Beneficiary [and the Linked Third Party] that could have a bearing on the Report. The total fee paid to the Auditor for producing the Report was EUR [] (including EUR [] of deductible VAT).

We look forward to discussing our Report with you and would be pleased to provide any further information or assistance which may be required.

Yours sincerely

[legal name of the Auditor]

[name and title of the authorised representative]

[dd Month yyyy]

Signature of the Auditor

² A conflict of interest arises when the Auditor's objectivity to establish the certificate is compromised in fact or in appearance when the Auditor for instance:

- was involved in the preparation of the Financial Statements;
- stands to benefit directly should the certificate be accepted;
- has a close relationship with any person representing the beneficiary;
- is a director, trustee or partner of the beneficiary; or
- is in any other situation that compromises his or her independence or ability to establish the certificate impartially.

Statements to be made by the Beneficiary/Linked Third Party ('the Statements') and Procedures to be carried out by the Auditor ('the Procedures') and standard factual findings ('the Findings') to be confirmed by the Auditor

The Commission reserves the right to provide the auditor with guidance regarding the Statements to be made, the Procedures to be carried out or the Findings to be ascertained and the way in which to present them. The Commission reserves the right to vary the Statements, Procedures or Findings by written notification to the Beneficiary/Linked Third Party to adapt the procedures to changes in the grant agreement(s) or to any other circumstances.

If this methodology certificate relates to the Linked Third Party's usual accounting practices for calculating and claiming direct personnel costs declared as unit costs any reference here below to 'the Beneficiary' is to be considered as a reference to 'the Linked Third Party'.

<i>Please explain any discrepancies in the body of the Report.</i>	
Statements to be made by Beneficiary	Procedures to be carried out and Findings to be confirmed by the Auditor
A. Use of the Methodology I. The cost accounting practice described below has been in use since /dd Month yyyy/. II. The next planned alteration to the methodology used by the Beneficiary will be from [dd Month yyyy/.	Procedure: ✓ The Auditor checked these dates against the documentation the Beneficiary has provided. Factual finding: 1. The dates provided by the Beneficiary were consistent with the documentation.
B. Description of the Methodology III. The methodology to calculate unit costs is being used in a consistent manner and is reflected in the relevant procedures. <i>[Please describe the methodology your entity uses to calculate <u>personnel costs</u>, productive hours and hourly rates, present your description to the Auditor and annex it to this certificate]</i> <i>[If the statement of section "B. Description of the methodology" cannot be endorsed by the Beneficiary or there is no written methodology to calculate unit costs it should be listed here below and reported as exception by the Auditor in the main Report of Factual Findings:</i> - ...]	Procedure: ✓ The Auditor reviewed the description, the relevant manuals and/or internal guidance documents describing the methodology. Factual finding: 2. The brief description was consistent with the relevant manuals, internal guidance and/or other documentary evidence the Auditor has reviewed. 3. The methodology was generally applied by the Beneficiary as part of its usual costs accounting practices.

<i>Please explain any discrepancies in the body of the Report.</i>	
Statements to be made by Beneficiary	Procedures to be carried out and Findings to be confirmed by the Auditor
C. Personnel costs <u>General</u> IV. The unit costs (hourly rates) are limited to salaries including during parental leave, social security contributions, taxes and other costs included in the remuneration required under national law and the employment contract or equivalent appointing act; V. Employees are hired directly by the Beneficiary in accordance with national law, and work under its sole supervision and responsibility; VI. The Beneficiary remunerates its employees in accordance with its usual practices. This means that personnel costs are charged in line with the Beneficiary's usual payroll policy (e.g. salary policy, overtime policy, variable pay) and no special conditions exist for employees assigned to tasks relating to the European Union or Euratom, unless explicitly provided for in the grant agreement(s); VII. The Beneficiary allocates its employees to the relevant group/category/cost centre for the purpose of the unit cost calculation in line with the usual cost accounting practice; VIII. Personnel costs are based on the payroll system and accounting system. IX. Any exceptional adjustments of actual personnel costs resulted from relevant budgeted or estimated elements and were based on objective and verifiable information. <i>[Please describe the 'budgeted or estimated elements' and their relevance to personnel costs, and explain how they were reasonable and based on objective and verifiable information, present your explanation to the Auditor and annex it to this certificate].</i> X. Personnel costs claimed do not contain any of the following ineligible costs: costs related to return on capital; debt and debt service charges; provisions for future losses or debts; interest owed; doubtful debts; currency exchange losses; bank costs charged by the Beneficiary's bank for transfers from the Commission/Agency; excessive or reckless expenditure; deductible VAT or costs incurred during suspension of the implementation of the action. XI. Personnel costs were not declared under another EU or Euratom grant	Procedure: <i>The Auditor draws a sample of employees to carry out the procedures indicated in this section C and the following sections D to F.</i> <i>[The Auditor has drawn a random sample of 10 employees assigned to Horizon 2020 action(s). If fewer than 10 employees are assigned to the Horizon 2020 action(s), the Auditor has selected all employees assigned to the Horizon 2020 action(s) complemented by other employees irrespective of their assignments until he has reached 10 employees.].</i> For this sample: ✓ the Auditor reviewed all documents relating to personnel costs such as employment contracts, payslips, payroll policy (e.g. salary policy, overtime policy, variable pay policy), accounting and payroll records, applicable national tax, labour and social security law and any other documents corroborating the personnel costs claimed; ✓ in particular, the Auditor reviewed the employment contracts of the employees in the sample to verify that: i. they were employed directly by the Beneficiary in accordance with applicable national legislation; ii. they were working under the sole technical supervision and responsibility of the latter; iii. they were remunerated in accordance with the Beneficiary's usual practices; iv. they were allocated to the correct group/category/cost centre for the purposes of calculating the unit cost in line with the Beneficiary's usual cost accounting practices; ✓ the Auditor verified that any ineligible items or any costs claimed under other costs categories or costs covered by other types of grant or by other grants financed from the European Union budget have not been taken into account when calculating the personnel costs; ✓ the Auditor numerically reconciled the total amount of personnel costs used to calculate the unit cost with the total amount of personnel costs recorded in the statutory accounts and the payroll system.

<i>Please explain any discrepancies in the body of the Report.</i>	
Statements to be made by Beneficiary	Procedures to be carried out and Findings to be confirmed by the Auditor
(including grants awarded by a Member State and financed by the EU budget and grants awarded by bodies other than the Commission/Agency for the purpose of implementing the EU or Euratom budget in the same period, unless the Beneficiary can demonstrate that the operating grant does not cover any costs of the action). <u>If additional remuneration as referred to in the grant agreement(s) is paid</u> XII. The Beneficiary is a non-profit legal entity; XIII. The additional remuneration is part of the beneficiary's usual remuneration practices and paid consistently whenever the relevant work or expertise is required; XIV. The criteria used to calculate the additional remuneration are objective and generally applied regardless of the source of funding; XV. The additional remuneration included in the personnel costs used to calculate the hourly rates for the grant agreement(s) is capped at EUR 8 000 per full-time equivalent (reduced proportionately if the employee is not assigned exclusively to the action). <i>[If certain statement(s) of section "C. Personnel costs" cannot be endorsed by the Beneficiary they should be listed here below and reported as exception by the Auditor in the main Report of Factual Findings:</i> - ...]	✓ to the extent that actual personnel costs were adjusted on the basis of budgeted or estimated elements, the Auditor carefully examined those elements and checked the information source to confirm that they correspond to objective and verifiable information; ✓ if additional remuneration has been claimed, the Auditor verified that the Beneficiary was a non-profit legal entity, that the amount was capped at EUR 8 000 per full-time equivalent and that it was reduced proportionately for employees not assigned exclusively to the action(s). ✓ the Auditor recalculated the personnel costs for the employees in the sample. Factual finding: 4. All the components of the remuneration that have been claimed as personnel costs are supported by underlying documentation. 5. The employees in the sample were employed directly by the Beneficiary in accordance with applicable national law and were working under its sole supervision and responsibility. 6. Their employment contracts were in line with the Beneficiary's usual policy; 7. Personnel costs were duly documented and consisted solely of salaries, social security contributions (pension contributions, health insurance, unemployment fund contributions, etc.), taxes and other statutory costs included in the remuneration (holiday pay, thirteenth month's pay, etc.); 8. The totals used to calculate the personnel unit costs are consistent with those registered in the payroll and accounting records; 9. To the extent that actual personnel costs were adjusted on the basis of budgeted or estimated elements, those elements were relevant for calculating the personnel costs and correspond to objective and verifiable information. The budgeted or estimated elements used are: — (indicate the elements and their values). 10. Personnel costs contained no ineligible elements; 11. Specific conditions for eligibility were fulfilled when additional

<i>Please explain any discrepancies in the body of the Report.</i>	
Statements to be made by Beneficiary	Procedures to be carried out and Findings to be confirmed by the Auditor
	remuneration was paid: a) the Beneficiary is registered in the grant agreements as a non-profit legal entity; b) it was paid according to objective criteria generally applied regardless of the source of funding used and c) remuneration was capped at EUR 8000 per full-time equivalent (or up to up to the equivalent pro-rata amount if the person did not work on the action full-time during the year or did not work exclusively on the action).
D. Productive hours XVI. The number of productive hours per full-time employee applied is <i>[delete as appropriate]</i>: A. 1720 productive hours per year for a person working full-time (corresponding pro-rata for persons not working full time). B. the total number of hours worked in the year by a person for the Beneficiary C. the standard number of annual hours generally applied by the beneficiary for its personnel in accordance with its usual cost accounting practices. This number must be at least 90% of the standard annual workable hours. <u>If method B is applied</u> XVII. The calculation of the total number of hours worked was done as follows: annual workable hours of the person according to the employment contract, applicable labour agreement or national law plus overtime worked minus absences (such as sick leave and special leave). XVIII. ‘Annual workable hours’ are hours during which the personnel must be working, at the employer’s disposal and carrying out his/her activity or duties under the employment contract, applicable collective labour agreement or national working time legislation. XIX. The contract (applicable collective labour agreement or national working time legislation) do specify the working time enabling to calculate the annual workable hours.	Procedure (same sample basis as for Section C: Personnel costs): ✓ The Auditor verified that the number of productive hours applied is in accordance with method A, B or C. ✓ The Auditor checked that the number of productive hours per full-time employee is correct. ✓ If method B is applied the Auditor verified i) the manner in which the total number of hours worked was done and ii) that the contract specified the annual workable hours by inspecting all the relevant documents, national legislation, labour agreements and contracts. ✓ If method C is applied the Auditor reviewed the manner in which the standard number of working hours per year has been calculated by inspecting all the relevant documents, national legislation, labour agreements and contracts and verified that the number of productive hours per year used for these calculations was at least 90% of the standard number of working hours per year. Factual finding: <u>General</u> 12. The Beneficiary applied a number of productive hours consistent with method A, B or C detailed in the left-hand column. 13. The number of productive hours per year per full-time employee was accurate. <u>If method B is applied</u> 14. The number of ‘annual workable hours’, overtime and absences was

<i>Please explain any discrepancies in the body of the Report.</i>	
Statements to be made by Beneficiary	Procedures to be carried out and Findings to be confirmed by the Auditor
<u>If method C is applied</u> XX. The standard number of productive hours per year is that of a full-time equivalent. XXI. The number of productive hours per year on which the hourly rate is based i) corresponds to the Beneficiary's usual accounting practices; ii) is at least 90 % of the standard number of workable (working) hours per year. XXII. Standard workable (working) hours are hours during which personnel are at the Beneficiary's disposal performing the duties described in the relevant employment contract, collective labour agreement or national labour legislation. The number of standard annual workable (working) hours that the Beneficiary claims is supported by labour contracts, national legislation and other documentary evidence. <i>[If certain statement(s) of section "D. Productive hours" cannot be endorsed by the Beneficiary they should be listed here below and reported as exception by the Auditor:]</i> - ...]	verifiable based on the documents provided by the Beneficiary and the calculation of the total number of hours worked was accurate. 15. The contract specified the working time enabling to calculate the annual workable hours. <u>If method C is applied</u> 16. The calculation of the number of productive hours per year corresponded to the usual costs accounting practice of the Beneficiary. 17. The calculation of the standard number of workable (working) hours per year was corroborated by the documents presented by the Beneficiary. 18. The number of productive hours per year used for the calculation of the hourly rate was at least 90 % of the number of workable (working) hours per year.
E. Hourly rates The hourly rates are correct because: XXIII. Hourly rates are correctly calculated since they result from dividing annual personnel costs by the productive hours of a given year and group (e.g. staff category or department or cost centre depending on the methodology applied) and they are in line with the statements made in section C. and D. above. <i>[If the statement of section 'E. Hourly rates' cannot be endorsed by the Beneficiary they should be listed here below and reported as exception by the Auditor:]</i> - ...]	Procedure ✓ The Auditor has obtained a list of all personnel rates calculated by the Beneficiary in accordance with the methodology used. ✓ The Auditor has obtained a list of all the relevant employees, based on which the personnel rate(s) are calculated. For 10 employees selected at random (same sample basis as Section C: Personnel costs): ✓ The Auditor recalculated the hourly rates. ✓ The Auditor verified that the methodology applied corresponds to the usual accounting practices of the organisation and is applied consistently for all activities of the organisation on the basis of objective criteria irrespective of the source of funding. Factual finding:

<i>Please explain any discrepancies in the body of the Report.</i>	
Statements to be made by Beneficiary	Procedures to be carried out and Findings to be confirmed by the Auditor
	19. No differences arose from the recalculation of the hourly rate for the employees included in the sample.
F. Time recording XXIV. Time recording is in place for all persons with no exclusive dedication to one Horizon 2020 action. At least all hours worked in connection with the grant agreement(s) are registered on a daily/weekly/monthly basis <i>[delete as appropriate]</i> using a paper/computer-based system <i>[delete as appropriate]</i>; XXV. For persons exclusively assigned to one Horizon 2020 activity the Beneficiary has either signed a declaration to that effect or has put arrangements in place to record their working time; XXVI. Records of time worked have been signed by the person concerned (on paper or electronically) and approved by the action manager or line manager at least monthly; XXVII. Measures are in place to prevent staff from: i. recording the same hours twice, ii. recording working hours during absence periods (e.g. holidays, sick leave), iii. recording more than the number of productive hours per year used to calculate the hourly rates, and iv. recording hours worked outside the action period. XXVIII. No working time was recorded outside the action period; XXIX. No more hours were claimed than the productive hours used to calculate the hourly personnel rates. <i>[Please provide a brief description of the <u>time recording system</u> in place together with the measures applied to ensure its reliability to the Auditor and annex it to the</i>	Procedure ✓ The Auditor reviewed the brief description, all relevant manuals and/or internal guidance describing the methodology used to record time. The Auditor reviewed the time records of the random sample of 10 employees referred to under Section C: Personnel costs, and verified in particular: ✓ that time records were available for all persons with not exclusive assignment to the action; ✓ that time records were available for persons working exclusively for a Horizon 2020 action, or, alternatively, that a declaration signed by the Beneficiary was available for them certifying that they were working exclusively for a Horizon 2020 action; ✓ that time records were signed and approved in due time and that all minimum requirements were fulfilled; ✓ that the persons worked for the action in the periods claimed; ✓ that no more hours were claimed than the productive hours used to calculate the hourly personnel rates; ✓ that internal controls were in place to prevent that time is recorded twice, during absences for holidays or sick leave; that more hours are claimed per person per year for Horizon 2020 actions than the number of productive hours per year used to calculate the hourly rates; that working time is recorded outside the action period; ✓ the Auditor cross-checked the information with human-resources records to verify consistency and to ensure that the internal controls have been effective. In addition, the Auditor has verified that no more hours were charged to Horizon 2020 actions per person per year than the number of productive hours per year used to calculate the hourly rates, and verified that

<i>Please explain any discrepancies in the body of the Report.</i>	
Statements to be made by Beneficiary	Procedures to be carried out and Findings to be confirmed by the Auditor
<i>present certificate¹].</i> <i>[If certain statement(s) of section “F. Time recording” cannot be endorsed by the Beneficiary they should be listed here below and reported as exception by the Auditor: - ...]</i>	no time worked outside the action period was charged to the action. Factual finding: 20. The brief description, manuals and/or internal guidance on time recording provided by the Beneficiary were consistent with management reports/records and other documents reviewed and were generally applied by the Beneficiary to produce the financial statements. 21. For the random sample time was recorded or, in the case of employees working exclusively for the action, either a signed declaration or time records were available; 22. For the random sample the time records were signed by the employee and the action manager/line manager, at least monthly. 23. Working time claimed for the action occurred in the periods claimed; 24. No more hours were claimed than the number productive hours used to calculate the hourly personnel rates; 25. There is proof that the Beneficiary has checked that working time has not been claimed twice, that it is consistent with absence records and the number of productive hours per year, and that no working time has been claimed outside the action period. 26. Working time claimed is consistent with that on record at the human-resources department.

¹ The description of the time recording system must state among others information on the content of the time records, its coverage (full or action time-recording, for all personnel or only for personnel involved in H2020 actions), its degree of detail (whether there is a reference to the particular tasks accomplished), its form, periodicity of the time registration and authorisation (paper or a computer-based system; on a daily, weekly or monthly basis; signed and countersigned by whom), controls applied to prevent double-charging of time or ensure consistency with HR-records such as absences and travels as well as its information flow up to its use for the preparation of the Financial Statements.

Grant Agreement number: [insert number] [insert acronym] [insert call identifier]

H2020 Model Grant Agreements: H2020 General MGA — Multi: v5.0 – dd.mm.2017

<i>Please explain any discrepancies in the body of the Report.</i>	
Statements to be made by Beneficiary	Procedures to be carried out and Findings to be confirmed by the Auditor
<i>[official name of the [Beneficiary] [Linked Third Party]]</i>	<i>[official name of the Auditor]</i>
<i>[name and title of authorised representative]</i>	<i>[name and title of authorised representative]</i>
<i>[dd Month yyyy]</i>	<i>[dd Month yyyy]</i>
<i><Signature of the [Beneficiary] [Linked Third Party]></i>	<i><Signature of the Auditor></i>



EUropean Joint Programme on **RAD**ioactive Waste Management **EURAD**

5-year implementation phase 1 – EURAD-1

Annual Work Programme – Year 1 (AWP1)

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1. Coherence with proposal Part B

1.1. AWP1 objectives

This Annual Work Plan – Year 1 (AWP1) provides a detailed description of activities for the initial twelve-month period (from Month 1 to Month 12) of the first implementation of the European Joint Programme on Radioactive Waste Management (EURAD-1), in line with the objectives and description of work presented under proposal Part B and with EURAD Founding Documents.

This document defines the objectives and expected impact of AWP1 and their correspondence with the description of work provided in Proposal Part B. It contains the details of the implementation of the action with regard to **set of activities** to be carried out in full or simply initiated during Period 1, **deliverables**, **specific resources** and **costs** of the participants.

The main objectives of the Annual Work Plan of Year 1 is:

- Launch the European Joint Programme on Radioactive Waste Management (EURAD) ;
- Initiate the 7 RD&D Work Packages and 2 Strategic Studies Work Packages that constitute the “first wave” of EURAD-1;
- Initiate the Knowledge Management Work Packages

1.2. Expected impacts

EURAD proposal (Section 2.1) and EURAD Founding Documents (Section 2.5) each list a number of impacts that can be expected:

1. **Support compliance with European regulations** – by supporting Member States in implementing RD&D, developing skills and providing for transparency in order to develop solutions for their radioactive waste (see, Waste Directive articles 8, 10 and 12.1(f));
2. **Support passive safety of radioactive waste** – by contributing to the responsible and safe management of radioactive waste in Europe, including the safe start of operation of the first geological disposal facilities for high-level and long-lived radioactive waste / spent nuclear fuel as well as improvement, innovation and development of science and technology for the management and disposal of other radioactive waste categories;
3. **Help to gain or maintain public confidence and awareness in radioactive waste management** - by fostering transparency, credibility and scientific excellence;
4. **Support radioactive waste management innovation and optimisation** – by supporting the development of solutions for different waste streams and types and continuously improving and optimising waste management routes and disposal solutions, including identifying needs specific to small inventory programmes with their particular challenges with respect to access to critical mass of expertise and developing appropriate disposal options;
5. **Contribute to addressing scientific/technical challenges and evolving regulatory concerns** – by prioritising activities of high common interest, and creating conditions for cross fertilization, interaction and mutual understanding between different Joint Programme contributors and participants;
6. **Enhance knowledge transfer to early stage programmes** – by providing an opportunity for less advanced programmes, and in particular those in an early stage of geological disposal programme implementation, to benefit from the cross-European integration in radioactive waste management;

7. **Foster efficient use of the RD&D resources at the EU level** - by sharing and advancing existing knowledge, facilities and infrastructure rather than repeating and duplicating efforts; and
8. **Foster a better transfer of knowledge across generations of experts** – by helping to bridge the risk of shortage of the skilled, multidisciplinary human resources and critical infrastructure needed to develop, assess, license and operate RWM facilities, in view of the long lead-times and the intergenerational operational time-spans.

EURAD proposal (Section 2.2) lists a number of measures to be implemented to maximise these impacts, and EURAD Founding Documents (Section 6.2) lists illustrative criteria that could be used in the first 5-year implementation plan for evaluating the overall progress of the Joint Programme, noting that key performance criteria will be formally established and built in close consultation and collaboration with Joint Programme participants at the start of EURAD-1 (scheduled for Month 1).

Above and beyond the KPIs that will be developed and agreed for measuring progress of the overall Joint Programme, we also propose to agree in-year metrics (KPIs) associated with each Work Package. These will be agreed at the start of each year in consultation with Work Package Leaders and the wider EURAD community. They will focus on assessing activities and outcomes of that year that are central for the overall success of that specific Work Package, including how they relate to one of the above stated EURAD impacts.

As the Work Package progresses, and EURAD evolves, we expect that the nature of the KPIs will evolve and their emphasis towards different EURAD impacts might change. We will commit to learning from how such metrics help to manage our programme of work, and will adapt the approach as necessary. We anticipate that this will be discussed at General Assembly meetings on an annual basis.

For this 1st Annual Work Plan, which will be the first year of implementing a Joint Programme on Radioactive Waste Management, we naturally have placed high emphasis on KPIs to continue to build awareness and confidence in our work, and KPIs that will drive strong interactions and behaviours to ensure the work packages don't operate as previous standalone EC projects, but more as packages of work integrated into a wider programme. To illustrate this approach, a list of example KPI's link to EURAD impacts are drafted below – 2 for each Work Package. Such in-year KPIs will be agreed and drafted in consultation with each Work Package Manager and the wider EURAD community at Month 1.



Table 1 -Example* In-year Key Performance Indicators across EURAD Work Packages and their links to EURAD Stated Impacts 1-8 (*to be revised and agreed at Month 1 with WP Managers)

1. Support compliance with European regulations
WP12 Guidance (KM) - Prioritisation list for Delineation of the PLANMAN Guide addresses the RD&D, expertise and skills, and transparency requirements of the Waste Directive and priorities of the call (KPI - Prioritisation list illustrates links with Waste Directive and call priorities).
2. Towards passive safety of radioactive waste
WP6 Gas (R&D) - Experimental parameters are agreed and linked back to specific Safety Case scenarios to show link with passive safety features (KPI – Demonstrate integration with safety).
3. Enhance public confidence and awareness
- WP1 PMO - Establish EURAD website and regularly post news items and communications (KPI - monitor website views). - WP2/3/4/5/6/7/8 (R&D) - State-of-the-art is peer reviewed (KPI - independent reviewer used to provide comments prior to issue). - WP10 UMAN (SS) - Identify potential participants/organisations and MoU for participation in pluralistic analysis seminars (KPI - participant list and MoU issued for wider engagement at GA).
4. Support Innovation and Optimisation
- WP2 ACED (R&D) - Demonstrate engagement with WMO College to discuss how model developments will support implementation, and how it will contribute to demonstration of compliance with safety criteria (KPI- engagement with WMO and TSO Colleges) - WP3 CORI (R&D) - Demonstrate engagement with WMO College to discuss superplasticisers of common interest across Europe (KPI- engagement with WMO College) - WP8 SFC (R&D) - Establish Spent Fuel Owners Group (KPI - broad representation across EU) - WP9 ROUTES (SS) - Obtain inputs from Member States representing a broad range of challenging waste types and challenges facing both early-stage and advanced stage programmes (KPI - Demonstration of engagement)
5. Contribute to evolving regulatory concerns
- WP1 PMO - Maintain / update SRA and Roadmap to align activities of high common interest between EURAD participants (KPI - updated roadmap with KM activities prioritised) - WP10 UMAN (SS) – State-of-the-art is peer reviewed by WMO, TSO and RE colleges (KPI – prior to issue, in order to provide confidence that both safety review and implementation aspects are covered, and that they are up-to-date);
6. Enhance Knowledge Transfer to Early Stage Programmes
- WP9 ROUTES (SS) - Demonstrate engagement to determine specific issues relating to small inventory programmes (KPI - demonstration of engagement). - WP12 Guidance (KM) - 1. Update of the PLANDIS Guide and establishing priority list for delineation of the PLANDIS guidance is done in consultation with Early Stage Programmes (KPI - Final approval endorsed by 2+ ESPs).
7. Foster efficient use of the RD&D resources at the EU level
- WP4 DONUT (R&D) - Demonstrate wide engagement and dissemination of the benchmarking task (KPI - presentation at key industry conference / scientific meeting). - WP6 GAS (R&D) - Demonstrate that modellers and experimentalists have worked together in the design of experiments (KPI - Meeting with both groups to discuss experimental design) - WP11 SoK (KM) - Engagement with RD&D and SS Work Packages on State-of-the-art (KPI - demonstrate engagement and level of coordination) - WP13 Training (KM) - Identify historical and ongoing training material (KPI - Demonstrate that a broad number of sources has been surveyed)
8. Foster a better transfer of knowledge across generations of experts
- WP11 SoK (KM) – Specification for the KM Platform approved by EURAD community (KPI - demonstrate engagement and feedback from end-users); - WP13 Training (KM) – Identify and align with existing training for optimum use of training resources (KPI - Demonstrate that training is not duplicated)



1.3. Correspondence with the Description of Work - Annex 1

EURAD proposal (Section 1.4) and EURAD Founding Documents (Section 3) describes the Strategic Research Agenda (SRA), which includes 7 scientific themes each containing tables of activities (topics and sub-topics) of high-common interest (scope that was developed, agreed and consulted on by the EC JOPRAD project).

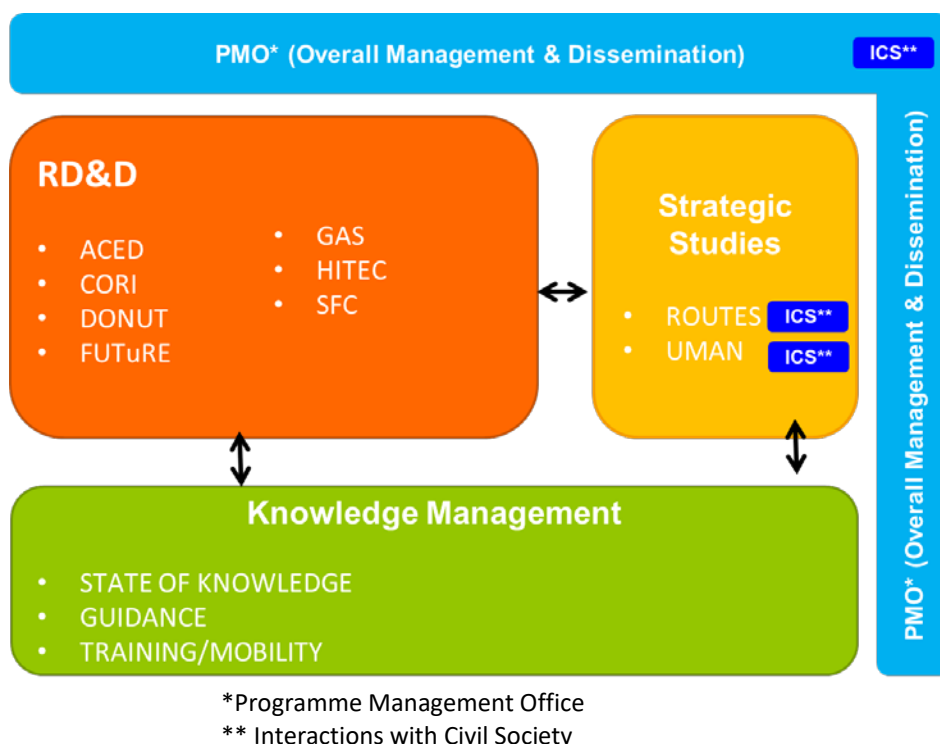
To explain the relevance of the AWP to the specific challenge and scope of EURAD, as set out in the SRA, we have illustrated the direct links of the scope of the 13 EURAD-1 Work packages to specific topics of the SRA (see the table below). In order to aid traceability between the strategic objectives of EURAD on the one hand, and the description of work including the annual work programmes on the other hand, in year 1 of EURAD , the SRA and its topics/sub-topics will adopt an updated and more formal numbering system.

EUROPEAN JOINT PROGRAMME ON RADIOACTIVE WASTE MANAGEMENT (EURAD)			
Identifier No.	EURAD 1 Work Packages (2019-2024)	EURAD Strategic Research Agenda	1st AWP Scope
		Specific Topics of the EURAD Strategic Research Agenda that will be met (in-full or partially) by scope included in the description of work for each Work Package. <i>Work Packages show original JOPRAD scope and numbers</i>	How the work package (and activities in the Description of work) meet the stated objective
Programme Management Office			
WP1	Administration, Scientific Coordination, Communication and Dissemination	Not addressed as a theme in the SRA	Support to other WPs in launching their work
Collaborative RD&D			
WP2	Assessment of Chemical Evolution of ILW and HLW Disposal Cells (ACED)	Theme 7 Performance assessment, safety case development and safety analyses - Topic: Improved understanding the role of physical/chemical processes at different scales and linking bottom-up and top-down approaches in performance assessments (Joprad 2.3.5 Upscaling in Support of Performance Assessment)	State of the Art New data and models
WP3	Cement-Organics-Radionuclide-Interactions (CORI)	Theme 4: Geoscience to understand rock properties, radionuclide transport and long-term geological evolution - Topic: Improved understanding of the role of organics (either naturally occurring or as introduced in the wastes) (Joprad 1.5.6 Organic-Radionuclide Migration)	State of the Art New data, models and experimental methods for analysis and detection
WP4	Development and Improvement of Numerical Methods and Tools for Modelling Coupled Processes (DONUT)	Theme 7 Performance assessment, safety case development, and safety analyses - Topic: Improved understanding of the upscaling of THMC modelling for coupled hydro-mechanical-chemical processes in time and space (Joprad 2.2.4 Upscaling THMC Models)	State of the Art New data and models
WP5	Fundamental Understanding of Radionuclide Retention (FUTURE)	Theme 4: Geoscience to understand rock properties, radionuclide transport and long-term geological evolution - Topic: Quantification of long-term entrapment of key radionuclides in solid phases to inform reactive transport models and the influence of redox (Joprad 1.5.3 Incorporation of Radionuclides in Solid Phases)	State of the Art New data and models
WP6	Mechanistic Understanding of Gas Transport in Clay Materials (GAS)	Theme 4: Geoscience to understand rock properties, radionuclide transport and long-term geological evolution - Topic: To increase understanding of gas migration in different host rocks (Joprad: Gas Migration through the Excavated disturbed Zone/EBS and Far-Field)	State of the Art New data and models
WP7	Influence of Temperature on Clay-based Material Behaviour (HITEC)	Theme 3: Engineered barrier system properties, function and long-term performance - Topic: Improved description of the spatial and temporal evolution of transformations affecting the porous media and degrading materials in the near-field of HLW and ILW disposal systems (Joprad 1.3.7 HLW/ILW Near-field Evolution)	State of the Art New data and models, validated by prototype-scale experiments
WP8	Spent Fuel Characterisation and Evolution Until Disposal (SFC)	Theme 2: Radioactive waste characterisation, processing and storage (Pre-disposal activities), and source term understanding for disposal - Topic: Consolidation of existing understanding of post-closure Spent Fuel release processes (Joprad 1.1.9 Spent- Fuel Evolution)	State of the Art New data and models, and benchmarking across EU
Strategic Studies to Address Complex Issues and Expert Networking			
WP9	Waste management routes in Europe from cradle to grave (ROUTES)	Theme 2: Radioactive waste characterisation, processing and storage (Pre-disposal activities), and source term understanding for disposal - Topic: Waste Management Routes across Europe considering different waste types and their specified endpoints (Originates from networking needs identified by ENEF NAPRO Guide)	Guidance and consensus view on areas to focus future RD&D work and Guidance
WP10	Uncertainty Management multi-Actor Network (UMAN)	Theme 7 Performance assessment, safety case development, and safety analyses - Topic: Further refinement of methods to make sensitivity and uncertainty analyses (Joprad 2.1.3 Uncertainty Treatment)	State of the Art Consensus view of areas to focus future work
Knowledge Management			
WP11	KM State-of-Knowledge (SoK)	Theme 1: Managing implementation and oversight of a radioactive waste management programme - Topic: To maintain information, knowledge and records over the long lead- and implementation-timelines of geological disposal programmes, from pre-licensing through to the post-operational phase (Joprad J3.14)	Development and test of procedures for establishing SoK on demonstration cases
WP12	Guidance	Theme 1: Managing implementation and oversight of a radioactive waste management programme - Topic: To identify RD&D and knowledge transfer needs in support of defining pre-licensing activities that can support success in the siting and licensing phase/process (Joprad J3.11)	Update of overall open-access guidance, and agreement on subsequent detailing of guidance
WP13	Training & Mobility	Theme 1: Managing implementation and oversight of a radioactive waste management programme - Topic: Training and competence maintenance of skills and expertise to support safe radioactive waste management including disposal (Joprad J3.16)	Open-access online training material, initial training courses and opportunities for mobility measures

2. Annual Work Programme Activities

2.1. Structure of the Annual Work Programme

AWP1 is made up of thirteen separate Work Packages (WPs) – seven RD&D WPs, two Strategic Studies WPs, three Knowledge Management WP and the WP dedicated to the Programme Management Office - each of which is split into a number of tasks and subtasks.



a. Programme Management Office (Management and Dissemination)

▪ **WP 1 – Programme Management Office (PMO)**

b. Collaborative RD&D WPs

For the first wave of EURAD-1, the following RD&D WPs have been collaboratively established:

- **WP2 - Assessment of Chemical Evolution of ILW and HLW Disposal Cells (ACED);**
Multiscale approach and process integration to improve long-term modelling and assessments
- **WP3 - Cement-Organic-Radionuclide interactions (CORI);**
Improved understanding of the role off organics (either naturally occurring or as introduced in the wastes and their influence on radionuclide migration in cement based environments
- **WP4 - Development and Improvement Of Numerical methods and Tools for modelling coupled processes (DONUT);**
Improved understanding of the upscaling THMC modelling for coupled hydro-mechanical-chemical processes in time and space
- **WP5 - Fundamental understanding of radionuclide retention (FUTURE)**

Quantification of long-term entrapment of key radionuclides in solid phases to inform reactive transport models and the influence of redox

- **WP6 - Mechanistic understanding of gas transport in clay materials (GAS);**
To increase understanding and predictability of gas migration in different host rocks
- **WP7 - Influence of temperature on clay-based material behaviour (HITEC); and**
Improved THM description of clay based materials at elevated temperatures
- **WP8 - Spent Fuel characterisation and evolution until disposal (SFC);**
Reduce uncertainties in spent fuel properties in predisposal phase

c. Strategic Studies WPs

For the first wave of EURAD-1, the following Strategic Studies WPs have been collaboratively established:

- **WP9 - Waste Management routes in Europe from cradle to grave (ROUTES); and**

Share experience and knowledge on RWM routes between WMOS, TSOs and REs from different countries, with programmes at different stages of development, with different amounts and types of radioactive waste to manage

- **WP10 - Understanding of uncertainty, risk and safety (UMAN).**

Further refinement methods to make sensitivity and uncertainty analyses and the development of multi-actor network for uncertainty management

d. Knowledge Management WPs

Under EURAD-1, Knowledge Management is enabled by three permanent WPs that derive directly from EURATOM expectations under WP2018:

- a. **WP11 - State of Knowledge** - Activities under this WP consist of developing a systematic approach of establishing the state-of-knowledge in the field of RWM research. This shall be done on a stepwise basis: i) establishing of procedures to document the SoK; ii) testing and improving these procedures on a few demonstration topics/sub-topics (of the Roadmap); iii) performing a review on existing tools/platforms and evaluating the added-value of establishing such a platform dedicated to provide access to SoK developed in EURAD.
- b. **WP12 - Methodological guidance** - Activities under this WP consist of developing a comprehensive suite of instructional guidance documents that can be used by Member-States with RWM programmes that are at an early stage of development with respect to their national RWM programme. Such WP shall pursue and complement the work initiated with the PLANDIS Guide.
- c. **WP13- Training/mobility** - Activities under this WP consist of developing a diverse portfolio of tailored basic and specialised training courses under the umbrella of a “School of Radioactive Waste Management”, taking stock of and building upon already existing initiatives (i.e. IAEA and NEA) and creating new initiatives to bridge the identified gaps. The end-users are defined as professionals and potential new professionals at graduated and post-graduated level from EU and non-EU countries (via the IAEA and NEA programmes), and in particular the next generation of experts This WP will also organise a mobility programme to provide access to dedicated infrastructures associated with the Mandated Actors/Linked Third Parties within EURAD. This work will be carried out in close interaction with European networks having a recognised experience in training/mobility in the field of RW

d. Interaction with Civil Society

For the first wave of EURAD -1, the following Work Packages have been selected for specific contribution from civil society:



- SS WP9 - Waste Management routes in Europe from cradle to grave (ROUTES); and
- SS WP10- Understanding of uncertainty, risk and safety (UMAN).

2.2. Timing of the different programmed activities and their components

The breakdown of WPs into tasks and subtasks and the timing of each is included in the diagrams below. Tasks are denoted 'TX' and subtasks are denoted as 'TX.X'. The timing of deliverables is included using notation of 'DX.X'. The final column shows the extent to which the activities will be complete within the first year, expressed as a percentage.

Legend



Training



Combined
Workshop



Meeting



WP Workshop



Task Workshop

WP 2 – Assessment of Chemical Evolution of ILW and HLW Disposal Cells (ACED)

		Year1 / Period 1												Activity Completion
		1	2	3	4	5	6	7	8	9	10	11	12	
		WP meetings / workshops												
ACED	T1	T1.1												25%
		T1.2												25%
		T1.3												0%
		T1.4												100%
		T1.5												100%
	T2	T2.1												25%
		T2.2												25%
	T3	T3.1												39%
		T3.2												16%
		T3.3												16%
	T4	T4.1												27%
		T4.2												0%
		T4.3												0%

WP3 – Cement-Organic-Radionuclide-Interactions (CORI)



			Year1 / Period 1												Activity Completion
			1	2	3	4	5	6	7	8	9	10	11	12	
CORI	WP meetings / workshops														
	T1	T1.1													25%
		T1.2						D3.1							25%
		T1.3								D3.3					25%
	T2														25%
	T3														25%
	T4														25%

WP4 – Development/improvement of numerical methods & tools for modelling coupled processes (DONUT)

			Year1 / Period 1												Activity Completion
			1	2	3	4	5	6	7	8	9	10	11	12	
DONUT	WP meetings / workshops														
	T1	T1.1													25%
		T1.2						D4.1							25%
		T1.3													0%
	T2														25%
	T3														25%
	T4														25%
	T5														0%

WP5 – Fundamental understanding of radionuclide retention (FUTuRE)

			Year1 / Period 1												Activity Completion
			1	2	3	4	5	6	7	8	9	10	11	12	
FUTuRE	WP meetings / workshops														
	T1	T1.1													25%
		T1.2						D5.1							25%
		T1.3													0%
	T2	T2.1													25%
		T2.2													25%
		T2.3													25%
	T3														25%

WP 6 – Mechanistic understanding of gas transport in clay materials (GAS)

			Year1 / Period 1												Activity Completion
			1	2	3	4	5	6	7	8	9	10	11	12	
GAS	WP meetings / workshops														
	T1	T1.1													20%
		T1.2													20%
		T1.3													20%
	T2	T2.1													20%
		T2.2													20%
	T3	T3.1													20%
		T3.2													20%
		T3.3													20%
	T4	T4.1													20%
		T4.2													8%

WP 7 – Influence of temperature on clay-based material behaviour (HITEC)

			Year1 / Period 1												Activity Completion
			1	2	3	4	5	6	7	8	9	10	11	12	
HITEC	WP meetings / workshops														
	T1	T1.1													25%
		T1.2													25%
		T1.3													25%
	T2	T2.1													25%
		T2.2													25%
		T2.3													25%
	T3	T3.1													25%
		T3.2													25%
		T3.3													25%
	T4	T4.1													0%
		T4.2													0%



WP 8 – Spent Fuel Characterization and Evolution Until Disposal (SFC)

		Year1 / Period 1												Activity Completion
		1	2	3	4	5	6	7	8	9	10	11	12	
SFC	s / workshops													
	T1	T1.1												25%
		T1.2				D8.1								25%
		T1.3												0%
	T2	T2.1												25%
		T2.2												25%
		T2.3												25%
		T2.4												25%
	T3	T3.1												25%
		T3.2												25%
		T3.3												14%
	T4	T4.1												14%
		T4.2												0%


WP 9 – Waste management routes in Europe from cradle to grave (ROUTES)

		Year1 / Period 1												Activity Completion
		1	2	3	4	5	6	7	8	9	10	11	12	
ROUTES	WP meetings / workshops													
	T1	T1.1												20%
		T1.2												20%
		T1.3												20%
	T2	T2.1												50%
		T2.2												0%
	T3	T3.1												33%
		T3.2												0%
	T4	T4.1												80%
		T4.2												29%
		T4.3												0%
	T5	T5.1												37%
		T5.2												0%
	T6	T6.1												100%
		T6.2												0%
		T6.3												0%
	T7	T7.1												100%
		T7.2												0%
		T7.3												0%



WP 10 – Uncertainty Management multi-Actor Network (UMAN)

		Year1 / Period 1												Activity Completion
		1	2	3	4	5	6	7	8	9	10	11	12	
UMAN	WP meetings / workshops													
	T1	T1.1												25%
		T1.2												25%
		T1.3												25%
	T2	T2.1												33%
		T2.2												33%
		T2.3												0%
	T3	T3.1												33%
		T3.2												14%
		T3.3												33%
		T3.4												33%
		T3.5												25%
	T4	T4.1											D10.10	100%
		T4.2												28%
		T4.3												0%
	T5	T5.1												25%
		T5.2												25%

WP11 – State-of-Knowledge (SoK)

		Year1 / Period 1											
Month		1	2	3	4	5	6	7	8	9	10	11	12
State-of-Knowledge	T1												
	T2									D11.2			
	T3												
	T4				D11.5								
	T5												

WP12 – Guidance

		Year1 / Period 1											
Month		1	2	3	4	5	6	7	8	9	10	11	12
Guidance	T1											D12.1	D11.2
	T2									D12.3		D12.4	
	T3												

WP13 – Training/Mobility

		Year1 / Period 1											
Month		1	2	3	4	5	6	7	8	9	10	11	12
Training/Mobility	T1			D13.1									
	T2							D13.2					D13.3
	T3											D13.4	
	T4								D13.5			D13.6	
	T5											D13.7	

2.3. Detailed Annual Work Programme Activities

2.3.1.MNG-WP1-PMO-1

Set of Activities Number	MNG-WP1-PMO-1						Start Date or Starting Event	1
Set of Activities Title	Programme Management Office (PMO), including Dissemination							
Participant Number	1	8	19	22	23	37		
Short name of participant	Andra	CNRS	IRSN	JSI	JRC	RWM		
Person-months per Participant:	20	3	3,16	0,45	3	3		
Start month	1			End month			12	

Objectives

The 'Programme Management Office' (PMO) has a strategic role in ensuring the overall coordination of the deployment of EURAD. More specifically, the PMO ensures:

- Day-to-day management of the administrative, legal and financial aspects;
- Internal communication between EURAD Beneficiaries (Mandated Actors);
- Reporting to and interfaces with EC;
- Scientific and technical coordination of the overall programme of activities (RD&D, Strategic Studies, Knowledge Management, Interaction with Civil Society);
- Interfaces with third parties;
- Dissemination of EURAD progress and overall results (of RD&D WPs, Strategic Studies WPs and KM WPs) and outreach activities.

Activity No	Activity Title	lead participant	Total pm AWP1	Start Month	End month
WP1-PMO-1	Programme Management Office (PMO), including Dissemination	1/Andra	31,27	1	12
Task 1	Management and coordination of the administrative, legal and financial aspects	1/Andra	12	1	12
	The PMO is in charge of the day-to-day management of the administrative, legal and financial aspects of EURAD. The work under this task will be permanent over the 5 Annual Work Plans and full details are provided under Proposal Part B. Specific tasks during AWP1 consist of : - Developing a Quality Management Plan (D1.1) that will describe all the procedures for a smooth coordination and fulfilment of obligations as stated in the Grant Agreement and the Consortium Agreement (this includes procedures for assuring reporting standards, check of industrial or intellectual property rights, risk management, respect of ethical EU standards etc.) - Coordinating the preparation and submission to EC of the Year 2 Annual Work Plan to be submitted at Month 9				

Task 2	Overall scientific and technical coordination/integration (RD&D, Strategic Studies and KM)	1/Andra	8	1	12
	The PMO shall ensure appropriate coordination and integration of the overall programme of activities (RD&D, Strategic Studies and Knowledge Management) for an effective deployment of the objectives, in line with EURAD SRA and Roadmap. The work under this task will be permanent over the 5 Annual Work Plans and full details are provided under Proposal Part B. Specific tasks during AWP1 consist of : - Establish monitoring and evaluation criteria to assess EURAD outputs, early affects and long-term impacts constructed (this will be integrated in the Quality Management Plan). This will serve as the basis for the development of a set of key performance indicators (KPI) and shall be in alignment with the Strategic Research Agenda and the Roadmap in order to analyse the impacts of EURAD work on strategies for RWM. Such KPIs shall help measuring outcomes and impacts towards the phases of the Roadmap and in terms which can also be assessed by decision makers (EC, Programme Owners).The list of KPIs will be annually assessed and revised and sent for review to EC in the framework of EC annual reviews of the EJP. As part of this task, and towards the end of the action the PMO shall prepare a tool (e.g. questionnaire aligned to the Waste Directive) for getting the views from national programme owners on EURAD impacts during phase 1. - In addition to KPIs, the PMO will actively maintain and monitor a Risk Register to document those risks identified within each Work Package that may impact the overall performance of the EJP. With respect to the DONUT Work Package (and other WPs that require significant coordination and strategic oversight to ensure consistency and continued support by each College), it is anticipated that a key risk will be raised that relates to meeting the needs of safety assessment end-users with a focus on generic methodologies (exact wording to be agreed). This risk will be managed through identified mitigation measures to be developed and continuously monitored together with the WP Leader, Key WP Contributors from each College, and the PMO. - Propose and ensure the implementation of a set of criteria for monitoring the performance of each Work Package and regularly update the report on the evolution of the implementation; - Ensure, in liaison with the WP Leaders that quality control and quality assurance practice is applied. - Ensure that the quality of the scientific/technical reporting from each WP is adequate and that uniform standards are applied; - Coordinate the preparation of the Annual Work Plan (scientific/technical aspects) based on the inputs provided by the WP Boards; - Ensure and enhance that activities at interfaces among WPs are properly implemented and developed by the WP Boards (e.g. joint workshops between WPs, identification of clear experimental boundary conditions, which allow better exchange between model and experimental teams, development of KPI to monitor the performance of these exchanges); - Ensure effective internal scientific/technical communication and transfer of results from WPs to WPs, and effective coordination of the communities of practice.				
Task 3	Support the Bureau/General Assembly in the extension/update of the SRA and the Roadmap	1/Andra	3,5	1	12
	As a permanent task over the 5 years of EURAD-1, the PMO shall support the Bureau/General Assembly in the exercise that consists of extending/updating the SRA and the Roadmap. During AWP1, the following exercise is anticipated:				

	- [Year 1] Roadmap Extension - Complete EURAD Roadmap with a Competency Matrix, to identify competencies for different Actors (WMOs, TSOs and REs) and to map existing/available SoK, Guidance and Training material (open access) against Themes of EURAD SRA for different phases of implementation of a RWM programme. This shall support identification of the key need-gaps, which will then be used to prioritise the scope of each of the main KM WPs. This task will be undertaken by the PMO, with inputs from participants of the KM WPs and with oversight and guidance by the appointed Joint Programme Fellows/Experts.				
Task 4	Identification of Subject Matter/Theme Experts from EURAD Colleges	1/Andra	0.6	1	12
	During AWP1, the PMO will issue invitations to WMO, TSO and RE Colleges to identify subject matter experts against each of the Roadmap Sub-themes/topics (Deliverable 1.5), who will be able to provide adhoc technical support for a set term (possibly be reviewed/updated annually). The approach is that we utilise those identified to guide EURAD Knowledge Management Activities, to oversee and direct (with limited effort) SoK, Guidance and Training efforts in collaboration with the KM Work Package Leaders				
Task 5	Internal communication and meetings of the Consortium	1/Andra	2.4	1	12
	The PMO shall coordinate the organisation of EURAD Consortium meetings. The work under this task will be permanent over the 5 Annual Work Plans and full details are provided under Proposal Part B. Specific to AWP1, the PMO will prepare organisation for: - EURAD Kick-off meeting (General Assembly 1) (Month 1) - EURAD General Assembly 2 (Month 7) - EURAD Annual Meeting 1 (incl. General Assembly n°3) (Month 13)				
Task6	Dissemination	1/Andra	2.6	1	12
Subtask 6.1	Dissemination Strategy	1/Andra	1.3	1	12
	During AWP1, the PMO will develop EURAD Dissemination Strategy (D1.6) to identify the key messages to be delivered, the target audiences to be addressed, the method/channels to address them, and the timing and process of dissemination. A first version of this strategy shall be available in its first version at month 3.				
Subtask 6.2	Tools to deploy the Dissemination Strategy	1/Andra	1.3	1	12
	During AWP1, the work shall consist of the following component a) <i>Development, update and maintenance of a website</i> As a communication tool with the broader community, a public website (D1.7) will be developed and maintained for disseminating the Joint Programme objectives, main results and achievements, as well as main open events and workshops. b) <i>Newsletters</i> 4 EURAD newsletters will be issued during AWP1 in order to keep all interested parties informed on EURAD activities. This newsletter will be sent by email to all interested parties, and will also be made available on EURAD website. c) <i>Briefs and news papers</i> EURAD will be a step change in the visibility of European research on RWM. The voice of EURAD shall therefore be solicited on key research findings for example for press statements, newspaper articles, public hearings etc. d) <i>EURAD Annual Meetings</i> EJP Meetings will be organised on an annual basis with the main objectives to i) disseminate EJP on-going activities, results and achievements to the large RWM community ii) explore new ideas that may be developed in the framework of EURAD-1 (2nd wave of RD&D/Strategic Studies, annual work programme of the KM activities) iii) organise sessions in the framework the Interactions with Civil Society activities; iv) initiate or deepen collaborations with organisations such as IAEA, NEA, NUGENIA, ENEN, etc. e) <i>Presentation of EURAD in international/European/national events/forums.</i>				

	Personal contacts and presentations through attendance at relevant workshops, conferences, and events are important channels for the dissemination of EJP results. Networking remains a crucial way to exchange, give information about EURAD, and keep informed about the latest developments and outcomes. Non-exhaustive list of external events related to RWM: IGD-TP events, SITEX events, IAEA events, NEA events, NUGENIA events, ENEF Forum, EURADWASTE, Clay Conference, Annual Waste Management Conference, national and local events, etc.				
Task 7	EJP in the international arena	1/Andra	0.6	1	12
	The size and the inclusiveness of EURAD consortium as well as its large generic RD&D/Strategic Studies programme and KM activities will make it a key player in European and worldwide RWM. Exchange with other international actors is essential for increasing the impact of EURAD in the international landscape. EURAD will as well be solicited by various partner organisations and programme owners in their National Programme dissemination. The PMO will ensure interfaces and interactions at EURAD level with IGD-TP, SITEX, RE Group, IAEA, NEA, third country organisations (DOE...) and any other relevant organisations. This can include the formulation of MoU or any other joint agreements, to be validated at the GA and in agreement with EC rules.				
Task 8	Coordination of Interactions with Civil Society	19/IRSN	3.16	1	12
	This task is dedicated to the coordination of CS interactions with the different WPs of EURAD. It is organizing the attendance of the CS members of the CS group to EURAD workshops and will ensure the integration of the results of the participants of the CS teams involved in the ROUTES and UMAN WPs, as well as methodological support for interactions between CS and stakeholders. During AWP1, the composition of the CS group will be finalised according to a selection procedure open to Civil Society applicants from the EU. The CS group includes several categories of participants such as representatives of European or national Civil Society Organisations, members of local communities having interest in RWM, be they representatives of local groups such as local association, local Committee of Information, local partnership (or having participated to such groups)¹. A call for expression of interest will be sent to identified potential members in the first quarter of the first year of EURAD-1 with the perspective to finalize the CS group by the end of the first semester of the project. In order to select the members of the CS group, a list of criteria will be established and after receiving all the applications, they will be assessed through this list of criteria. According to the evaluation, the applicants will receive a formal confirmation of their participation or a formal answer explaining why they do not fulfil the criteria of the CS group". It will be still possible to enter the CS group after and the applicants will be assessed on the same basis. Also during AWP1, the first workshop on ICS will be organised. It will gather the participants of the CS group, the CS Experts together with a panel of WMOs, TSOS and REs participants in EURAD. It will be divided in one general session and topical sessions on ROUTES & UMAN WPs. The general and topical sessions will each be prepared and animated by the dedicated CS experts team. This includes elaboration of material, methodologies, processes and sessions to prepare EURAD participants and CS representatives in order facilitate fruitful interactions.				

¹ Each candidate will demonstrate evidence of a standing engagement (of his institution or of himself) in the follow-up of RWM activities (for a period is a period of at least 3 years in the RWM field). Each participant is to be prepared to attend (at least twice a year) to a programme of meetings where facilitated interactions with EURAD participants will be organised.



Deliverables

- **D1.1 – Second Annual Work Plan** [Month 9] – Lead: [**Andra**]
- **D1.5 – EURAD Quality Management Plan** [Month 3] + its annual update - Lead: [**Andra**]
- **D1.6 – EURAD Data Management Plan** [Month 12] – Lead [*Andra*]
- **D1.7 - EURAD Roadmap, extended with Competence Matrix** and mapping exercise on related SoK, Guidance, and Training/Mobility Resource input from D1.9 [Month 12] - Lead: [**Andra**]
- **D1.8 - ‘Soft’ update of the EURAD SRA/Roadmap** – [Month 12] - Lead: [**Andra**]
- **D1.10 - Identification of Subject Matter/Theme Experts from EURAD Colleges** [Month 12] + its update - Lead: [**Andra**]
- **D1.11 - EURAD Dissemination strategy** [Month 3] + annual update - Lead: [**Andra**]
- **D1.12- EURAD website** [Month 3] - Lead: [**Andra**]
- **D1.13 List of members of the CS group** [Month 6] + its annual update Lead [IRSN (**Mutadis**)]

Additional Deliverables (if applicable - brief description and month of delivery)

N/A

2.3.2.RDD WP2-ACED-1

Set of Activities Number	RDD WP2-ACED-1				Start Date or Starting Event			Month 1		
Set of Activities Title	Assessment of Chemical Evolution of ILW and HLW Disposal Cells (ACED)									
Participant number	1	3	5	6	8	9	14	15	19	22
Short name of participant	Andra	Bel V	CEA	CIEMAT	CNRS	COVRA	ENRESA	FZJ	IRSN	JSI
Person/months per participant	7.1	1.0	23.0	13.8	10.7	5.0	7.0	7.9	12.1	12.2
Participant number	25	26	27	31	34	38	43	51		
Short name of participant	LEI	MTA EK	NAGRA	NRG	PSI	SCK•CEN	SURAO	VTT		
Person/months per participant	2.1	3.4	13.5	3.6	4.4	6.9	10.9	9.0		
Start month	1				End month			12		

Objectives

The broader scope of this WP is the assessment of the chemical evolution at the disposal cell scale involving interacting components/materials and thermal, hydraulic and/or chemical gradients by considering ILW and HLW disposal concepts representative for different concepts throughout Europe. To increase the attention towards relevant materials and processes, the work package addresses ILW and HLW components up to the disposal cell scale. The study of the disposal cell in this WP ranges from microscale processes at interfaces between different materials up to interactions of waste packages with their immediate surrounding near field environment and the host rock.

The main objective is to improve methodologies to obtain multi-scale quantitative models for the chemical model at cell disposal scale based on existing and new experimental data and process knowledge and to improve the description of the most relevant processes driving the chemical evolution into robust mathematical frameworks. This is done for four selected representative disposal cell designs by analysing and combining information from available experimental studies, new targeted experimental studies developed within this WP and modelling exercises at both process and system levels. Applications will lead to integrated process understanding at larger temporal and spatial scales compared to individual process scale studies. The outcomes will impact the safety case in different ways such as with respect to material specifications and establishment of requirements for deposition scenarios. The representative designs are set for ILW and HLW in both crystalline and sedimentary rock types, representing prevailing designs of the WMOs as end-users.

More specifically, the WP seeks to:

- Compile and integrate the process level knowledge and description of reactivity at the interfaces between materials relevant for ILW and HLW disposal cells
- Develop and evaluate methodologies to integrate available process-level knowledge and processes into a multi-process and multi-scale modelling framework for assessing chemical evolution at the disposal cell level
- Propose and apply a step-wise scale-up process-based approach to identify (i) processes and features which control the chemical evolution for representative HLW and ILW disposal cells and (ii) to which detail and complexity these processes should be incorporated in models for different type of safety and performance related studies. The information gained through study of the more generic but European representative HLW and ILW disposal cells can later be used and adapted for more specific, national disposal cell designs.

The main aim of the RDD WP2-ACED-1 Set of Activities during AWP1 will mainly consist of establishing the State-of-the-Art and initiate each individual activities as described below.

Activity No	Activity Title	lead participant	Total pm AWP 1	Start Month	End month
RDD WP2-ACED-1	Assessment of Chemical Evolution of ILW and HLW Disposal Cells	SCK•CEN	153.4	1	12
Task 1	S/T coordination, State-of-the-art and training material	SCK•CEN	24.5	1	12
Subtask 1.1	S/T coordination	SCK•CEN	0.5	1	12
	The scientific and technical coordination of ACED will be performed by the WP Leader [SCK•CEN]. The WP Leader will be supported by the Task leaders and co-leaders: [IRSN], [PSI], [Andra], [VTT] [COVRA] [FZJ] [SURAO (UJV)] which together with [SCK•CEN] constitute the WP Board of ACED. The WP Leader will make sure that the rules of the EJP are followed by all partners, that the scientific milestones and deliverables are reached timely, and that the results are disseminated efficiently inside and outside the project. It includes also participation to PMO meetings twice a year. Subtask 1.1 consists of ensuring information transfer between different (sub)tasks. This is accomplished by a number of WP meetings, workshops and general milestones. During first Annual Work Plan (AWP1), two meetings will be held: • Kick-off meeting (ACED WP Meeting 1) at Month 1 including a discussion on the specifications of the representative systems (leading to Milestone Mx.x in Month 2) and discussion between experimentalists and modellers on requirements for modelling approaches and expected experimental input. • ACED WP Meeting 2 (including task meetings) + ACED workshop n°1 on data, model concepts, and parameters based on expected experimental results for interface and waste package scales, on coordination of information exchange between experiments and models within and between scales and on scale transitions of data, model approaches and model results – Month 7				
Subtask 1.2	State-of-the-art	COVRA	1.5	1	12
	During AWP1, the work shall consist of compiling and evaluating the state-of-the-art regarding relevant processes that influence the long-term chemical evolution in disposal cells for vitrified HLW and for cemented ILW (Deliverable 2.1). Besides information from integrated experiments, other alternative routes to study the long-term chemical evolution are included as well such as evidence from natural or archaeological analogues. Also, current practices of integration are reviewed. These desktop studies will provide: • Description of relevant processes and transients that influence the chemical evolution in the disposal cells (e.g. with respect to pH, redox, temperature, chemistry of near field water, etc.) and at the following six interfaces glass-steel, cement/mortar granite, cement/concrete-clay, steel/iron bentonite, steel/iron-cement/concrete and steel/iron-granite (e.g. formation of new phases, porosity/permeability changes influencing fluid/gas transport, etc.) • Overview about which conceptual and mathematical models have been and are used to describe these processes and the chemical evolution; how are these models parameterized (e.g. sources of data to parameterize long-term processes, e.g. application of data/insight from experiments, natural/archaeological analogues, etc.) Participants: [SCK•CEN] [FZJ] [COVRA] with input from all participants				
Subtask 1.4	Current handling of the chemical evolution	COVRA	11.0	1	5
	During AWP1, this task will consist of collecting the conceptualisations of the chemical evolutions and which parts have been modelled in Europe For countries not participating in Task 1, teleconferences with authors of safety cases will be held to get the conceptualisations, model descriptions and sources of data at a sufficient detail from the other national programmes. (Deliverable 2.4) Participants: [SCK•CEN] [FZJ] [Andra] [VTT] [SURAO] [ENRESA] [LEI] [COVRA]				

Subtask 1.5	Analysis of experiments and numerical model studies on interfaces	FZJ	11.5	1	5
	During AWP1, desk-based studies will be performed to provide a structured overview of existing (experimental) data on relevant processes occurring at the following six interfaces: glass-steel, cement/mortar-granite, cement/concrete-clay, steel/iron-bentonite, steel/iron-cement/concrete and steel/iron-granite. The overviews includes also natural/ archaeological analogues that may provide insight/data for long-term processes relevant to the chemical evolution of the disposal cells not accessible in short-term (laboratory) experiments. In addition, the desk-based studies will also provide an overview on the conceptual models used to describe the processes at the interface. This overview forms the basis for conceptualisation of the chemical evolution at these interfaces in the other tasks and will be used to support model validation and parametrization of models (Deliverable 2.5) Participants: [SCK•CEN] [Andra] [VTT] [SURAO] [COVRA] [CIEMAT] [FZJ]				
Task 2	Interface scale: Reactivity of Steel/Material Interfaces	IRSN	64.8	1	12
Subtask 2.1	Steel/clay material interface reactivity	SURAO (UJV)	42.4	1	12
	During AWP1, a workshop is organised to initiate interaction between the experimentalists and the modellers working on the steel/clay interface. This provides input to the detailed specifications of the experimental set ups, and the description of measurement and characterization leading to an experimental work plan for subtask 2.1. Further, the models used to describe existing and new experiments will be defined. A summary will be made which serves as input to the first workshop at WP level (M7, see subtask 1.1). During the second half of AWP1, the new experiments will be set-up and characterization (existing experiments) will be performed according to the experimental work plan. Modelling will start for the existing experiments which will lead to a deliverable in AWP2. Participants: [SURAO (UJV)] [CIEMAT (UAM)] [ENRESA] [NAGRA (UBERN)] [IRSN (Mines Paris Tech)] [MTA EK] [NRG] [CNRS-SUBATECH (IMT Atlantique)]				
Subtask 2.2	Steel/cement material interface reactivity	IRSN	22.4	1	12
	During AWP1, a workshop is organised to initiate interaction between the experimentalists and the modellers working on the steel/cement interface. This provides input to the detailed specifications of the experimental set ups, and the description of measurement and characterization leading to an experimental work plan for subtask 2.1. Further, the models used to describe existing and new experiments will be defined. A summary will be made which serves as input to the first workshop at WP level (M7, see subtask 1.1). During the second half of AWP1, the new experiments will be set-up and characterization (existing experiments) will be performed according to the experimental work plan. Modelling will start for the existing experiments which will lead to a deliverable in AWP2. Participants: [BELV], [IRSN (Mines ParisTech)], [MTA EK], [NRG], [PSI], [CNRS-SUBATECH (IMT Atlantique)], [VTT], [JSI (ZAG)]				
Task 3	Waste package scale (conditioned waste, disposal container, overpack)	PSI	54.0	1	12
Subtask 3.1	Experimental analysis	CEA	44.3	1	12
	During AWP1, the experimental program related to task 3 (waste package scale) will be initiated. This consists of (i) interaction with the partners in subtask 3.2 and 3.3 (modelling subtasks) to coordinate exchange of information between the experimentalists and modellers, and (ii) to summarize the selected experiments. The latter will include a detailed description of the experimental conditions, available data for model implementation and evaluation, and expected data for future model evaluation (D2.10 for high-level waste package, and D2.11 for intermediate level waste packages, M7). In addition, the experimental work plan for this subtask will be defined. In the second half of the AWP1, sample collection and preparations are foreseen and samples will be distributed to the different characterization laboratories.				

	Participants: [CEA (EDF)] [CNRS-SUBATECH (IMT Atlantique) (ULorraine)] [SCK•CEN] [MTA EK] [VTT] [Covra] [FZJ] [JSI (ZAG)] [PSI]				
Subtask 3.2	Modelling of chemical evolution of HLW waste package scale	SCK•CEN	5.3	6	12
	Activities will be initiated after the specifications of the waste disposal cells are finalized (WP Kick-off meeting, subtask 1.1), the deliverable on the selected experiments for HLW is finished (Deliverable 2.10), and the workshop 1 (subtasks 1.1) is finished. Partners will then start to develop and implement their conceptual and mathematical models to describe the evolution of a HLW disposal cell at the waste package scale. This is an activity which will be continued in AWP2. Participants: [CEA] [COVRA] [Andra (BRGM)] [MTA EK] [SCK•CEN]				
Subtask 3.3	Modelling of chemical evolution of ILW waste package scale	NRG	4.4	6	12
	Activities will be initiated after the specifications of the waste disposal cells are finalized (WP Kick-off meeting, subtask 1.1), the deliverable on the selected experiments for ILW is finished (D2.11), and the workshop 1 (subtasks 1.1) is finished. Partners will then start to develop and implement their conceptual and mathematical models to describe the evolution of a HLW disposal cell at the waste package scale. This is an activity which will be continued in AWP2. Participants : [Andra (BRGM)], [COVRA], [VTT], [PSI], [NRG]				
Task 4	Disposal cell scale	VTT	10.1	1	12
Subtask 4.1	Conceptual and mathematical formulation for a mechanistic based model (reactive transport model) to simulate the chemical evolution at the disposal cell scale	FZJ (UFZ)	10.1	6	12
	Based on the different deliverables finished in the first half of the AWP1, this subtask will perform a first integration of available knowledge into a conceptual and mathematical model for the chemical evolution at the disposal cell scale for each of the four system (2 HLW disposal cell systems, 2 ILW disposal cell systems). The choices of the model will be bounded by the current capabilities of the numerical codes. The models are summarized in D2.16 . Participants: [Andra] [LEI] [COVRA] [FZJ (UFZ)] [SCK•CEN] [ENRESA] [VTT] [NRG] [IRSN (MINES ParisTech)] [SURAO (UJV)]				

Deliverables

- **D2.1 – Subtask 1.2 – State-of-the-art report** – SOTA of model and experiment with identification of knowledge gaps of experimental data – Lead: COVRA (Month 6) – Completion at 100%.
- **D2.4 – Subtask 1.4 – Treatment of chemical evolution in national programmes** – Lead: COVRA (Month 5) – Completion at 100%.
- **D2.5 – Subtask 1.5 – Experiments and numerical model studies on interfaces** – Lead: FZJ (Month 5) – Completion at 100%.
- **D2.10 – Subtask 3.1 – HLW: Report describing the selected experiments and the existing/expected experimental results** as input for MS31 – Lead: MTA EK (Month 7) – Completion at 100%.
- **D2.11 – Subtask 3.1 – ILW: Report describing the selected experiments and the existing/expected experimental results** as input for MS31 – Lead: [JSI (ZAG)] (Month 7) – Completion at 100%.
- **D2.16 – Subtask 4.1 – Report on the conceptual model formulation for a mechanistic based model on implementing the initial SOTA knowledge on models and parameters (link to T1&T3) in existing numerical tools** – Lead: ENRESA (Month 12) – Completion at 100%.

Additional Deliverables (if applicable - brief description and month of delivery)

N/A

2.3.3.RDD WP3-CORI-1

Set of Activities Number	RDD WP3-CORI-1				Start Date or Starting Event			Month 1		
Set of Activities Title	<u>C</u> ement- <u>O</u> rganic- <u>R</u> adionuclide- <u>I</u> nteractions (CORI)									
Participant number	1	5	6	8	11	10	15	22	24	34
Short name of participant	Andra	CEA	CIEMAT	CNRS	CVREZ	FTMC	FZJ	JSI	KIT	PSI
Person/months per participant	6.0	8.9	18.6	15.0	3.0	5.0	6.8	6.6	26.3	6.0
Participant number	36	43	38	48						
Short name of participant	RATEN	SURAO	SCK•CEN	UCY						
Person/months per participant	4.3	21.7	4.6	1.0						
Start month	1				End month			12		

Objectives

CORI aims to improve the knowledge on the organic release issues which can accelerate the radionuclide migration in the context of the post closure phase of geological repositories for ILW and LLW/VLLW, including surface/shallow disposal. The RD&D in CORI is expected to extend the current state-of-the-art, contribute to optimized disposal solutions and consider questions of regulatory concern. CORI will help member states to further develop their national RD&D programmes and support programmes at an early implementation stage. Enhancing cooperation between the different participating beneficiaries and countries is an important objective in CORI. Knowledge transfer and training of young researchers in view of future demands for qualified staff is likewise a key aspect of CORI.

CORI objectives are addressing topics in the context of cement-organic-radionuclide-interactions. Organic materials are present in some nuclear waste and as admixtures in cement-based materials and can potentially influence the performance of a geological disposal system, especially in the context of low and intermediate level waste disposal. This potential effect of organic molecules is related to the formation of complexes in solution with some radionuclides of interest (actinides and lanthanides) which can (i) increase the radionuclide solubility and (ii) decrease the radionuclide sorption. Organic substances require increased attention since a significant quantity exists in the waste and in the cementitious materials, with a large degree of chemical diversity. Cement-based materials will be degraded with time in the context of waste disposal inducing a large range of alkaline pH conditions according to their degradation state. Alkaline pH provides specific conditions under which the organics can degrade, which contributes to increasing their impact on repository performance. The most critical open topics and data needs required to better assess and quantify cement-organic-radionuclide-interactions are reflected in the three R&D oriented CORI Tasks:

- Organic Degradation
- Organic-Cement-Interactions
- Radionuclide-Organic-Cement-Interactions

Activity No	Activity Title	lead participant	Total pm AWP1	Start Month	End month

RDD WP3- CORI-1	Cement-Organic-Radionuclide-Interactions (CORI)	KIT	133.6	1	12
Task 1	S/T coordination, State-of-the-art and training material	KIT	2.5	1	12
Subtask 1.1	S/T coordination	KIT	0.9	1	12
	In order to ensure that the CORI WP is progressing according to the agreed planning, S/T coordination will start from month 1 involving the Coordinator [KIT] and the Task leaders, [Andra] [CNRS-SUBATECH] for Task 2, [KIT (Amphos21)] [Andra] for Task 3, and [CEA] [CIEMAT] for Task 4. Main activities will include the WP Board meetings scheduled for months 1, 6, and 12, and the continuous communication with the CORI partners and the Project Management Office. The Coordinator, with the support of the CORI Board, will make sure that Deliverables are prepared and submitted on time, Milestones are reached, and support CORI partners in the process of setting up the experimental RD&D programme starting at month 7, as required. The organisation and preparation of the First Annual CORI Workpackage Meeting (at month 12) will be an additional focus of activities within the first project year in this Subtask. The Annual CORI Workpackage Meetings are key events in CORI, clustering several activities including information exchange, monitoring of work progress, dissemination of results, interaction with End Users and other stakeholders, amongst others, and thus require various coordination activities.				
Subtask 1.2	State-of-the-art	KIT	0.8	1	12
	CORI will prepare a state-of-the-art report on cement-organic-radionuclide-interactions as D3.1 , which is scheduled at month 6 (with updating at month 48 as D3.2), for which [KIT] is responsible. The work in the first six months will accordingly focus on preparing the related Deliverable D3.1 . Feeding into D3.1 are the Technical Reports developed on Task level, which focus on the state-of-the art for specific topics, namely (i) organic degradation by hydrolytic and radiolytic processes [CNRS-SUBATECH] [Andra], (ii) organic-cement-interactions [KIT (Amphos21)] [Andra], (iii) radionuclide-organic-cement-interactions [CEA] [CIEMAT], and (iv) fundamental cement chemistry [Andra] [CEA] [CIEMAT] [CNRS-SUBATECH] [KIT (Amphos21)]. All partners in CORI will contribute to D3.1 via exchange with the respective Task leaders.				
Subtask 1.3	Training Materials	KIT	0.8	1	12
	The Deliverable on Training Materials D3.3 will be developed until month 8 (and later updated at month 48 as D3.4). Key input for this work is the Deliverable D3.1 , the state-of-the-art report on cement-organic-radionuclide-interactions prepared in Subtask 1.2, as described above. The preparation of D3.3 is consequently placed 2 months after this state-of-the-art report. All Task leaders [Andra] [CEA] [CIEMAT] [CNRS-SUBATECH] [KIT (Amphos21)] will contribute to this work, which will be coordinated by [KIT]. The training materials will be made available and distributed as ppt- or pdf-files.				
Task 2	Organic Degradation	CNRS, ANDRA	38.8	1	12
	Work in CORI Task 2 starts with the preparation of the state-of-the-art Technical Report on organic degradation by radiolytic and hydrolytic processes. [Andra] [CNRS-SUBATECH] [SCK-CEN], with the support of all partners involved in Task 2, will develop the related milestone-document at month 6, which will directly feed into D3.1 . Further work during the first six months will be the preparation of the RD&D programme starting at month 7. After the start of the experimental work programme at month 7, efforts will be strongly focused on performing experimental studies on the radiolytic and hydrolytic degradation of organic materials, involving the partners [Andra (BRGM)] [CNRS-(UOrléans)] [FTMC] [JSI] [FZJ] [KIT] [PSI] [SURAO (CTU)] [SURAO (UJV)] [CVREZ] [SCK-CEN]. Contributing to the First Annual CORI Workpackage Meeting at month 12 will be a key				

	activity for all partners within the first year, also in view of the First Technical Meeting of Task 2 integrated into the meeting, and the exchange with other Tasks in CORI.				
Task 3	Organic-Cement-Interactions	KIT, ANDRA	40.9	1	12
	Task 3 in CORI features the preparation of a Technical Report placed as milestone-document at month 6. This document will include a state-of-the-art report on organic-cement-interactions directly feeding into D3.1 , prepared by [Andra] [KIT (Amphos21)] with the support of all partners involved in Task 3. It will further include the final detailed documentation of the systems to be studied and the experimental techniques and approaches. Further work during the first six months will be the preparation of the RD&D programme starting at month 7. After the start of the experimental programme at month 7, efforts will be strongly focused on performing experimental studies on organic-cement-interactions, involving the partners [CEA] [CIEMAT (CSIC)] [CVREZ] [JSI] [KIT] [PSI (EMPA)] [RATEN] [SCK-CEN] [SURAO (CTU)] [SURAO (UJV)]. The First Annual CORI Workpackage Meeting at month 12 will be a key activity within the first year, also in view of the integrated First Technical Meeting of Task 3, which will specifically address organic retention studies on cementitious materials, and the exchanging with other CORI Tasks.				
Task 4	Radionuclide-Organic-Cement-Interactions	CEA, CIEMAT	51.4	1	12
	Work in CORI Task 4 includes the preparation of a Technical Report defined as milestone-document at month 6. This is including (i) a state-of-the-art report on radionuclide-organic-cement-interactions directly feeding into D3.1 , prepared by [CEA] [CIEMAT] with support of all partners involved in Task 4, and (ii) the final detailed documentation of the systems to be studied and the experimental techniques and approaches. Further work during the first six months will be the preparation of the RD&D programme starting at month 7. After the start of the experimental programme at month 7, efforts will be strongly focused on performing experimental studies on radionuclide-organic-cement-interactions, involving the partners [Andra] [CNRS-SUBATECH] [FTMC] [FZJ (HZDR)] [KIT (Amphos21) (UMAINZ) (UPOTSDAM)] [SURAO (CTU) (UJV)] [RATEN] [SCK-CEN] [UCY]. The First Annual CORI Workpackage Meeting at month 12 will be a key activity within the first project year, also in view of the integrated First Technical Meeting of Task 4, which will specifically address radionuclide retention studies onto cementitious material in presence of organics, and the exchange with other Tasks in CORI. Work will additionally include a second Technical Report at month 12, prepared by [CEA] [CIEMAT] and all partners involved in Task 4, on (i) radionuclide retention on CSH or CASH or AFm/AFt in the presence of organics, and (ii) radionuclide retention on HCP in the presence of organics.				

Deliverables

- **D3.1 – Subtask 1.2 – SOTA on cement-organic-radionuclide-interactions in the content of L/ILW disposal** – Chapters to include: (i) Organic degradation by hydrolytic and radiolytic processes; (ii) Organic-cement-interactions; (iii) Radionuclide-organic-cement-interactions; (iv) Fundamental Cement Chemistry – Lead: KIT (Month 6) – Completion at 100%.

Additional Deliverables (if applicable - brief description and month of delivery)

N/A

2.3.4.RDD WP4-DONUT-1

Set of Activities Number	RDD WP4-DONUT-1				Start Date or Starting Event			Month 1		
Set of Activities Title	Development and Improvement Of Numerical methods and Tools for modelling coupled processes (DONUT)									
Participant number	1	5	8	9	14	15	16	19	25	26
Short name of participant	Andra	CEA	CNRS	COVRA	ENRESA	FZJ	GRS	IRSN	LEI	MTA EK
Person/months per participant	8.5	18.9	41.0	2.4	3.0	6.0	1.3	14.6	4.5	5.0
Participant number	31	34	38	43	46	47	49			
Short name of participant	NRG	PSI	SCK•CEN	SURAO	TS-Enercon	TUS	UHelsinki			
Person/months per participant	4.9	3.1			4.2		6.5			
Start month	1				End month			12		

Objectives

Improvement of numerical methods and tools for modelling multi-physical Thermo-Hydro-Mechanical-Chemical coupled processes (THMC) occurring in radioactive waste disposal is a major and permanent issue to support its optimization of design. It is worth noticing that the R&D objectives, later described in the document, are a not direct input of safety case, but contributes to improve scientific knowledge, which could if appropriate support safety case abstraction.

Numerical simulations are necessary to make predictive multi-physical assessments, at time frames and space scales larger than experiments can cover. These numerical simulations require integrating, in a consistent framework, an increasing scientific knowledge acquired for each of the individual components of a system for radioactive waste disposal. This implies to consider couplings of different and non-linear processes, applied to a wide range of materials with contrasting properties as a function of time and space in ever-larger systems.

The development of cutting-edge and efficient numerical methods is thus necessary, in the scope of development and use of powerful and relevant numerical tools for assessments. In parallel, it is also necessary to manage the uncertainties associated to the input data that feed the models, and to the representation of the processes, in order to assess the range of variability of the results and to identify the main parameters and processes that drive the behaviour of the systems of interest. Managing uncertainties in these complex systems requires the improvement and the development of innovative, appropriate and efficient methods.

According to the needs described previously, main objectives of this WP are:

- The development of relevant, performant and cutting-edge numerical methods that can easily be implemented in existing or new tools, in order to carry out high-performance computing to facilitate the study of highly coupled processes in large systems. These methods and their implementation in tools will be mainly applied to reactive transport, 2-phase flow, and THM modelling in porous and fractured media;
- The development of numerical scale transition schemes for coupled processes (meso² to macro scale), supporting the study of specific multi-scale couplings such as chemo-mechanics;
- The development of innovative numerical methods to carry out uncertainty and sensitivity analyses;
- The set-up and the achievement of benchmark exercises, on representative test cases, to test the efficiency of developed methods (robustness, accuracy, time computational) on relevant tools.

² The mesoscale modelling domains are defined by the representative elementary volume (REV) that is applicable to the material of interest

Activity No	Activity Title	Short name of lead participant	Person-Months	Start Month	End month
RDD WP4-DONUT-1	Development and Improvement Of NUMerical methods and Tools for modelling coupled processes (DONUT)	Andra (BRGM)	123.8	1	12
Task 1	S/T coordination, State-of-the-art and training material	Andra (BRGM)	1.5	1	12
Subtask 1.1	S/T coordination	Andra (BRGM)	0.9	1	12
	In the first year the work carried out in this subtask will be: - Organizing and holding the WP kickoff meeting; - Establishing the communication within the WP; - Ensuring that the partners follow the agreed work plan and taking mitigation actions if necessary; - Organizing the T+1 years annual meeting Participants : [Andra (BRGM)] [CNRS (ULille)] [FZJ (UFZ)] [SURAO] [TS Enercon]				
Subtask 1.2	State-of-the-art	Andra (BRGM)	0.6	1	12
	A state-of-the-art report is due after 6 months. The workload will be distributed and agreed at the kick off meeting with the different partners to achieve this goal. The WP coordination team will harmonize the contributions of the different partners as a quality control measure. Participants: [Andra (BRGM)] [CNRS (ULille)] [FZJ (UFZ)] [SURAO] [TS Enercon] All WP participants will contribute to this subtask.				
Task 2	Numerical methods for high performance computing of coupled processes	CNRS	65.5	1	12
	A detailed scientific description of the task work and the role of the partners is given in the paragraph 3.2.4 of the main document of EURAD proposal. The partners involved in task 2 will contribute to the state-of-the-art report in the first year. Based on this state-of-the-art report the partners will start to develop further the numerical methods and tools according to their work description. At the end of the first year, partners will present their preliminary results to the first annual meeting and contribute to the proceedings of the first annual workshop. Task Contributors: [CNRS-LJAD (ULille) (UNice)] [PSI] [SURAO (CTU) (CU) (IGN) (TUL)] [CEA (EDF)] [MTA EK (SORC)] [Andra (BRGM)] [IRSN] [NRG]				
Task 3	Scale transition schemes for coupled processes	FZJ, PSI	18.3	1	12
	A detailed scientific description of the task work and the role of the partners is given in the paragraph 3.2.4 of the main document of EURAD proposal. The partners involved in task 3 will contribute to the state-of-the-art report in the first year. Based on this state-of-the-art report involved partners will start to develop transition schemes to bridge spatial scales and improve tools that enable the consideration of chemo-mechanical process couplings. At the end of the first year, partners will present their preliminary results to the first annual meeting and contribute to the proceedings of the first annual workshop. Participants : [SURAO (TUL)], [Andra (BRGM)], [FZJ (UFZ)], [PSI]				
Task 4	Tools and methods to quantify/derive uncertainties induce by coupled processes	TS Enercon	38.6	1	12



	A detailed scientific description of the task work and the role of the partners is given in the paragraph 3.2.4 of the main document of EURAD proposal. The partners involved in task 4 will contribute to the state-of-the-art report in the first year. Based on this state-of-the-art report involved partners will start to develop both innovating numerical methods to treat uncertainty and sensitivity analysis on complex coupled representative cases and mathematical representations of uncertain parameters applied for coupled processes. At the end of the first year, partners will present their preliminary results to the first annual meeting and contribute to the proceedings of the first annual workshop. Participants: [SCK•CEN], [SURAO (IGN) (TUL) (ÚJV Řež)], [Andra (BRGM)], [GRS], [University of Helsinki (TUT)], [ENRESA], [FZJ (HZDR)], [TS Enercon]

Deliverables

- D4.1 – Subtask 1.2 – State-of-the-art in the fields of numerical analysis and scientific computing**
 - This will identify numerical solutions taking advantage of the recent breakthrough in the fields of numerical analysis and scientific computing. It will also describe representative experimental data needed for the upscaling procedure – Lead: Andra (BRGM) (Month 6) – **Completion at 100%.**

Additional Deliverables (if applicable - brief description and month of delivery)

N/A



2.3.5.RDD WP5-FUTuRE-1

Set of Activities Number	RDD WP5-FUTuRE-1				Start Date or Starting Event			Month 1		
Set of Activities Title	Fundamental Understanding of Radionuclide Retention (FUTuRE)									
Participant number	1	5	6	8	15	16	24	26	33	34
Short name of participant	Andra	CEA	CIEMAT	CNRS	FZJ	GRS	KIT	MTA EK	POSIVA	PSI
Person/months per participant	8.1	5.8	13.3	31.0	19.5	2.6	18.0	5.3	20.5	5.5
Participant number	36	38	43	45	49					
Short name of participant	RATEN	SCK•CEN	SURAO	TNO	UHELSINKI					
Person/months per participant	8.0	3.1	3.5	4.5	8.0					
Start month	1				End month			12		

Objectives

The objectives of this WP are:

- Fundamental insights into the impact of chemical boundary conditions and the role of microstructures on radionuclide speciation and mobility in “real” clay rocks as well as crystalline rocks
- Enhance the quantitative and mechanistic understanding of the impact of (i) specific surface properties of materials (diffusive double layer, surface potential), (ii) the role of grain boundaries, (iii) the effect of water saturation, content and chemistry (pH, ionic strength) as well as (iv) the impact of pore size variability and heterogeneity on the mobility of chemical species
- Refined understanding of the relation between fracture/ pore structures and transport as well as the feedback of mineral reactions (dissolution/precipitation, clogging) on pore structure and connectivity
- Closing knowledge gaps regarding sorption reversibility, uptake mechanisms (adsorption vs. incorporation, precipitation), sorption competition and surface diffusion which have not been addressed sufficiently in previous European projects (e.g. FUNMIG, SKIN).
- Fundamental understanding and thus reducing uncertainties of surface induced (heterogeneous) redox processes with regard to coupled sorption and electron transfer interface reactions governing the retention of redox-sensitive radionuclides at Fe(II)/Fe(III) bearing minerals surfaces – going beyond previous European projects (e.g. RECOSY).

Activity No	Activity Title	lead participant	Total pm AWP1	Start Month	End month
RDD WP5-FUTuRE-1	Fundamental understanding of radionuclide retention (FUTuRE)	FZJ	148.5	1	12
Task 1	S/T coordination, State-of-the-art and training material	FZJ	1.8	1	12
Subtask 1.1	S/T coordination	FZJ	0.8	1	12

	The scientific and technical coordination of WP5-FUTuRE will be performed by the WP Leader [FZJ]. The WP Leader will be supported by the Task leaders and co-leaders: [PSI], [SURAO (UJV)], [FZJ (HZDR)], [SCK-CEN], [Andra (BRGM)] which together with [FZJ] constitute the WP Board of FUTuRE. The WP Leader will make sure that the rules of the EJP are followed by all partners, that the scientific milestones and deliverables are reached timely, and that the results are disseminated efficiently inside and outside the project. The WP Leader will ensure the interface between the WP Board, between the participants of WP5-FUTuRE, and with the Program Management Office and the other EURAD WPs. A kick-off meeting will be organized shortly after the start of the WP (WPM1).				
Subtask 1.2	State-of-the-art	SCK•CEN	1.1	1	12
	A state-of-the-art report will be drafted at the start of the project (Month 6) with the aim to provide a comprehensive overview of the available knowledge on the understanding of radionuclide retention in clay and crystalline rocks (D5.1). Emphasis will be on the current available knowledge with respect to i) transferability of sorption phenomena to compacted/realistic systems and sorption reversibility and, ii) surface induced (heterogeneous) redox processes. Participants: [SCK•CEN] [CEA] [PSI] [SCK•CEN] [TNO]				
Task 2	Mobility	PSI	87.4	1	12
Subtask 2.1	Mobility of radionuclides in compacted clay	PSI	43.7	1	12
	During AWP1, the work shall consist of: - Kick-off workshop: Task leaders will communicate and discuss with the FUTuRE partners the final fine-tuning of their contributions and the schedule. - The potential for streamlining the activities will be discussed and implemented in the sense that the measurements on real clay systems shall be accompanied by measurements on related model systems wherever necessary. - Selection and preparation of clay materials to be shared between the partners and characterization of clay materials incl. method development (including analytics) for sorption/transport on compacted clays as well as first measurements and benchmarking. Participants: [Andra] [CEA] [CIEMAT] [CNRS-IC2MP/ SUBATECH/ IPHC (UPoitiers)] [KIT (UMAINZ)] [FZJ] [MTA EK] [PSI] [SCK•CEN]				
Subtask 2.2	Mobility of radionuclides in crystalline rock	FZJ	18.5	1	12
	During AWP1 and after an initial kick-off meeting the team will analyze up-to date state of the art of interaction and migration experiments and will utilize a detailed work plan for experimental activities, defining a workflow of experiments and post-mortem analyses on crystalline rock samples, altogether with activities in-situ. The crystalline rock samples and fissure infills will be sampled in Bukov URL and/or at other sites. The samples will be characterized prior to flow, diffusion, and sorption experiments and prepared for the experimental activities. The complementing activities in Grimsel tests site, based on quantification of speciation and transport of under natural crystalline fracture conditions under natural shear zone will be also starting. Participants [FZJ (HZDR)] [GRS] [KIT] [POSIVA] [SURAO (UJV)] [UHelsinki]				
Subtask 2.3	Reversibility of sorption	PSI	25.3	1	12



	Selection and preparation of clay materials to be shared between the project partners; characterization of clay materials; method development and testing (including analytics) for sorption/desorption studies on clays; first measurements and benchmarking Participants: [Andra (BRGM)] [CIEMAT] [CNRS-IPHC] [FZJ] [MTA EK] [PSI] [SCK•CEN] Reports on set-up of experiments within Task 2 will be delivered at Month 10 led by [PSI] and [FZJ (HZDR)]				
Task 3	Redox reactivity of radionuclides on mineral surfaces	BRGM	59.3	1	12
	During AWP1, the “Redox” task will essentially be dedicated to preparing the samples that will be subsequently used for wet chemistry and diffusion experiments. More specifically, in the case of diffusion experiments, the compacted samples will be rested to the relevant nuclear waste agencies and, when obtained, it will be verified that they are suitable for the foreseen experiments (i.e., adequate compaction, absence of fractures, absence of visible sample oxidation). In the case of batch samples, clays and iron oxides will be obtained from the relevant sources or synthesized, and purification processes will be performed. In addition, the different institutions that foresee to work on the same samples will share the available samples, when purified, and will coordinate to ensure an adequate repartition of the workload. In all cases, if samples are found to be adequate for the experiments, the deep characterization of the solid samples will be started. Reports on set-up of experiments within Task 3 will be delivered at Month 10 led by [PSI, and [Andra (BRGM)]. Participants: [Andra (BRGM)] [CEA] [CIEMAT] [CNRS (UGrenoble)] [FZJ (HZDR)] [KIT] [PSI] [RATEN] [TNO]				

Deliverables

- **D5.1 – Subtask 1.2 – State-of-the-art report on the understanding of radionuclide retention in clay and crystalline rocks** – Emphasis will be on the current available knowledge with respect to i) transferability of sorption phenomena to compacted/realistic systems and sorption reversibility and, ii) surface induced (heterogeneous) redox processes – Lead: SCK (Month 6) – **Completion at 100%.**

Additional Deliverables (if applicable - brief description and month of delivery)

N/A

2.3.6.RDD WP6-GAS-1

Set of Activities Number	RDD WP6-GAS-1				Start Date or Starting Event			Month 1		
Set of Activities Title	Mechanistic understanding of gas transport in clay materials (GAS)									
Participant number	1	4	5	6	8	9	15	16	19	24
Short name of participant	Andra	BGE	CEA	CIEMAT	CNRS	COVRA	FZJ	GRS	IRSN	KIT
Person/months per participant	2.3	0.7	1.4	9.0	28.2	3.2	2.4	2.2	6.9	2.2
Participant number	25	27	32	34	37	43	38	49	50	
Short name of participant	LEI	NAGRA	<u>ONDRAF/</u> <u>NIRAS</u>	PSI	RWM	SURAO	SCK•CEN	UHElsinki	UKRI-BGS	
Person/months per participant	0.5	17.4	9.9	4.8	0.7	10.6	5.6	0.5	21.6	
Start month	1				End month			12		

Objectives

The main objectives of this WP are:

- To improve the mechanistic understanding of gas transport processes in natural and engineered clay materials, their couplings with the mechanical behaviour and their impact on the properties of these materials;
- To evaluate the gas transport regimes that can be active at the scale of a geological disposal system and their potential impact on barrier integrity and repository performance.

The programme of work will aim to provide results that are applicable to a wide range of national programmes. This is possible because the results of previous efforts on the identification and characterisation of the possible gas transport processes suggest that the mechanisms at play in different clays are generally similar, while the conditions (gas pressure, stresses/deformations, saturation, ...) for the transition from one transport regime (diffusion, two-phase flow, pathway dilation and fracturing) to another strongly depend on the specific properties of a given clay material.

This WP will also aim to transfer knowledge gained from lab and *in situ* experiments to configurations that are commonly found in current repository designs, to address key questions from the end-users:

- How could gas migrate within the repository and which water soluble and volatile radionuclide transport could be associated with it?
- How and to what extent could the hydro-mechanical perturbations induced by gas effect barrier integrity and long-term repository performance?

This WP will build up heavily on the experience feedback and conclusions from the previous EC Project FORGE. The experimental investigation of gas transport in FORGE sometimes revealed complex mechanisms (e.g. such as the development of discrete, unstable pathways controlled by the mechanical behaviour of the porous media). However, it was also suggested that this complexity can be addressed as long as one can bound the effects of these mechanisms using simpler and robust descriptions for evaluation purposes. This WP will then aim at increasing the confidence in the overall understanding of gas behaviour in clay materials gained from the FORGE EC project and improving its integration in the conceptualisation process for the different components of a repository system. This should in turn support and justify the use of robust evaluation approaches and confirm the expert judgement at the end of FORGE that gas is not a show stopper for geological disposal but a question of managing uncertainties.

Activity No	Activity Title	lead participant	Total pm AWP1	Start Month	End month
RDD WP6-GAS-1	Mechanistic understanding of gas transport in clay materials (GAS)	ONDRAF/NIRAS	130.1	1	12
Task 1	S/T coordination, State-of-the-art and training material	ONDRAF/NIRAS	2.0	1	12
Subtask 1.1	S/T coordination	ONDRAF/NIRAS	0.4	1	12
	Substantial coordination work will be carried out in the first year, to ensure that scientific and technical tasks start in line with the WP programme and objectives, to materialize the interactions with other WPs (especially HITEC) and to prepare the first training. The S/T coordinator [ONDRAF/NIRAS] will initiate and coordinate the drafting of the initial state-of-the-art report (D6.1) as input to the KM WP State-of-Knowledge. The S/T coordinator will organise two WP meetings (in workshop format) during the first year, one of these will be organised jointly with HITEC and will be aligned with the EJP annual meeting. A detailed work plan for the second year will also be prepared by month 9.				
Subtask 1.2	State-of-the-art reporting	ONDRAF/NIRAS	1.2	1	12
	The drafting of the initial state-of-the-art report (D6.1) on gas transport through clay materials will be initiated at the start of the WP (Month 1). This SOTA aims at feeding to KM WP State-of-Knowledge (by month 18, in the middle of the second year) and to providing a yardstick against which progress in the WP can be measured. It will include a synthesis of the state of knowledge on gas transport through clay materials and an overview of the current conceptualisations of gas migration through geological disposal systems in the context of the safety case. This SOTA will be produced by [BGS] [SCK•CEN] [NAGRA] and [IRSN], with input from WP tasks 2-4. [ONDRAF/NIRAS] will coordinate this effort in cooperation with [BGS] and ensure interactions with the KM WPs to ensure that the report content and format is fit-for-purposes.				
Subtask 1.3	Training materials	SCK•CEN	0.4	1	12
	A first training workshop on multi-physical couplings in geomechanics (including gas and THM) will be organised in the format of a doctoral school jointly with WP HITEC and in collaboration with the Training/Mobility KM WP during the first year (around month 6). Experts from tasks 2-4 will contribute course materials. The assembly of the course programme, practical organisation and hosting will be led by [ONDRAF-NIRAS (ULiège)], in cooperation with [SCK•CEN].				
Task 2	Transport Mechanisms	SCK•CEN	72.9	1	12
Subtask 2.1	Diffusion and retardation	CNRS	27.4	1	12
	Key objectives of this subtask are to determine gas diffusion parameters on different clayey materials at different degrees of water saturation, to support experimental data interpretation by pore network modelling, and to understand gas physisorption mechanisms in microporous systems. The first year will be devoted to setting up these experiments and defining the experimental protocols, ensuring that these are consistent and complementary between the labs involved. This work will be led by [CNRS (UGrenoble)] and will involve [SCK•CEN] [PSI] [BGS] [IRSN] and [CNRS(Subatech)]. Sampling and sample distribution to the labs will also be organised for the materials of interest (COx, Boom Clay, OPA, bentonite). Modellers participating to this subtask will support experiment and protocol design through scoping calculations.				

Subtask 2.2	Advection (displacement versus dilatant gas flow)	BGS	45.5	1	12
	The focus of this subtask is to determine if visco-capillary, dilatant flow or a combination of the two apply in clay-rich materials. It is split into integrated components (laboratory/field and numeric) for which new experimental studies provide reference data to guide and validate numerical modelling. As for subtask 2.1, the first year will be devoted to setting up these experiments and defining the experimental protocols, ensuring that these are consistent and complementary between the labs involved. This work will be led by [BGS] and will involve [CNRS (UPoitiers)] [CIEMAT] [SURAO (CTU) and (UJV)] [SCK•CEN]. Sampling and sample distribution to the labs will also be organised for the materials of interest (COx, Boom Clay, OPA, bentonite). The modelling teams involved in this subtask [ONDRAF/NIRAS (ULiège)] [IRSN] [COVRA (TU Delft)] [CIEMAT (UPC)] [BGE] [FZJ (UFZ)] [KIT (BGR)] will review the experimental programme and, when required, support experiment design and the definition of protocols through scoping calculations. [SCK•CEN] will ensure the general coordination of these two subtasks (2.1 and 2.2), in cooperation with the WP S/T coordinator [ONDRAF/NIRAS].				
Task 3	Barrier Integrity	NAGRA	47.4	1	12
Subtask 3.1	Gas-induced impacts on barrier integrity	NAGRA	16.9	1	12
	During the first year, the programme of laboratory experiments will be designed and started, aimed at investigating the evolution of damage in clay-rich geomaterials when subjected to excessive pore fluid (gas/water) pressures. As in the subtasks of task 2, care will be taken that the experimental matrix and test procedures (e.g. stress paths) in this subtask adequately covers the range of conditions and the materials (argillaceous rock, clayey EBS material) representative for geological disposal systems. Sampling and sample distribution to the labs will also be organised for the materials of interest (COx, Boom Clay, OPA, bentonite). This subtask 3.1 is led by [NAGRA] and involves [NAGRA (CIMNE) and (ZHAW) and (EPFL)] [GRS] [SURAO (CTU)] [IRSN] [BGS] [CNRS (UPoitiers) and (ULorraine)] and [Andra]. To foster dialogue between experimentalist and modeller early on, the proposed test programme will be reviewed by the modelling teams involved in Task 3. Complementary activities in Task 3.1 comprise desk studies and the compilation of experimental data bases on gas induced rock failure from in-situ experiments in URLs (Andra, Nagra). Thus, a review of gas-related FEPs will be conducted as an initial action in the context of the State-of-the-art report (D6.1) to address further detrimental effects associated with gas transport. The outcome of the FEP screening may lead to complementary experimental investigations in the later stages of the WP.				
Subtask 3.2	Pathway closure and sealing processes	Andra	14.4	1	12
	This tasks aims at assessing the effectiveness of self-sealing processes along gas-induced pathways in the clay barriers of a geological repository. Not only the mechanisms that promote self-sealing, but also phenomena and processes that could prevent pathway closure will be investigated experimentally. Especially during the first year, the nature of the work in this subtask will be very similar to the one described in subtask 3.1 above as similar, and sometimes common experiments will be performed to address both aspects (hydromechanical damage/self-sealing), except for chemical processes that are specific to this subtask. This subtask 3.2 is led by [Andra] and involves the same team as subtask 3.1. As the self-sealing studies of this subtask are closely connected to the ones planned in the subtask 2.1 of the HITEC WP, part of the test programme will elaborated jointly (a common GAS/HITEC will be organised during the first year, see subtask 1.1), to optimise experiments carried out during the duration of EURAD under various thermal and chemical conditions for coherency and complementarity.				

Subtask 3.3	Model-based interpretation and synthesis of results	FZJ	16.1	1	12
	During the first year, [FZJ (UFZ)] [Andra] and [NAGRA] will survey the state of knowledge by contributing to the drafting of the SOTA (D6.1). Experimental databases from previous research programmes (e.g.; NEA/Clay Club Initiatives on “Gas” and on “Self-sealing”; EU FP7-FORGE) will be compiled. Drawing on the input from Tasks 3.1 & 3.2, [FZJ (UFZ)] will coordinate the elaboration of an experimental design report, which includes a detailed description of the experimental set-ups and test procedures and the detailed work programme of Tasks 3.1, 3.2 and 3.3 for the following years. The modelling teams [NAGRA (CIMNE) and (EPFL)] [CIEMAT (UPC)] [COVRA (TU Delft)] [ONDRAF/NIRAS (ULiège)] [CNRS (UPoitiers)] [CEA (EDF)] and [BGE] [KIT (BGR)] and [FZJ (UFZ)] will contribute to the design of the laboratory experiments.				
Task 4	Repository performance aspects	Andra	7.8	1	12
Subtask 4.1	Conceptualization of gas migration at repository scale	RWM	3.7	1	12
	During the first year (month 12), a draft compilation and comparison of current conceptualizations of gas transport through repositories as considered in the Member States will be produced by [RWM](lead),[Andra] [COVRA] [IRSN] [NAGRA] [ONDRAF/NIRAS]. Storyboards will be used as tools for communicating the conceptualizations. These conceptualizations, and how these are derived from the scientific bases, will be presented in D6.1 (first SOTA as input to KM – State of Knowledge, to be completed in the second year, Month 18). The aim of producing a first draft by Month 12 is to allow a review by the “science” tasks 2 and 3 before the finalisation of D6.1 and also to support interactions at the beginning of the second year with WP ACED (to assess together how gas-driven system evolution and the chemical evolution at the scale of disposal cells may affect each other). Another important activity during the first year will be to propose a generic repository configuration and sets of properties and conditions on which subtask 4.2 will test (from year 2) various evaluation approaches. A proposal for a set of indicators to be evaluated will also be provided by subtask 4.1.				
Subtask 4.2	Model assisted assessment of gas induced effects	IRSN	4.2	9	12
	This task starts in Month 9. Until Month 12, [IRSN](lead), [UHelsinki (Aalto University)] [Andra] [BGR] [CEA (EDF)] [LEI] [SCK•CEN] [COVRA (TU Delft)] and [ONDRAF/NIRAS (ULiège)] will focus on complementing the input of subtask 4.1 to the SOTA (D6.1) by summarizing the current modelling approaches used to assess the impact of gas on repository performance in the programmes of the Member States, highlighting similarities and identifying the rationale for differences.				

Deliverables

- **D6.3 – Subtask 1.3 – Training materials of the 1st GAS/HITEC Joint training course** – Consists of: presentations of each doctoral school organised during the course of the project – Lead: ONDRAF/NIRAS (Month 6) – **Completion at 100%.**

Additional Deliverables (if applicable - brief description and month of delivery)

N/A



2.3.7. RDD WP7-HITEC-1

Set of Activities Number	RDD WP7-HITEC-1				Start Date or Starting Event			Month 1		
Set of Activities Title	Influence of temperature on clay-based material behaviour (HITEC)									
Participant number	1	4	5	6	7	8	14	24	25	27
Short name of participant	Andra	BGE	CEA	CIEMAT	ChRDI	CNRS	ENRESA	KIT	LEI	NAGRA
Person/months per participant	3.2	3.2	3.8	17.3	22.9	20.8	0.3	2.3	2.5	0.6
Participant number	32	33	37	39	43	49	50	51		
Short name of participant	ONDRAF/ NIRAS	POSIVA	RWM	SKB	SURAO	UHElsinki	UKRI- BGS	VTT		
Person/months per participant	11.2	0.4	29.3	2.3	1.5	15.5	21.2	5.4		
Start month	1				End month			12		

Objectives

The overall objective is to evaluate whether an increase of temperature is feasible and safe by applying existing and within the work package produced novel knowledge about the behaviour of clay materials at elevated temperatures:

- to improve understanding of the THM behaviour of clay rock and engineered clay material (buffer) under high temperature and provide suitable THM models both for clay host rock and buffer,
- to better assess effect of overpressures build up induced by the heat produced from the radioactive waste on the THM behaviour and properties of the clay host rock, and
- to identify processes at high temperature and the impact of high temperature on the THM properties of the buffer material.

Host clays formations: aim is to deploy knowledge to mechanics of clay in order to better evaluate and model possible damage evolution during the temperature transient phase, and better assess the consequences of a possible damage.

Buffer bentonite: aim is to deploy knowledge to hydro-mechanical behaviour at high temperature. The temperature impact on important processes will be measured either while the clay is at the high temperature or after a high temperature exposure. Processes that may have a temperature dependence are swelling pressure, hydraulic conductivity, erosion properties, transport of solutes etc.

The fourth objective is to document all the above to be utilised in Safety Cases studies

- The safety functions include properties such as mechanical properties, swelling pressure, hydraulic conductivity, while the integrity of the clay may be evaluated as changes in mineralogy, chemical content or physical integrity of the compacted blocks.
- The safety functions and the overall integrity of the bentonite and/or clay host rock will be evaluated after a high temperature exposure.

To assure interaction between Civil Society organisations and participants of the WP, and with this interaction improve the scientific results, too.

The programme of work will aim to provide results that are applicable to a wide range of buffer material and clay host rock, which can be useful for different national programmes.

Activity No	Activity Title	lead participant	Total pm AWP1	Start Month	End month
RDD WP7-HITEC-1	Influence of temperature on clay-based material behaviour (HITEC)	VTT	170.5	1	12
Task 1	S/T coordination, State-of-the-art and training material	VTT	6.3	1	12
Subtask 1.1	S/T coordination	VTT	0.5	1	12
	The scientific and technical coordination of HITEC WP will be performed by the WP Leader [VTT]. The WP Leader will be supported by the Task leaders and co-leaders: [CNRS (ULorraine)], [SURA (CTU)], [Andra], [SKB], [NAGRA] which together with [VTT] constitute the WP Board of HITEC. The WP Leader will make sure that EURAD rules are followed by all partners, that the scientific milestones and deliverables are reached timely, and that the results are disseminated efficiently inside and outside the project. The WP Leader will ensure the interface between the WP Board, between the participants of HITEC WP, and with the Programme Management Office and the other EURAD WPs. During first Annual Work Plan (AWP1), two meetings will be held: • HITEC kick off meeting • HITEC first annual meeting.				
Subtask 1.2	State-of-the-art reporting	CIEMAT	4.1	1	12
	A literature review, mainly referring to on-going national and community-supported programmes, on the THM behaviour of buffer materials focusing on temperatures over 100°C will be carried out. Similarly, a synthesis of the knowledge on the THM behaviour of host claystone and on the effect of the canister temperature on the EDZ and far field. The outcomes of this subtask will be delivered at Month 6 under Deliverable 7.1. Participants: [Andra] [BGE] [CIEMAT] [ENRESA] [ONDRAF-NIRAS (EURIDICE)] [NAGRA] [POSIVA] [RWM] [SKB] [SURA]				
Subtask 1.3	Training materials	ONDRAF/NIRAS	1.7	1	12
	During AWP1, one training workshop (in the format of a doctoral school) will be organised jointly with the WP6-GAS at Month 6, with lectures and tutors on geomechanics and multi-physical coupling. The topic will be on multi-physical coupling in geomechanics (especially THM and Gas coupling issues). The objective will be to draw a state-of-knowledge at the beginning of the project. (Combined deliverables with WP6-GAS D6.3) Participants: Subtask contributors : [SURA (CTU)] [VTT] [ONDRAF/NIRAS (ULiège)]				
Task 2	Clay host rock <120°C	CNRS	65.8	1	12
Subtask 2.1	Experiments near field with EDZ	CNRS	13.6	1	12
	This subtask will focus on lab experiments on different clay host rock (Boom, Opalinus, Callovo Oxfordian) to study fracture propagation and the self-sealing process in the near field zone. During the first year, the fractured samples mimicking the damage expected in the near field will be selected. The different teams (CNRS-GEORESSOURCES, CNRS-3SR, BGS/RWM) will develop their experimental apparatuses (triaxial and shear cells) and define the experimental loading conditions. The first tests will start after month 6 with the lowest temperature conditions (40 °C). It is expected that the first results on the fracture propagation and the effect of heating on the material properties and the self-sealing capacity will be obtained at the end of the first year. Participants : [CNRS-3SR (ULorraine)] [UKRI-BGS] [RWM]				

Subtask 2.2	Experiments on far field - effect of over pressure due to thermal load	BGS	15.5	1	12
	This subtask will focus on lab experiments on different clay host rocks (Boom, Opalinus, Callovo Oxfordian) to study the effect of the heating on the mechanical behaviour, overpressure and permeability in the far field zone. The first year will be devoted to the development of the experimental apparatuses (triaxial and biaxial cells, monitoring systems) and the experimental test plan. It is expected that the tests will start after month 9 and that the first results on the short-term behaviour at the lowest temperature (40 °C) will be provided to the modelling teams (subtask 2.3) by the end of the first year. Participants: [RWM] [CNRS (ULorraine)] [CEA] [UKRI-BGS]				
Subtask 2.3	THM modelling of effect of temperature in near and far field – Benchmark exercise	Andra	36.6	1	12
	The sub task leader will exchange with the other modelling teams and in-situ data provider (Andra, Euridice, Nagra) to select and prepare the different benchmark exercises. At month 9, in-situ data as well as selected experimental lab test results will be furnished to start the benchmark exercise with the different modelling stages defined for the next three years. The modelling team will start to develop and update their model and start to simulate the in-situ experiment and lab tests after month 9. Participants: [Andra] [BGE] [CNRS-UGrenoble] [CEA (EDF)] [ONDRAF-NIRAS (EURIDICE)] [LEI] [NAGRA] [ONDRAF-NIRAS (Uliege)] [CIEMAT (UPC)]				
Task 3	Clay buffers >100°C	SURAO	98.0	1	12
Subtask 3.1	Characterisation of material treated by high temperature	SKB	34.0	1	12
	This subtask will focus on investigate material changes after high temperature treatment and on determination of parameters necessary for mathematical modelling. During the first year, materials will be selected for the high temperature treatment, investigation & treatment plan will be developed and baseline investigation started. The treatment itself is expected to start in the second half of first year. Material coming from other experiments will be analysed as it comes. Participants: [CIEMAT (UAM)] [KIT (BGR)] [ChRDI (KIPT) (SIIGNASU)] [SKB] [SURAO (CTU) (CU)] [UHelsinki] [VTT]				
Subtask 3.2	Determination of parameters at temperatures >100°C	BGS	38.5	1	12
	This subtask will focus on lab experiments on buffer bentonite at temperatures above 100°C to understand how the permeability, swelling and mechanical behaviour of the bentonite buffer evolves under high thermal loads. The apparatus required to conduct the experiments will be assembled and the sample material will be acquired. The experimental testing plan will be developed and it is expected that the tests will then begin after month 9. The characterisation of the material pre-test will have started and the first tests will be yielding results. Participants: [Andra] [UKRI-BGS] [ChRDI (KIPT)] [CIEMAT] [RWM] [SURAO (CTU) (CU)] [UHelsinki (GTK) (JYU)] [VTT]				
Subtask 3.3	Small scale experiments, model development and verification	CIEMAT	25.5	1	12

	The components required to perform the thermo-hydraulic tests will be selected, purchased and assembled, and the decision on the buffer materials to be tested will be made. It is expected that the TH test will have started by the end of the first year. CIEMAT will prepare to dismantle a TH test with MX80 bentonite pellets that has been running since 2012 and will fine-tune the techniques for postmortem analyses. The online measurements of this test and of those starting during the first year will be provided to the modelling teams. The modelling teams will start updating the conceptual frameworks and mathematical models to incorporate the effects of high temperature. Participants: [CIEMAT] [POSIVA] [SURAQ] [VTT]

Deliverables

- **D7.1 – Subtask 1.2 – Initial State-of-the-art** – Covering: THM behaviour of i) buffer clay materials and of ii) host clay materials – Lead: [CIEMAT] (Month 6) – **Completion at 100%**.

Additional Deliverables (if applicable - brief description and month of delivery)

N/A



2.3.8.RDD WP8-SFC-1

Set of Activities Number	RDD WP8-SFC-1				Start Date or Starting Event				Month 1		
Set of Activities Title	Spent Fuel Characterization and Evolution Until Disposal (SFC)										
Participant number	5	6	7	8	10	14	15	22	23	24	25
Short name of participant	CEA	CIEMAT	ChRDI	CNRS	FTMC	ENRESA	FZJ	JSI	JRC	KIT	LEI
Person/months per participant	10.8	1.6		38.2	19.8	0.1	2.0	1.4	9.0	10.8	1.75
Participant number	26	27	34	38	39	41	43	47	51		
Short name of participant	MTA EK	NAGRA	PSI	SCK•CEN	<u>SKB</u>	SSTC NRS	SURAO	TUS	VTT		
Person/months per participant	1.8	4.8	1.2	6.5	3.3	10.3	0.1	1.7	2.5		
Start month	1				End month				12		

Objectives

Reduce uncertainties in spent fuel properties in predisposal phase

The objectives of this WP are to:

- To produce experimentally verified procedures to reliably determine the nuclide content (here called source terms) of spent nuclear fuel (SNF), including realistic uncertainties.
- To establish beyond state-of-the-art characterization techniques for spent nuclear fuel during its evolution from reactor unloading until disposal (here called pre-disposal activities).
- To establish beyond state-of-the-art uncertainty quantification of the characteristics of the spent fuel during its evolution during pre-disposal activities.
- To understand the performance of the spent fuel during prolonged storage prior to its transport, during the transport and emplacement in a deep geological repository, in order to build the capability for ensuring the safety of all safety relevant operations.
- To understand the behaviour of fuel, cladding, pellet-cladding interaction and ageing effect under normal and postulated accident scenarios until disposal, in order to identify relevant or typical bounding cases at time of re-conditioning and pre-disposal activities (treatment, conditioning and transport).
- To provide contributions to operational safety concepts for fuel handling at SNF packaging facilities.
- To contribute to education, training and building of competence in the subject.

Activity No	Activity Title	lead participant	Total pm AWP1	Start Month	End month
RDD WP8-SFC-1	Spent Fuel Characterization and Evolution Until Disposal (SFC)	SKB	136.3	1	12
Task 1	S/T coordination, State-of-the-art and training material	SKB	2.1	1	12
Subtask 1.1	S/T coordination	SKB	1.1	1	12
	The scientific and technical coordination of SFC begins when the programme starts. It will be performed by the WP Leader [SKB (UU)]. The WP Leader will be supported by the Task leaders and co-task leaders: [JRC], [KIT (BAM)], [CIEMAT], [JSI (EIMV)] [PSI] [FZJ (HZDR)] and [NAGRA] which together with [SKB (UU)] constitute the WP Board of SFC.				

	Monthly remote status reporting meetings will be executed and monitoring of the progress of the work plan will begin.				
Subtask 1.2	State-of-the-art and Gap analysis	NAGRA	1.0	1	12
	During AWP1, the work related to the subtask 1.2 will be mainly focused on gap analysis as well as literature research, aiming to collect and summarise state-of-the-art research activities. The document will be delivered at Moth 6 (Deliverable 8.1) and will be periodically shared with the other task/subtask leaders and constantly updated throughout the project. Participants: [NAGRA] [KIT (BAM)] [CIEMAT] [JRC]				
Task 2	Fuel properties characterisation and related uncertainty analysis	JRC	35.5	1	12
Subtask 2.1	Theoretical study of SNF source terms	PSI	9.8	1	12
	The different necessary quantities to perform the code-to-code comparisons will be defined during AWP1. A selection of a number of representative assemblies (PWR and BWR) will be made, with their specificities (enrichments, fuel type, geometry...). This can be based on public database, inspired by existing comparisons (e.g. SKB/Vattenfall blind test), and complementary to previous studies. Quantities of interest to be calculated will also be proposed, together with simulations tools. A list of possible “input parameters” for sensitivity and uncertainty calculations will be established. These definitions will be the starting point for the rest of study and give boundaries for the conclusions of this subtask. Participants: [CIEMAT] [JSI] [NAGRA] [PSI] [SCK•CEN] [VTT]				
Subtask 2.2	Develop, improve and demonstrate NDA methods/systems for SNF characterisation	SCK•CEN	21.3	1	12
	During AWP1, the performance of NDA techniques that can presently be used for the characterisation of spent nuclear fuel will be investigated and described. A SNF pellet, with a well-known fuel history, will be prepared and its fuel history documented. The neutron output of this pellet will be measured by a dedicated neutron detection system. At the start of the project we will start the preparation of these measurements. Participants: [CIEMAT] [JRC] [ENRESA] [SCK•CEN] [SKB] [SKB (UU)]				
Subtask 2.3	Determine the inventory of activation and fission products in cladding material	KIT	4.4	1	12
	The first year of subtask 2.3 will be mainly dedicated to preparation of sub-samples of clad fuel pellets of UO₂ (50 GWd/tHM) and mixed oxide fuel (38 GWd/tHM), both irradiated in pressurised water reactors. Characteristic fuel data, such as enrichment, burn-up and other irradiation parameters will be compiled and distributed within the subtask. These data-sets will be the starting point for inventory calculations. Calculated inventories will be compared to measured activation and fission products’ inventories at a later stage of subtask 2.3. Participants : [CIEMAT] [SURA (CTU)] [KIT] [LEI] [NAGRA] [VTT]				
Task 3	Behaviour of nuclear fuel and cladding after discharge	KIT	93.3	1	12
Subtask 3.1	Thermo-mechanical-chemical properties of the SNF rods and cladding	UPM	45.4	1	12
	Experimental work in subtask 3.1 will start at Month 1 with the preparation of irradiated and unirradiated samples of spent nuclear fuel rod segments and cladding. Unirradiated cladding samples are treated to represent the hydride distribution of irradiated samples. Experimental setups are built up and tested. First tests (bending tests, impact tests, and ring compression tests) will be performed. Suitable numerical procedures for simulation will be				

	identified and checked. Needed parameters for material models and contact formulations as well as initial and boundary conditions are defined (hydride distribution, radially oriented hydrides, temperature, etc.). Participants: [KIT (BAM)] [CIEMAT (UPM)] [EC-JRC] [MTA-EK] [NAGRA] [PSI] [TUS] [VTT]				
Subtask 3.2	Behaviour of SNF pellets under interim storage conditions	CIEMAT	36.9	1	12
	During AWP1, subtask 3.2 will start the experiments to identify the behaviour of irradiated fuels and simulated spent nuclear fuel pellets both under (ab-)normal dry interim storage conditions and under conditions of water contact, such as effect of the moisture, aqueous dissolution of the UO ₂ matrix, corrosion of the SNF, etc. Participants: [CIEMAT] [CNRS-CEMHTI & ICSM (UMontpellier)] [FZJ (HZDR)]				
Subtask 3.3	Pellet-cladding interaction under conditions of extended storage, transport and handling of SNF rods	CIEMAT	11.1	6	12
	The work related to subtask 3.3 will begin at month 6, mainly focused on set-up of analytical methods and sampling materials of pellet / cladding interfaces of irradiated UO ₂ and MOX fuel segments. In parallel, pellet/cladding interactions will be studied using non-irradiated UO ₂ fuel. Later in the year, aliquots of the irradiated material will be prepared for various chemical and spectroscopic analyses and inventory analyses will be started. Participants: [CIEMAT] [KIT] [MTA-EK] [PSI]				
Task 4	Accident scenario and consequence analysis	NAGRA	4.3	6	12
Subtask 4.1	Accident scenario for fuel under dry interim storage conditions	ChRDI	4.3	6	12
	During AWP1, the work related to the subtask 4.1 will start at Month 6 and be mainly focused on the identification and first analysis of credible accident scenarios related to the transport/storage of SNF. This analysis will include a first attempt to set-up a methodology to assess the scenario by developing analytical tools. Activities devoted to link this task to the Task 2 and 3 are also foreseen. Participants: [CIEMAT] [KIT] [MTA-EK] [PSI]				

Deliverables

- **D8.1 – Subtask 1.2 - State-of-the-art report** - This report will summarize the state-of-the-art of nuclear fuel characterisation and evolution of its properties at the beginning of the WP – **Lead:** NAGRA (Month 6) – Completion 100%.

Additional Deliverables (if applicable - brief description and month of delivery)

N/A



2.3.9. SS WP9-ROUTES-1

Set of Activities Number	SS WP9-ROUTES-1				Start Date or Starting Event			Month 1		
Set of Activities Title	Waste management routes in Europe from cradle to grave (ROUTES)									
Participant number	1	2	3	5	6	9	12	13	10	15
Short name of participant	Andra	ARAO	Bel V	CEA	CIEMAT	COVRA	Dekom	EEAE	FTMC	FZJ
Person/months per participant	1.7	0.2	0.1	1.0	1.5	1.0	1.0	0.8	0.7	1.5
Participant number	16	17	18	19	21	20	22	25	28	29
Short name of participant	GRS	IAE	INCT	IRSN	IST-ID	IST-LPSR	JSI	LEI	NCSR	NES
Person/months per participant	0.7	0.5	1	2.8	0.8	0.7	1.9	0.5	2.7	0.8
Participant number	30	31	32	36	43	38	39	40	41	42
Short name of participant	NJF	NRG	ONDRAF/ NIRAS	RATEN	SURAO	SCK•CEN	SKB	SSE Ecocentre	SSTC NRS	STUBA
Person/months per participant	0,5	0.1	1.5	1.2	0.5	0.2	0.5	14.7	2.5	0.9
Participant number	44	46	47	48	51	52				
Short name of participant	SURO	TS Enercon	TUS	UCY	VTI	VUJE				
Person/months per participant	1.4	0.1	1.1	0.3	1.6	0.3				
Start month	1				End month			12		

Objectives

The objectives of this WP are to:

- Provide an opportunity to share experience and knowledge on waste management routes between interested organisations (from different countries, with programmes at different stages of development, with different amounts and types of radioactive waste to manage).
- Identify safety-relevant issues and their R&D needs associated with the waste management routes (cradle to grave), including the management routes of legacy and historical waste, considering interdependencies between the routes.
- Describe and compare the different approaches to characterisation, treatment and conditioning and to long-term waste management routes, and identify opportunities for collaboration between MS (member states).

SS WP9-ROUTES-1	Waste management routes in Europe from cradle to grave (ROUTES)	IRSN	49.2	1	12
Task 1	S/T coordination, State-of-the-art and training material	IRSN	0.8	1	12
Subtask 1.1	S/T coordination	IRSN	0.8	1	12
	The technical coordination of ROUTES will be performed by the WP Leader [IRSN]. The WP Leader will be supported by the Task leaders [Andra], [FZJ], [ONDRAF/NIRAS], [NCRS (DMT)] [COVRA] which together with [IRSN] constitute the WP Board of ROUTES. The WP Leader will make sure that the rules of the EJP are followed by all partners, that the scientific milestones and deliverables are reached timely, and that the results are disseminated efficiently inside and outside the project. During first Annual Work Plan (AWP1), two meetings will be held: • Kick-off meeting (ROUTES WPM1) at Month 2 including development of a collective questionnaire for collecting information from the organisations involved in this WP on member states practices in waste management as an input to task 2, 3; 4 and 6. This will be done in collaboration with their task leaders. • ROUTES WP Meeting 2 (ROUTES WPM2) at Month 12				
Subtask 1.2	Interactions with KM WP	IRSN	1	1	12
	Interaction with KM WPs regarding the input of the WP to the state-of-knowledge, guidance and training/mobility in terms of content and format. This work will be ensured and coordinated by [IRSN].				
Task 2	Identify challenging wastes to be collaboratively tackled within the EJP	Andra, SSTC NRS	11.6	1	12
Subtask 2.1	Collection and analysis of existing work on categorisation and classification of radioactive waste with regard to disposal options, identification of waste for which there is not yet a complete management plan in each Member State, identification of waste management routes for pre-disposal steps	Andra, SSTC NRS	11.6	1	12
	This subtask will start with an up-to-date overview on radioactive waste categorisation/classification based on collection and synthesis of answers to questionnaire of Task. NEA and IAEA initiatives on waste classification will be used in parallel. Comprehensive contributions on waste without complete management plans will also be collected. The work takes into account information gained in other EU projects such as CHANCE and THERAMIN. R&D needs as well as opportunities of collaboration will be identified. An exchange meeting will be organized (month 7). The overview of existing work on categorization/classification of RWs in participating states will be compiled in the deliverable 9.4 (<i>final version: Month 10</i>) Participants: [Andra] [SSTC NRS] [BEL V]; [CIEMAT]; [FTMC]; [FZJ]; [GRS]; [VTT (GSL)]; [RATEN]; [IRSN]; [IST-LPSR]; [IAE]; [JSI]; [LEI]; [NRG]; [SCK/CEN]; [ONDRAF/NIRAS]; [CEA (ORANO)]; [SKB]; [SURAO]; [SURO]; [TS Enercon]; [TUS]; [UCY]; [Andra] ; [SSTC NRS] ; [NCRS D (DMT)]; [EEAE], [INCT]; [NES]; [STUBA] [SSE Ecocentre]				

Task 3	Description and comparison of radwaste characterisation approaches	FZJ, CIEMAT	14.4	1	12
Subtask 3.1	Radioanalytical characterisation of radioactive waste and waste with complex/toxic properties	FZJ, CIEMAT	14.4	7	12
	Organization of the first workshop of the subtask 3.1 (months 7) for collection, analysis and comparison of the existing knowledge about techniques and practices for radioanalytical characterisation of radioactive waste, identified in Task 2. The motivations and criteria for characterisation of radioactive wastes (e.g. treatment, reprocessing or WAC for existing repositories) will be identified (input from Task 4). Participants: [IRSN] [FZJ] [CIEMAT] [CEA (ORANO)] [JSI (EIMV)] [SCK•CEN] [EEAE] [ONDRAF/NIRAS] [NCRS (DMT)] [UCY] [TUS] [SSTC NRS] [SKB], [INCT]; [IST-ID]; [STUBA] [SSE Ecocentre] [VUJE]				
Task 4	Identification of WAC used in EU Member States for different disposal alternatives in order to inform development of WAC in countries without WAC/facilities	ONDRAF/NIRAS, VTT	9.8	1	12
Subtask 4.1	Current use of waste acceptance criteria	RATEN, VTT	5.6	1	12
	Based on the questionnaire, descriptions of the current use of WAC (considering also preliminary/draft WAC) per country will be collected as well as the methodology for setting up WAC and link with waste classification. A review of available existing information (e.g. from NEA and IAEA) will be done and used as input. Also, how compliance with WAC is verified as well as how non-conformances are dealt with will be identified. Participants: [RATEN] [ONDRAF/NIRAS] [VTT (GSL)] [TUS], [Andra], [IRSN], [CEA (ORANO)], [FZJ], [LEI], [IAE], [INCT], [JSI (EIMV)], [CIEMAT], [SKB], [SSTC NRS], [SURAO], [FTMC], [GRS] ; [STUBA]				
Subtask 4.2	Sharing experience on waste management with/without WAC available	ONDRAF/NIRAS, VTT	4.2	6	12
	Case descriptions, per country, of challenging wastes (identified in Task 2) conditioning without a final disposal solution will be collected. The descriptions will be based on the questionnaire. Also, case descriptions derived from a review of existing information available from e.g. NEA and IAEA will be used. Participants: [ONDRAF/NIRAS] [VTT (GSL)] [TUS], [RATEN], [Andra], [IRSN], [CEA (ORANO)], [LEI], [INCT], [JSI (EIMV)], [CIEMAT], [SSTC NRS], [SURAO], [FTMC], [IST-LPSR] [NCSR], [EEAE], [GRS], [SURO]				
Task 5	RWM solutions for small amounts of wastes	NCRS, SURO	5.5	6	12
Subtask 5.1	Collecting and analysing actual existing knowledge about disposal options for SIMS	NCRS, SURO	5.5	6	12
	A kick-off meeting will be organised (month: 7) in order to coordinate the collection and analysis of the existing knowledge about disposal options (with increasing depth from the surface) in principle suitable for SIMS. This work will be performed complementary to the relevant IAEA project. Participants: [NCSR (DMT)] [SURO] [NES] [JSI], [INCT] [GRS] [EEAE], [IST-LPSR] [IST-ID]				

Task 6	Shared solutions in European countries	COVRA	5.5	1	12
Subtask 6.1	State of the art on shared development and use of technologies and facilities	COVRA, Dekom	5.5		12
	Summarise EC (including SAPIERR, SAPIERR II, Chance, Theramin) and IAEA studies on shared development and use of technologies and facilities for characterisation, treatment, storage and disposal. Summarise any existing or planned sharing of facilities between member states. A workshop will be organized for this subtask (month 7) The results and outputs of subtask 6.1 will be compiled in a dedicated chapter of the final task 6 deliverable (<i>final version of the chapter: Month 12</i>) Participant: [COVRA] [DEKOM] [ARAO] [FZJ], [SSTC NRS] [CIEMAT] [SKB], [EEAE], [NCRSD (DMT)] [NES] [NJF] [SURO] [IRSN] [JSI (EIMV)] [FTMC] [IST-LPSR] [VTI (GSL)] [CEA (ORANO)]				
Task 7	Civil Society interaction	IRSN (NTW)	1.6	1	12
Subtask 7.1	Scoping of ROUTES tasks 2-6 and initial input from CS	IRSN (NTW)	1.6	1	12
	The first year all activities of task 7 on interaction with civil society (ICS) will be in subtask 7.1 and will be focused on scoping of the objectives and actions in ROUTES tasks 2-6 in order to identify topics that are deemed of more specific interest in the perspective of developing interactions between civil society and EURAD partners along the course of the WP. Part of the work of the CS experts in task 7 will be to analyse the ROUTES WP in a larger context - how is it related to on-going RWM activities and connected with disposal projects and the challenges they are facing. Based on collaboration with all partners in the ROUTES WP, the deliverable D9.15 “Scoping of ROUTES, initial ICS input and ICS action plan” with topics for further work will be adopted (Month 11). Representatives from the CS experts in task 7 will participate in all related meetings of the WP in the first year and coordinate the interaction with the broader CS Group. Participants [JSI (EIMV)], [IRSN (NTW)]				

Deliverables

- **D9.4: Overview of existing work on categorization/classification of RWs in participating states** (*Andra, SSTC NRS; draft version: Month 6; final version: Month 10*)
- **D9.12 Studies and plans for developing shared solutions for radioactive waste management in Europe** - This deliverable summarises the knowledge on and approaches to sharing technology and facilities between members states. It also provides an overview of the plans of Member States for shared solutions in different steps of the waste lifecycle. lead organisations: [COVRA] due month: 12
- **D9.15 - Scoping of ROUTES, initial CS input and ICS action plan** (task 7.1) - Lead organisations: [JSI (EIMV)] - Due month: 11

Additional Deliverables (if applicable - brief description and month of delivery)

N/A



2.3.10. SS WP10-UMAN-1

Set of Activities Number	SS WP10-UMAN-1				Start Date or Starting Event			Month 1		
Set of Activities Title	Uncertainty Management multi-Actor Network (UMAN)									
Work package number	10		Start Date or Starting Event					Month 1		
Work package title	Uncertainty Management multi-Actor Network (UMAN)									
Participant number	1	3	4	6	8	9	10	14	15	16
Short name of participant	Andra	Bel V	BGE	CIEMAT	CNRS	COVRA	FTMC	ENRESA	FZJ	GRS
Person/months per participant	2	2.6	2.2	1	0.8	0.3	0.3	0.2	0.8	1
Participant number	19	22	24	25	27	31	32	33	34	36
Short name of participant	IRSN	JSI	KIT	LEI	NAGRA	NRG	ONDRAF/ NIRAS	POSIVA	PSI	RATEN
Person/months per participant	4.8	2.1	1.6	0.8	0.9	0.5	0.7	0.9	0.5	2.2
Participant number	37	38	41	42	43	44	46	47	51	
Short name of participant	RWM	SCK•CEN	SSTC NRS	STUBA	SURAO	SURO	TS Enercon	TUS	VTT	
Person/months per participant	0.7	0.7	1.3	0.3	1.2	1.4	0.2	1.3	0.5	
Start month	1				End month			12		

Objectives

The main objectives of the WP are as follows:

- Develop a common understanding among the different categories of actors (WMOs, TSOs, REs & Civil Society) on uncertainty management and how it relates to risk & safety. In cases where a common understanding is beyond reach, the objective is to achieve mutual understanding on why views on uncertainties and their management are different for different actors.
- Share knowledge/know-how and discuss common methodological/strategical challenging issues on uncertainty management.
- Identify the contribution of past & on-going R&D projects to the overall management of uncertainties.
- Identify remaining and emerging issues and needs associated with uncertainty management.

Activity No	Activity Title	lead participant	Total pm AWP1	Start Month	End month

SS WP10-UMAN-1	Uncertainty Management multi-Actor Network (UMAN)	Bel V	34.4	1	12
Task 1	S/T coordination, State-of-the-art and training material	Bel V	2.9	1	12
Subtask 1.1	S/T coordination	Bel V	1.8	1	12
	During AWP1, this subtask will organize 2 WP board meetings at Month 1 and Month 7 to ensure that the project is progressing according to the agreed specifications, milestones and planning. The work progress will be reported to the PMO and, if necessary, modifications to the work plan will be considered. Subtask contributors: [Bel V] [BGE] [GRS] [IRSN (MUTADIS)] [RATEN]				
Subtask 1.2	Interactions with KM WP	Bel V	0.5	1	12
	During AWP1, interactions will be initiated with KM WPs regarding the input of the WP to the state-of-knowledge, development of guidance and training activities in terms of content and format. Subtask contributors: [Bel V]				
Subtask 1.3	Integration	Bel V	0.6	1	12
	During AWP1, this subtask will integrate recommendations for EURAD-1 2nd wave RD&D, strategic study and KM activities identified by WP participants in other tasks at Month 10 and report them to the PMO for further consideration at Month 12 (MS67). Subtask contributors: [Bel V] [BGE] [GRS] [IRSN (MUTADIS)] [RATEN]				
Task 2	Task 2 - Strategies, approaches and tools	GRS	6.5	1	12
Subtask 2.1	Generic strategies for managing uncertainties	VTT (GSL)	2.5	1	12
	During AWP1 this subtask will produce at Month 7 a draft version of deliverable D10.2 as input to Tasks 4 and 5 (MS40). This draft will include a first overview of the regulatory background and applied strategies in participating countries. The work will include a compilation and analysis of existing documents on relevant regulations and regulatory guides as well as on uncertainty management and safety strategies. Subtask contributors: [Andra] [Bel V] [IRSN (MUTADIS)] [LEI] [NAGRA] [NRG] [SURAO] [RWM] [VTT (GSL)]				
Subtask 2.2	Uncertainty identification, classification and quantification	FZJ (HZDR)	4	1	12
	During AWP1, this subtask will develop a draft version of deliverable D10.3 as input to Task 3 in preparation of MS75. This draft will include a first overview of existing approaches for the identification, classification and quantification of uncertainties. The work will include a compilation and analysis of existing documents regarding these approaches. Interactions with Subtask 3.1 where the different types of uncertainties are identified and their evolution discussed are foreseen. Subtask contributors:[RWM] [SURAO] [NAGRA] [JSI (EIMV)] [FZJ (HZDR)] [ONDRAF/NIRAS] [CIEMAT] [GRS] [SCK•CEN] [TUS] [STUBA] [SSTC NRS]				
Task 3	Characterization and significance of uncertainties for different categories of actors	RATEN	10.4	1	12
Subtask 3.1	Types of uncertainties relevant to the safety analysis and the safety case	CNRS (IMT Atlantique)	2.8	1	12

	During AWP1, This subtask will develop a first high-level integrated picture of the various types of uncertainties that are potentially relevant for safety and of their evolution (Month 7). The activities will consist in the review of related literature and liaising with the community through a questionnaire to collect the views of the different actors. Subtask contributors: [ONDRAF-NIRAS] [JSI] [RATEN] [POSIVA (Envirocase)] [CNRS (IMT Atlantique)]				
Subtask 3.2	Uncertainties on waste inventory and on the impact of predisposal steps	SCK•CEN	1	1	12
	During AWP1, this subtask will first define the waste types that will be considered for the identification and characterization of uncertainties associated to waste inventory and on the impact of predisposal steps. This will notably be based on interactions with Task 3 of the SS WP WMR (dedicated to waste characterization). Then, the review of available information on these uncertainties from national programmes and international initiatives, and relevant past and ongoing European RD&D projects, will be started with the objective to develop a preliminary list of uncertainties for input to Task 4 during year 2. Subtask contributors: [TS Enercon] [ENRESA] [FTMC] [SCK•CEN]				
Subtask 3.3	Site and geosphere related uncertainties	RATEN	2.5	1	12
	During AWP1, this subtask will start the review of available information from national programmes and international initiatives, and relevant past and ongoing European RD&D projects, with the objective to develop a preliminary list of uncertainties associated to site and geosphere for input to Task 4 at Month 6 (MS22). Then, this review will be continued and complemented by information from other EJP1 participants (obtained through a questionnaire), in preparation of the draft version of deliverable D10.7 (MS76) to be issued at the beginning of year 2. Subtask contributors: [PSI] [IRSN] [SURAO] [RATEN]				
Subtask 3.4	Uncertainties related to human aspects	Andra	2.3	1	12
	During AWP1, this subtask will start the review of available information from national programmes and international initiatives, and relevant past and ongoing European RD&D projects, with the objective to develop a preliminary list of uncertainties associated to human aspects for input to Task 4 at Month 6 (MS23). Then, in preparation of the draft version of deliverable D10.8 (MS101) to be issued during year 2, the subtask will continue this review and a questionnaire will be prepared to complement the review with information from other EJP1 participants. Subtask contributors: [Andra] [VTT] [COVRA] [JSI (EIMV)]				
Subtask 3.5	Spent fuel related uncertainties	CIEMAT	1.8	1	12
	During AWP1, this subtask will start the review of available information from national programmes and international initiatives, and relevant past and ongoing European RD&D projects, with the objective to develop a preliminary list of uncertainties associated to spent fuel for input to Task 4 at Month 10 (MS54). Then, in preparation of the draft version of deliverable D10.9 (MS111) to be issued during year 2, this subtask will continue the review and a questionnaire will be prepared to complement the review with information from other EJP1 participants. Subtask contributors: [Bel V] [CIEMAT] [KIT] [SSTC NRS]				
Task 4	Uncertainty management options and preferences of different actors across the various programme phases	BGE	5.9	1	12

Subtask 4.1	Identification and characterization of the different actors across the entire radioactive waste management process	BGE	2.5	1	12
	During AWP1, this subtask will identify and characterize the different actors across all phases of a disposal programme in order to improve understanding of their interests and preferences regarding the management of different types of uncertainties. The outcome of this work will serve as input to Sub-Tasks 4.2 and 4.3 and Task 5 (Topic 3). To achieve this goal a questionnaire will be established. The questionnaire's structure will be based on the generic phases identified in the roadmap of the EJP. All organisations participating in the strategic studies (i.e. in this WP as well as in the WP on Waste Management Routes) will be invited to fill out the questionnaire and give information about actors and their characterization. The answers to the questionnaire will be the basis for the analysis, description and grouping the different actors. This will lead to the production of deliverable D10.10 identifying the different categories of actors involved in each phase of a disposal programme as well as their roles and interests. A draft version of this deliverable will be produced at Month 7 as input to Task 5 (MS24). Subtask contributors: [BGE] [SURO]				
Subtask 4.2	Compilation and review of available information on possible uncertainty management options	NAGRA	3.4	6	12
	During AWP1, the subtask will initiate the development of a comprehensive overview about different approaches and uncertainty management options to assess and where relevant to reduce risks and optimise safety. Existing documentation on the management of uncertainties including examples of pitfalls will be compiled and reviewed. The schemes for classification of uncertainties resulting from Subtask 3.1 will serve as a tool to identify management options depending on the type of uncertainty and temporal aspects. The focus will be put during year 1 on the following topics also addressed in Task 3: - Site- and geosphere-related uncertainties (in particular in the course of host rock and site selection processes), - Uncertainties related to human aspects. Subtask contributors: [Andra] [Bel V] [BGE] [SURO] [KIT] [LEI] [NAGRA] [NRG] [TUS]				
Task 5	Interactions between all categories of actors, including Civil Society	IRSN (MUTADIS)	8.7	1	12
Subtask 5.1	Preparation, support and reporting of pluralistic analyses	IRSN (MUTADIS)	6.8	1	12
	During AWP1, the subtask will work on the preparation and organisation of the 1st seminar gathering a pluralistic stakeholder group and dedicated to topic 1 (foreseen at Month 13). It will use as input existing literature, the outcomes of Subtask 2.1, Task 3 and Subtask 4.1. Interactions with these tasks/subtasks are thus foreseen. The work of the methodological group in charge of this seminar will include the following actions: • Setting up the stakeholder group (identification of potential members of the stakeholder group, preparation of a memorandum of understanding, contact and liaison with the different stakeholders, etc.) (Month 6 – MS25); • Reviewing materials of Tasks 2 to 4 and preparing materials to be discussed during the seminar, under a form enabling discussion between expert and non-expert members of the stakeholder groups (Month 12 – MS68); • Developing methods for structured discussions between stakeholders on Topic 1.				
Subtask 5.2	Input of civil society experts	IRSN (MUTADIS)	1.9	1	12



	During AWP1, a team of 4 civil society (CS) experts will be involved in different activities of the WP. The role of CS experts will be to sketch out and map the key stakes related to the work performed in the different subtasks from a civil society point of view in order to facilitate liaison with the broader CS group involved in the EJP and in seminar 1 organised by Subtask 5.1. These CS experts will: • Follow the work performed in Tasks 2 to 4 and participate in key working meetings of these tasks; • Contribute to the preparation of seminar 1 by performing a mapping of the stakes related to the outcomes of Task 2 and Subtask 3.1 from a civil society point of view (PowerPoint presentation) (Month 12 – MS69) • Contribute to skill building of the broader CS group by preparing and animating a specific session dedicated to the WP UMAN in the CS annual workshop of the EJP. Subtask contributors: [IRSN (MUTADIS)] [Andra] [KIT (TU Clausthal)] [RWM] [JSI (EIMV)] [TUS] [POSIVA (Envirocase)] [SSTC NRS] [Bel V] [GRS]

Deliverables

- **D10.10: Analysis and description of groups of different actors:** This deliverable will identify the different categories of actors involved in each phase of a disposal programme as well as their roles and interests. Lead [BGE] Due month: 12.

Additional Deliverables (if applicable - brief description and month of delivery)

N/A

2.3.11. KM WP11-SoK-1

Set of Activities Number	KM WP11-SoK-1			Start Date or Starting Event			1
Set of Activities Title	EURAD State-of-Knowledge (SoK)						
Participant Number	3	15	41	1	6		
Short name of participant	BGE	FZJ	SSTC NRS	Andra	CIEMAT		
Person-months per Participant	15	16	13	1,5	0,37		
Start month	1			End month		12	

Objectives

The objectives of this first set of activities under KM WP11-SoK is to start establishing the State-of-Knowledge (SoK), i.e. preserving, capitalising of and providing open-access to knowledge generated in the field of radioactive waste management (RWM) research that can be extracted by present and future generations of experts and by any interested end-users in Europe and beyond (including for example WMO, TSOs, REs, Programme Owners.).

During the first (and second year), the proposed stepwise approach of this WP consists of

- establishing procedures to document the State-of-Knowledge in a given topic, and how it can be regularly revised in order to integrate new knowledge.
- testing and improving the procedures on a few demonstration cases. By developing such demonstration cases the general approach of the KM Programme will establish a clear specification (i.e. requirements, procedures and functionalities) for the SoK.
- performing a review on experiences made for similar approaches by other organisations and in other areas. Subsequently the added-value of establishing a specific platform dedicated to provide access to SoK developed in EURAD will be evaluated. In addition, the EURAD community will be asked for feedback, prior to full development and initiation of a prioritised programme of SoK population.

KM WP11-SoK-1	EURAD State-of-Knowledge (SoK)	BGE		1	12
Task 1	Screening and review of existing knowledge programmes	FZJ (HZDR)	5.5	1	12
	Screening and review (Deliverable 11.1) of existing/available knowledge management approaches and/or tools that have been developed for similar purposes with respect to their functionalities and suitability for EURAD KM. This includes lessons learned and best practice. The work is managed by the WP team with input from the EURAD Bureau, from Experts identified as part of WP1 Task 4 EURAD.				
Task 2	Selection and development of demonstration cases	BGE	10.37	1	12
	At the onset of the WP, a few topics suitable as demonstration cases are selected. The topics are deduced from the Roadmap. Criteria for final selection of the best suitable demonstration cases include already existing training materials from other projects or international guidance, relevance for end-users, access to information/knowledge, active RD&D projects and availability of experts. For implementation of the demonstration cases, a first proposal is made for accessibility of, mapping, selection, structuring and processing of existing knowledge. This is an iterative process, including feed-back from the Bureau, PMO, etc. In a next step, an estimation is made for efforts and resources required for establishing further developed demonstration cases (individual cases), reflecting different levels of detail and width. This information is addressed to the Bureau, and is used for decisions on population options for the demonstration cases. (Deliverable 11.2)				

Task 3	Procedures to Involve Knowledge providers	BGE	20	3	12
	This task establishes procedures for engagement of knowledge providers (covering both individual experts, institutions, and international organisations) and will be elaborated in cooperation with them (e.g. IAEA) Deliverable 1.14. Such knowledge providers are needed to give orientation on generic waste disposal issues, as well as direct scientific-technical involvement on specific topics. Once developed, the competence matrix provides the key source for identification of knowledge providers. As necessary, additional competence carriers for specific needs in identifying, extracting and translating information and knowledge may be identified. When writing the SoK and populating it, there is an interplay between KM WP11 and EURAD identified experts. The WP 11 partners will contribute by organizing the work, i.e. managing the process. The key sources of expertise, however, will be recruited by addressing the colleges and where relevant, on-going RD&D WPs.				
Task 4	Procedures to Involve Knowledge providers Quality Management Plan	SSTC NRS	10	4	12
	The objective of this task is to develop QA procedures for the generation of SoK, assessing the appropriateness of the SoK generation process. For that purpose, with the support by the colleges, a QA plan is established, and revised and updated in several. The QA plan includes criteria, specifications, procedures for its implementation and control mechanisms. QA criteria reflect needs for end-users, including scientific excellence, inclusiveness, confidence levels and confidentiality levels. The GA approves the QA plan at the end of the second Project Year. The QA plan will ensure that the SoK is balanced and inclusive, provides the basis for next generation of experts to enter the field, contains the scientific-technical state-of-the-art (SOTA) and is fit for purpose in the overall KM Programme. Furthermore, the QA plan will ensure that the SoK does not contain policy statements or other statements potentially compromising the interests of the WMOs, TSOs or REs (Deliverables 11.5)				

Deliverables

- **Deliverable 11.1** – Draft Knowledge Platform specification integrating feedback from the Bureau (organized with the PMO) used for starting work on prototype platform under task 2 – Lead Organisation: [BGE] – Month 9
- **Deliverable 11.5** - Draft Quality Assurance Plan for Knowledge Platform – Lead Organisation: [FZJ (HZDR)] – Month 10

Additional Deliverables (if applicable - brief description and month of delivery)

2.3.12. KM WP12-Guidance-1

Set of Activities Number	KM WP12-Guidance-1			Start Date or Starting Event			1		
Set of Activities Title	KM Guidance								
Participant number	22	23	35	41	43	44			
Short name of participant	JSI	JRC	PURAM	SSTC NRS	<u>SURAO</u>	SURO			
Person/months per participant	2	1.5	5.3	1.5	9.5	1.5			

Objectives

The key objective of the KM Guidance WP is to develop a comprehensive suite of instructional Guidance Documents that can be used by Member-States with RWM programmes that are at an early stage of development with respect to their national RWM programme. The guidance will be focused on RD&D relating to planning and implementing a national radioactive waste management programme. It will be developed in such a way that it capitalises the experience and know-how gained by organisations having such responsibility in Member-States with advanced programmes.

The target end-user of the guidance will be primarily programme owners and managers (i.e. WMOs, and TSOs) responsible for planning and implementing RD&D at national level. Such guidance will also be of use and interest to other interested stakeholders, such as representatives of civil society and experts knowledgeable in governance and involvement of civil society.

The set of guidance developed shall be comprehensive for the purpose of the users, and unnecessary overlap shall be avoided, which includes complementary to existing IAEA, NEA and any other relevant documentation in the public domain.

Approach

The approach adopted for this WP consists of pursuing and complementing the work initiated previously with the [PLANDIS Guide](#)³. This Guide was prepared at the request of the Commission in the context of the EURATOM coordination and support action SecIGD2 (Secretariat for IGD-TP). It provides a framework of broad programme activities and related RD&D activities at different stages of a waste disposal programme, from the view point of a WMO. PLANDIS will be used as the starting point for WP2. Thereby, in addition to establishing a broader framework for planning and operating an RD&D programme in support of geological disposal, the scope is widened to include relevant RD&D needs for pre-disposal, as well as disposal solutions tailored to smaller inventories. Other areas where the need for R&D is identified may be added along with implementation of the work programme.

³ EC Project SecIGD2, “Guidance for less-advanced Programmes: RD&D Planning towards Geological Disposal of Radioactive Waste”, (the PLANDIS Guide), Deliverable C.N. 323260; 2015. <http://igdt.eu/wp-content/uploads/2018/04/secigd2-d2-3.pdf>

Activity No	Activity Title	lead participant	Total pm AWP 1	Start Month	End month
KM WP12-Guidance-1	KM Guidance	SURAO		1	12
Task 1	Updating the PLANDIS Guide and Quality Management Procedure	SURAO	14	1	12
	First step consists of updating the PLANDIS Guide in order to ensure consistency with EURAD Founding Documents (Vision, SRA, Roadmap). More precisely, the PLANDIS Guide will be revised, adjusted and complemented to be consistent with terminologies used in EURAD Founding Documents (Vision, Strategic Research Agenda, Roadmap) and to be aligned with EURAD SRA scientific themes/topics and with the successive phases of a RWM programme as elaborated in the Roadmap. As PLANDIS was developed by the IGD-TP, it was focussed on the perspectives of implementation by a WMO, therefore a second important part of this update will be to include the perspectives of implementation from the TSOs. The outcome will be the updated version of the PLANDIS Guide “<i>RD&D Planning for Radioactive Waste Management: Guidance for small and early-stage Programmes</i>” (PLANMAN Guide) at the end of the first year, considering feedback from the first EURAD Annual Meeting (Deliverable 12.1). The draft PLANMAN Guide will be previewed to the Bureau throughout development and the final form presented to the General Assembly in association with the 1st EURAD annual Workshop, requesting feedback during the special meeting and in the aftermath. Based on the feed-back, the final PLANMAN Guide will then be published at the end of the first year. The development of the PLANMAN Guide will also include the drafting of a clear quality management procedure for how it has been developed, which can be used in subsequent years (and updated and modified to reflect learning) as future Guides are developed (Deliverable 12.2). The substantial involvement of the WP organizations reflects the importance of the work, being the basis for the entire subsequent establishment of the detailed guidance. Additional involvement of experts from the Consortium and possibly external experts will ensure that all types of interest (especially small inventories, early stage programmes, particular waste inventory challenges, etc.) are considered. Task Contributors: [SURAO] [JSI (EIMV)] [PURAM] [SSTC NRS] [SURO,] [JRC]				
Task 2	Develop Prioritisation List and Schedule for Delineation of the PLANMAN Guide into more detailed Guidance Documents	PURAM	8.3	4	12
	The PLANMAN Guide is to be seen as an “umbrella document” that will need further more detailed guidance. Development of such more detailed guidance will commence in the second year. In order to plan and structure that work, a list of such guides is established together with implementation priorities and updated on an annual basis (Deliverable 12.3). The KM Guidance WP Team together with the PMO propose on an annual basis (from Year 2) to the Bureau/ General Assembly the Guidance Documents’ Editorial Plan for the year to come, i.e. the specific Guidance Documents that shall be established and issued in priority., to be updated on an annual basis). An important input to the editorial plan will be priorities identified by the competence/SoK/guidance mapping exercise to be completed by the PMO (see WP1) at initiation of the Joint Programme. Another important preparation for Task 3 is development of the prototype guidance document as well as Quality management procedure and methodology for developing the detailed delineation guidance of PLANMAN (see below) (Deliverable 12.4). Task contributors : [PURAM] [JSI (EIMV)] [SURAO] [SSTC NRS] [SURO] [JRC]				

2.3.13. KM WP13-Mobility/Training-1

Set of Activities Number	KM WP13- Training/Mobility-1			Start Date or Starting Event		1				
Set of Activities Title	KM Training & Mobility									
Short name of participant	Andra	CIEMAT	JRC	JSI	<u>SCK•CEN</u>	STC NRS	SURAO	SURO		
Person/months per participant	1.4	2.4	1.9	1.1	6.5	1.9	1.9	2.3		

Objectives

The objectives of the Training and Mobility WP are:

- To compose a **diverse portfolio of tailored basic and specialized training courses** for the end-users within EURAD-1 under the umbrella of a “School of Radioactive Waste Management”, newly created under EURAD-1, taking stock of and building upon already existing initiatives (i.e. IAEA and NEA) and creating new initiatives to bridge the identified gaps. The end-users are defined as professionals and potential new professionals at graduated and post-graduated level associated with the Mandated Actors/Linked Third Parties acting within EURAD-1, and in particular the next generation of experts. Tasks under this WP will include improving access to existing training materials (e.g. training modules developed in association with past and ongoing RD&D projects and EURAD WPs), and providing new training courses and material, both aimed at acquiring both state-of-the-art scientific background and at accessing the vast amount of “tacit” knowledge available within EURAD-1 through targeted hands-on training.
- To organise a **mobility programme** which provides access to dedicated infrastructures associated with the Mandated Actors/Linked Third Parties within EURAD-1. These mobility actions can be seen either as a complementary action after one or more training course(s) (enabling hands-on training related to the experimental programme executed within EURAD-1) or can be part of the Continuous Personal Development (CPD) of experienced personnel involved in RWM.

Approach

Both the mobility initiative and the training course portfolio will be developed along two tracks, associated with the different needs identified within EURAD.

- In a first track, and following the efforts undertaken to identify knowledge requirements within the Roadmap, specific training/mobility initiatives are developed to suit the specific needs of the end-users at the various phases of RWM programmes according to the Roadmap and following a systematic approach in response to priorities agreed with the General Assembly. The portfolio will be composed of existing (and past) training initiatives that fit EURAD-1 needs and for which the original developer/organiser agrees to be put at the disposal of EURAD-1 portfolio (without losing its identity), and of learning actions specifically developed in the frame of this EURAD-1 to bridge the identified gaps in the existing landscape.
- In a second track, specific training/mobility initiatives will be developed serving the needs identified within the RD&D and SS WPs. The oversight performed by the Training WP will allow 1) to identify the training/mobility needs, scope and opportunities present within these RD&D and SS WPs, and 2) integration of the developed training materials and resources within the Knowledge Platform which will be developed in WP1.

Thereby, “The School of RWM” is an umbrella for the entire catalogue of training/mobility either

- linked to (i.e., organized and “owned” by third partners, could be EURAD Beneficiaries, and to which EURAD provides funding for participation), or

- developed in order to meet needs and fill gaps to what is already available.

With respect to the division into more general training, aimed in particular at next generation of experts, and targeted training aimed in particular at exchange and deepening skills and knowledge between existing experts:

- More general courses, especially those following from a gap analysis in the Roadmap are to be delivered within the frame of a “summer school”, and are scheduled to start after the first EURAD year,
- Targeted training courses making use of existing training from past and on-going EURATOM projects, are best integrated as specific modules at the “summer school”, and

Targeted training courses, associated with the timing and tasks in the RD&D and SS WPs are to be organized depending on the interaction with, and input from these WPs. It could be organized back-to-back with a particular WP meeting, having all the involved experts gathered, nevertheless being open for participation for interested experts from beyond the specific WP. Such training should be aimed for already during the first EURAD year.

Activity No	Activity Title	lead participant	Total pm AWP1	Start Month	End month
KM WP13- Training/Mobility-1	Training & Mobility	SCK•CEN	19.3	1	12
Task 1	Identification of the training needs, scope and opportunities from the RD&D and SS WPs	SCK•CEN	2	1	12
	Within the RD&D and Strategic Studies WPs, specific training needs are present. These training needs need to be identified at the early phase of EURAD initiation by interaction with the WP leaders and coordination teams (Deliverable 13.1). The identified needs should at least encompass 1) the scope of the training needed (basic vs specialised course), 2) the proposed training mode (classroom/hands-on, including mobility needs), 3) the timing of training. This interrogation, which can be done by an easy questionnaire, will allow to provide input for task 3: Training and Mobility Schedule & Priority List. Task Contributors: [SCK•CEN] [JRC] [SURAO (CTU)] [SSTC NRS] [CIEMAT] [SURO]				
Task 2	Improving access to historical and ongoing training modules	SCK•CEN	3.5	1	12
	Apart from the training developed within EURAD, we will also link with ongoing or expected training modules developed within ongoing EC H2020 EURATOM projects (like Modern2020, BEACON, MIND, CHANCE) and with existing training modules developed within past EURATOM projects (FP6 and FP7). Also existing initiatives from IAEA or NEA will be taken into account. This will both increase the amount of training materials (and therefore total portfolio) made available within the JP, and at the same time capitalise the efforts made in the past by integrating these efforts into a durable knowledge platform which will be developed within EURAD. In order to achieve this goal, a mapping exercise will be performed within the first year of EURAD, in coordination with the PMO Task mapping exercise (Deliverable 13.2). The mapping will include (at least): - Scope of the training course (including content, learning outcomes, duration, etc.) - Course material availability (textbook, transparencies, exercises, etc.) - Practical information (when was the course given, how many participants, feedback from the participants if available, etc.) After the mapping, the generated info has to be translated to the Roadmap and the knowledge requirements identified therein. This will include how identified and available training material addresses knowledge requirements priorities (Deliverable 13.3), and				

	whether changes or adaptations might be required in order to better suit the needs identified within the Roadmap. Task Contributors: [SCK•CEN] [JRC] [SURAO (CTU)] [SSTC NRS] [CIEMAT]				
Task 3	Training and Mobility Schedule & Priority List	SCK•CEN	2.25	1	12
	Drawing from the outputs of Task 1 and KM Coordination Work carried out by the PMO, an annual training schedule and priority list shall be developed to prioritise scope and resources within the Training WP. Such a priority list would indicate on an annual basis the resources allocated, the targeted audience and the trainers who will be involved (Deliverable 13.4). Task Contributors: [SCK•CEN] [Andra] [JRC] [SURAO (CTU)] [SSTC NRS] [CIEMAT] [SURO]				
Task 4	Implementation of Training Courses	SCK•CEN	5.32	7	12
	The training programme within EURAD-1 will be developed taking into account the Systematic Approach to Training as defined by the IAEA (<i>e.g., IAEA Guidebook on Nuclear Power Plant Personnel Training and its Evaluation, Technical Reports Series No. 380, 1996</i>). This Approach consists of a cycled implementation with the following steps: - Evaluation of functional scientific/technical competences required at the different phases and for the different themes identified within the Roadmap for implementation of a radioactive waste management RD&D programme, through to geological disposal (using the outputs of the Competency Matrix to be completed by the PMO at EURAD launch as key input). - Design of a training programme based on a translation of competences into learning objectives. - Development of training materials to meet learning objectives. - Implementation of the training. - Evaluation of the training effectiveness, which feeds back into step 1. Quality criteria will be developed by which existing training initiatives can be appreciated in order to be taken up within the training portfolio of EURAD-1 (Deliverable 13.5). For the training course (Deliverable 13.6) developed based on the needs identified within the RD&D Work Packages and the Strategic Studies Work Packages (see Task 1) a strong interaction is pursued, both in identifying suitable training courses which could strengthen and enforce the scientific community involved in the different scientific and technical themes addressed within these Work Packages, and in the preparation and execution of new training modules, where experts identified within EURAD Work Packages will be appointed to develop and deliver the training. The corresponding budgets will be allocated and made available to the organisations delivering training (additionally to the budgets already foreseen within these Work Packages). All training modules developed or supported within EURAD-1 will be grouped under the umbrella of the “School of Radioactive Waste Management”, in order to provide a coherent and internally consistent portfolio which could substantially contribute in the short and long term to the maintenance of expert capacity in waste management and disposal. Trainings might be grouped into Summer or Winter Schools, possibly organised back-to back with main conferences or workshops in the domains of EURAD-1. Close interaction with KM WP1 is envisaged in order to align the training portfolio with the development of the State of Knowledge scope.				

	Task Contributors: [SCK•CEN] [Andra] [SURAO (CTU)] [JRC] [SSTC NRS] [CIEMAT]				
Task 5	Implementation of Mobility Programme	SURO	6.23	7	12
	A first deliverable of the mobility task will be to generate a proposal for the mobility programme responding to the different needs identified within Task 1 and prioritised within Task 3 (Deliverable 13.7). The needs are then converted into mobility measures, specified with respect to target groups, hosting organizations and types of facilities, lengths of mobility engagement and competence and skills enhancement outcomes. For the latter, the mobility programme will identify the expectations and quality requirements for defining, monitoring and assessing the competences and skills acquired (“learning outcomes”, similar to training deliverable). Given the broad set of potential needs and the width of potential mobility measures, within the given boundary conditions the calls will be very open. The mobility programme (Deliverable 13.8) will be developed in a spirit of complementarity with already existing initiatives (like the ENEN+ Mobility Fund or the NEA Nuclear Education, Skills and Technology (NEST) Framework) or to be developed projects (e.g. within current NFRP-2018-7) which also target facilitating access to dedicated infrastructures and promoting researcher’s mobility. This EURAD-1 focusses on professional end-users (from post-graduate onwards). However, a younger audience of students (MSc) is not to be neglected as they will populate tomorrow’s workforce in RWM. This task will explore the possibility to connect to existing initiatives primarily aiming at this target audience and will set up, if feasible, close collaborations with these initiatives or projects. Task Contributors: [SURO] [Andra] [SURAO (CTU)] [JRC] [SSTC NRS] [CIEMAT]				

2.4. List of AWP1 Deliverables

D1.1	2nd Annual Work Plan	ANDRA	R	CO	9
D1.5	PMO - EURAD Quality Management Plan	ANDRA	R	PU	3
D1.6	EURAD Data Management Plan	ANDRA	ORDP	CO	12
D1.7	EURAD Roadmap, extended with Competence Matrix	ANDRA	R	PU	12
D1.8	'Soft' update of the EURAD SRA/Roadmap	ANDRA	R	PU	12
D1.10	- Identification of Subject Matter/Theme Experts from EURAD Colleges	ANDRA	R	PU	12
D1.11	EURAD Dissemination strategy	ANDRA	R	PU	3
D1.12	EURAD website	ANDRA	DEC	PU	3
D1.13	List of members of the CS group	IRSN	R	PU	6
D2.1	ACED - State-of-the-art report	COVRA	R	PU	6
D2.4	ACED - Treatment of chemical evolution in national programmes	COVRA	R	PU	5
D2.5	ACED - Experiments and numerical model studies on interfaces	FZJ	R	PU	5
D2.10	ACED Task 3.1 - HLW: Report describing the selected experiments and the existing/expected experimental results	MTA EK	R	PU	7
D2.11	ACED Task 3.1 - ILW: Report describing the selected experiments and the existing/expected experimental results	JSI	R	PU	7
D2.16	ACED Task 4.1 - Report on the conceptual model formulation for a mechanistic based model on implementing the initial SOTA knowledge on models and parameters in existing numerical tools	ENRESA	R	PU	12
D3.1	CORI - SOTA on cement-organic-radionuclide-interactions in the content of L/ILW disposal	KIT	R	PU	6
D3.3	CORI - Training Materials	KIT	R	PU	8
D4.1	DONUT - State-of-the-art in the fields of numerical analysis and scientific computing	ANDRA	R	PU	6
D5.1	FUTuRE - Initial State-of-the-art report on the understanding of radionuclide retention in clay and crystalline rocks	SCK•CEN	R	PU	6
D6.3	GAS - Training materials of the 1st GAS/HITEC Joint training course (copy of the presentations of each doctoral school organised during the course of the project)	ONDRAF/NIRAS	R	PU	3
D7.1	HITEC - Initial State-of-the-art on THM behaviour of i) buffer clay materials and of ii) host clay materials	CIEMAT	R	PU	6
D8.1	SFC - State-of-the-art report	NAGRA	R	PU	6
D9.4	ROUTES - Overview of existing work on categorization/classification of RWs in participating states	ANDRA	R	PU	10
D9.12	ROUTES - Studies and plans for developing shared solutions for radioactive waste management in Europe	COVRA	R	PU	12
D9.15	Scoping of ROUTES, initial CS input and ICS action plan (task 7.1)	JSI	R	PU	11

D10.10	UMAN - Analysis and description of groups of different actors	BGE	R	PU	12
D11.2	List of selected demonstration cases, criteria for final selection, proposal and estimation of effort and resources	BGE	R	PU	9
D11.5	QA procedures for the generation of SoK demonstration cases	SSTC NRS	R	PU	4
D12.1	KM Guidance - PLANMAN Guide - Updated version of the PLANDIS Guide consistent with the EJP Roadmap and including perspectives of the TSOs needs (PLANMAN Guide)	SURAO	R	PU	12
D12.2	KM Guidance - Quality management procedure for PLANMAN development (incl. review and approval procedure)	SURAO	R	PU	12
D12.3	KM Guidance - Approved schedule for delineation of the PLANMAN Guide in-line with the PMO-developed competence matrix and approved Editorial Plan for Year 1	SURAO	R	PU	10
D12.4	KM Guidance - Quality management procedure and methodology for developing the detailed delineation guidance of PLANMAN	SURAO	R	PU	12
D13.1	KM Training - List of training needs from the RD&D and SS WPs	SCK•CEN	R	PU	3
D13.2	KM Training - Mapping of available course material	SCK•CEN	R	PU	8
D13.3	KM Training - Alignment of the available course material with the Roadmap	SCK•CEN	R	PU	12
D13.4	KM Training - Priority list and schedule for training/mobility	SCK•CEN	R	PU	12
D13.5	KM Training - Quality criteria and training specification as a reference guide of requirements and expectations of the training courses to be developed	SCK•CEN	R	PU	9
D13.7	KM Training - Specification document of the content, material, and learning outcomes of mobility training e.g. in relation with a curricular of S/T knowledge acquisition targets	SURO	R	PU	12
D14.1	EPQ - Requirement No. 1	ANDRA	ETHICS	CO	12
D14.2	EPQ - Requirement No. 2	ANDRA	ETHICS	CO	12
D14.3	EPQ - Requirement No. 3	ANDRA	ETHICS	CO	12

2.5. List of AWP1 milestones

M1	EURAD Kick-off meeting (General Assembly n°1)	ANDRA	1	EURAD Kick-off meeting (General Assembly n°1)
M2	ACED Kick-off meeting (WPM1)	SCK•CEN	1	ACED Kick-off meeting (WPM1)
M3	DONUT Kick off - WP Meeting 1	ANDRA	1	DONUT Kick off - WP Meeting 1
M4	FUTuRE Kick-off meeting (WPM1)	FZJ	1	FUTuRE Kick-off meeting (WPM1)
M5	Kick-off GAS WP Meeting 1	ONDRAF/NIRAS	1	Kick-off GAS WP Meeting 1
M6	Kick-off HITEC WP Meeting 1	VTT	1	Kick-off HITEC WP Meeting 1
M7	KM SoK - launch of screening exercise (task 1)	FZJ	1	KM SoK - launch of screening exercise (task 1)
M8	ACED Specifications of representative disposal cell systems and links with and between model approaches and expected experimental results M1.1.1	SCK•CEN	2	ACED Specifications of representative disposal cell systems and links with and between model approaches and expected experimental results M1.1.1
M9	ROUTES Kick-off meeting (ROUTES WPM1)	IRSN	2	ROUTES Kick-off meeting (ROUTES WPM1)
M10	KM Guidance - Editorial meeting for the update of PLANDIS	SURAO	2	KM Guidance - Editorial meeting for the update of PLANDIS
M11	ACED Task 2 workshop 1	SCK•CEN	3	ACED Task 2 workshop 1
M12	EURAD EJP Newsletters	ANDRA	3	EURAD EJP Newsletters (Due date : M3 and then every quarter)
M13	ROUTES Questionnaire	IRSN	3	ROUTES Questionnaire
M15	KM SoK - list of criteria for selecting demonstration cases	BGE	4	KM SoK - list of criteria for selecting demonstration cases
M78	KM SoK - Initial draft QA plan	SSTC NRS	4	KM SoK - Initial draft QA plan
M16	ACED - note on the specific experimental conditions at the steel/clay material interface, parameters and modelling approaches	SCK•CEN	6	ACED - note on the specific experimental conditions at the steel/clay material interface, parameters and modelling approaches with detailed information on set-ups and work flow, variables to measure and a dismantling and characterization plan. It will also define the link between the experiments and the model approaches (also input to general workshop 1, and MS31)
M17	CORI Technical Report - Task 2 State-of-art report on organic degradation by radiolytic and hydrolytic processes	KIT	6	CORI Technical Report - Task 2 State-of-art report on organic degradation by radiolytic and hydrolytic processes.
M18	CORI Technical Report- Task 3 with (i) Final documentation of the systems to be studied and (ii) State-of-art summary on organic-cement-interactions	KIT	6	CORI Technical Report- Task 3 with (i) Final documentation of the systems to be studied and (ii) State-of-art summary on organic-cement-interactions.
M19	CORI Technical Report- Task 4 with (i) Final documentation of the systems to be studied and (ii) State-of-art summary on organic-cement-interactions	KIT	6	CORI Technical Report- Task 4 with (i) Final documentation of the systems to be studied and (ii) State-of-art summary on organic-cement-interactions
M20	GAS Task 2.2 Experimental set-ups, geometries and boundary conditions	ONDRAF/NIRAS	6	GAS Task 2.2 Experimental set-ups, geometries and boundary conditions
M21	UMAN Draft D10.5 as input to Task 2, Task 4, Task 5 and other subtasks of Task 3	BEL V	6	UMAN Draft D10.5 as input to Task 2, Task 4, Task 5 and other subtasks of Task 3
M22	UMAN Preliminary list of uncertainties from UMAN subtask 3.3 as input to Subtask 4.2	BEL V	6	UMAN Preliminary list of uncertainties from UMAN subtask 3.3 as input to Subtask 4.2
M23	UMAN Preliminary list of uncertainties from subtask 3.4 as input to Subtask 4.2	BEL V	6	UMAN Preliminary list of uncertainties from subtask 3.4 as input to Subtask 4.2

M24	UMAN Identification of the different actors across the various programme phases including a first characterization of their roles and interests (Draft D10.10)	BEL V	6	UMAN Identification of the different actors across the various programme phases including a first characterization of their roles and interests (Draft D10.10)
M25	UMAN Composition of the pluralistic stakeholder group for Seminar 1	BEL V	6	UMAN Composition of the pluralistic stakeholder group for Seminar 1
M26	SOTA from RD&D CORI WP as input to UMAN T3.2	KIT	6	SOTA from RD&D CORI WP as input to UMAN T3.2
M27	SOTA from RD&D FUTuRE WP as input to UMAN T3.3	FZJ	6	SOTA from RD&D FUTuRE WP as input to UMAN T3.3
M28	HITEC/GAS training n°1 on multi-physical coupling in geomechanics (especially THM and Gas coupling issues)	VTT	6	HITEC/GAS training n°1 on multi-physical coupling in geomechanics (especially THM and Gas coupling issues)
M29	SOTA from RD&D SFC WP as input to UMAN T3.5	SKB	6	SOTA from RD&D SFC WP as input to UMAN T3.5
M14	KM SoK - List of Demonstration cases	BGE	7	KM SoK - List of Demonstration cases
M30	EURAD General Assembly n°2	ANDRA	7	EURAD General Assembly n°2
M31	ACED Experimental data as a first input for modelling and information exchange towards other scales M1.1.2	SCK•CEN	7	ACED Experimental data as a first input for modelling and information exchange towards other scales M1.1.2
M32	ACED WP meeting 2 + Workshop 1	SCK•CEN	7	ACED WP meeting 2 + Workshop 1
M33	CORI Start of experimental RD&D programme (task 2, 3 and 4)	KIT	7	CORI Start of experimental RD&D programme (task 2, 3 and 4)
M34	DONUT WP Meeting 2	ANDRA	7	DONUT WP Meeting 2
M35	GAS WP Meeting 2	ONDRAF/NIRAS	7	GAS WP Meeting 2
M36	HITEC WP Meeting 2	VTT	7	HITEC WP Meeting 2
M37	ROUTES Workshop 1 on Radioanalytical characterisation of radioactive waste and waste with complex/toxic properties (T3.1)	IRSN	7	ROUTES Workshop 1 on Radioanalytical characterisation of radioactive waste and waste with complex/toxic properties (T3.1)
M38	ROUTES Workshop 1 on disposal options for SIMS (T5.1)	IRSN	7	ROUTES Workshop 1 on disposal options for SIMS (T5.1)
M39	ROUTES workshop on European experience in developing shared solutions for RWM	IRSN	7	ROUTES workshop on European experience in developing shared solutions for RWM
M40	UMAN Draft deliverable D10.2 as input to Tasks 4 and 5	BEL V	7	UMAN Draft deliverable D10.2 as input to Tasks 4 and 5
M41	KM Guidance - Editorial Plan for PLANMAN Delineation Year 2	SURAO	7	KM Guidance - Editorial Plan for PLANMAN Delineation Year 2
M42	EURAD Annual Work Plan 2	ANDRA	9	EURAD Annual Work Plan 2
M43	ACED Identification of integration and upscaling strategies M1.1.3	SCK•CEN	9	ACED Identification of integration and upscaling strategies M1.1.3
M44	GAS State-of-the-art chapter on diffusion and gas sorption in clayey materials as an input to D6.1	ONDRAF/NIRAS	9	GAS State-of-the-art chapter on diffusion and gas sorption in clayey materials as an input to D6.1
M45	GAS State-of-the-art chapter on advective gas transport in clayey materials as an input to D6.1	ONDRAF/NIRAS	9	GAS State-of-the-art chapter on advective gas transport in clayey materials as an input to D6.1
M46	GAS State-of-the-art chapter on gas-induced impacts on barrier integrity including pathway closure and sealing processes as an input to D6.1	ONDRAF/NIRAS	9	GAS State-of-the-art chapter on gas-induced impacts on barrier integrity including pathway closure and sealing processes as an input to D6.1
M47	HITEC experimental progress report	VTT	9	HITEC experimental progress report
M48	HITEC Task 2.2 Experimental test plan	VTT	9	HITEC Task 2.2 Experimental test plan
M49	HITEC Selection of benchmark exercises for task 2.3	VTT	9	HITEC Selection of benchmark exercises for task 2.3
M50	FUTuRE Report on set-up of experiments – Task 2.1	FZJ	10	FUTuRE Report on set-up of experiments – Task 2.1
M51	FUTuRE Report on set-up of experiments – Task 2.2	FZJ	10	FUTuRE Report on set-up of experiments – Task 2.2
M52	FUTuRE Report on set-up of experiments – Task 2.3	FZJ	10	FUTuRE Report on set-up of experiments – Task 2.3
M53	FUTuRE Report on set-up of experiments – Task 3	FZJ	10	FUTuRE Report on set-up of experiments – Task 3

M54	UMAN Preliminary list of uncertainties from subtask 3.5 as input to Subtask 4.2	BEL V	10	UMAN Preliminary list of uncertainties from subtask 3.5 as input to Subtask 4.2
M55	ACED T3.1 - distribution of experimental samples to partners	SCK•CEN	12	ACED T3.1 - distribution of experimental samples to partners
M56	CORI First Annual WP Meeting (including technical meetings on Task level)	KIT	12	CORI First Annual WP Meeting (including technical meetings on Task level)
M57	CORI Technical Report- Task 4 (i) Radionuclide retention on CSH or CASH or AFm/AFt in the presence of organics, (ii) Radionuclide retention on HCP in the presence of organics	KIT	12	CORI Technical Report- Task 4 (i) Radionuclide retention on CSH or CASH or AFm/AFt in the presence of organics, (ii) Radionuclide retention on HCP in the presence of organics.
M58	GAS Task 3 – interim experimental design report comprising a revised detailed work programme of subtasks 3.1, 3.2 and 3.3	ONDRAF/NIRAS	12	GAS Task 3 – interim experimental design report comprising a revised detailed work programme of subtasks 3.1, 3.2 and 3.3
M59	GAS SOTA chapter on gas-induced impacts on model-based interpretation including a survey of previous research programmes and a screening of gas-related FEP lists as an input to D6.1	ONDRAF/NIRAS	12	GAS State-of-the-art chapter on gas-induced impacts on model-based interpretation including a survey of previous research programmes and a screening of gas-related FEP lists as an input to D6.1
M60	GAS SOTA chapter drawing an overview of the conceptualizations of gas migration through geological disposal systems and related processes, at the scale of a repository and how these can be translated into models	ONDRAF/NIRAS	12	GAS State-of-the-art chapter drawing an overview of the conceptualizations of gas migration through geological disposal systems and related processes, at the scale of a repository and how these can be translated into models as an input to D6.1
M61	GAS Technical Note defining a generic repository configuration, sets of parameters, conditions and relevant indicators	ONDRAF/NIRAS	12	GAS Technical Note defining a generic repository configuration, sets of parameters, conditions and relevant indicators on which sub-task 4.2 will test various evaluation approaches
M62	HITEC Task 2.1 Experimental test plan	VTT	12	HITEC Task 2.1 Experimental test plan
M63	HITEC Task 3.3 - Mathematical models – description of models and plan for improvements (Description of conceptual models and tools, plan for the models improvement)	VTT	12	HITEC Task 3.3 - Mathematical models – description of models and plan for improvements (Description of conceptual models and tools, plan for the models improvement)
M64	SFC Task 2.3 Characteristics of irradiated material to be characterised	SKB	12	SFC Task 2.3 Characteristics of irradiated material to be characterised
M65	ROUTES WPM2	IRSN	12	ROUTES WPM2
M66	ROUTES Workshop on Case studies on shared development and use of technologies and facilities	IRSN	12	ROUTES Workshop on Case studies on shared development and use of technologies and facilities
M67	UMAN Recommendations for future RD&D, strategic study and KM activities for the 2nd wave of EURAD-1	BEL V	12	UMAN Recommendations for future RD&D, strategic study and KM activities for the 2nd wave of EURAD-1
M68	Materials to be discussed in UMAN Seminar 1	BEL V	12	Materials to be discussed in UMAN Seminar 1
M69	UMAN Mapping of the stakes related to the outcomes of Task 2 and Subtask 3.1 from a civil society point of view for the 1st Task 5 seminar	BEL V	12	UMAN Mapping of the stakes related to the outcomes of Task 2 and Subtask 3.1 from a civil society point of view for the 1st Task 5 seminar
M70	KM Training - School of RWM – portfolio gathering all training courses developed and implemented depending on the priorities identified and approved within the EJP; Founding of the School	SCK•CEN	12	KM Training - School of Radioactive Waste Management – portfolio gathering all training courses developed and implemented depending on the priorities identified and approved within the EJP; Founding of the School
M71	Methodology for ICS activities assessment	IRSN	12	Methodology for ICS activities assessment

2.6. Participation in Annual Work Programme activities

2.6.1. Participants

1/Andra

Participant	1	Agence nationale pour la gestion des déchets radioactifs	Andra
Description of the legal entity Andra, The French National Agency for Radioactive Waste Management, is a public industrial and commercial organization created by the Act of 30 December 1991 (Nuclear Act related to Nuclear Waste Management). It comes under the supervision of the French Ministries for Energy, Research and the Environment, and is responsible for the long-term management of radioactive waste produced in France. It is in charge of the research program (concept design and long-term evolution) on a deep geological repository for high and intermediate level long lived radioactive wastes. It has also an industrial responsibility of operating the disposal facilities for short lived, low and intermediate level radioactive waste. For that purpose, Andra engaged its research process as of early 1994 and is currently operating an underground research laboratory in argillaceous rock, located in the Meuse/Haute-Marne region, in the vicinity of Bure. At the same time, Andra is further developing the technical concept of a repository. www.andra.fr			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal Andra is the Coordinator of EURAD and will be deeply involved in EURAD Programme Management Office (PMO-WP1). Andra will also be actively involved in : - WP2-ACED : In tasks 3 & 4, Andra's participation is aiming to describe the HLW cell evolution thanks to reactive transport modelling. These modelling will integrate experimental results and coupling processes between chemistry and environmental conditions. The reassembly of these different modelling will allow providing a coherent, comprehensive and systematic scheme of a HLW cell chemical evolution. - WP3-CORI: Andra will participate in CORI in the different tasks : - o Task 1 : Experiments in the deep geological laboratory in Bure on in-situ leaching tests to investigate the superplasticizer mobility. - o Task 2 : (co-Leader) Determination of the diffusion coefficient of various organic molecules by electro-diffusion tests and integration of the results. degradation and characterization of organic matter, production of a State of the Art about degradation of polymers and releasing of organic species - o Task 3 : Integration of the results on the basis of a geochemical model. - WP4-DONUT: - o Task 1: "S/T coordination, State-of-the-art and training material" - o Task 5: "Benchmarks of methods and tools and methods for coupled processes"; contribution as defining representative cases with couplings and use of numerical tools. - WP5-FUTuRE: - o Task 1: Andra will provide input data (sorption, redox of RN) and contribute to the state of the art report. - o Task 2 : Andra will provide rock samples, pore water and data on associated physico-chemical properties. - o Task 3 : Andra will provide rock samples, pore water and data on associated physico-chemical properties.			

- **WP6- GAS:** o involved in task 3 about “Barrier Integrity” and leader of sub task 3.2 (Pathway closure and sealing processes). Andra will participate in this task to the state of art document and will provide (i) preserved host rock samples and EBS material and (ii) experimental data sets from previous and from new in-situ experiments in Bure URL. Andra is also involved in task 4 “Repository Performance Aspects” as leader of the task, and will contribute to repository scale numerical simulations. Andra will also contribute as data provider for Task 2 “Transport Mechanisms”
- **WP7- HITEC** Andra is involved in task 1, 2 and 4 and leads the Subtask 2.3 – THM modelling of effect of temperature in near and far field – Benchmark exercise. Andra will participate in the task to the state of art report (Subtask 1.2) and will provide available data on Callovo Oxfordian claystone. In Subtask2.3, Andra will provided in situ data as a benchmark exercise and will also participate to the benchmark exercises. In subtask 4.1 Andra will participate to evaluate how the progress beyond the state-of-the-art allows reducing the uncertainties and increasing the margin by which the safety functions can be fulfilled.
- **WP9- ROUTES** Andra leads Task 2 « Identify challenging wastes to be collaboratively tackled within the Joint Programme - Mapping and shared understanding at EU level of the practical issues on waste management routes » and contributes to other tasks. Andra contribution aims to provide up to date information on the French situation on waste management routes including opened questions and to analyze and consolidate data from various situations within Europe.
- **WP10- UMAN:** Andra will contribute and share experience in tasks 2, 4 and 5. Namely, Andra will lead the subtask 3.4 on characterization and significance of uncertainties related to human aspects, and the topic 3 (Uncertainty management options throughout a GD Programme) of the subtask 5.1 devoted at preparing, supporting and reporting on pluralistic analyses.
- **WP11- KM SoK** – Andra will contribute to the establishment of EURAD Knowledge platform that will be developed under WP11.
- **WP13- KM Training/Mobility** – Andra will contribute to the establishment / implementation of the Training/Mobility programme under WP13.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

2/ARAO

Participant	2	Agencija za radioaktivne odpadke	ARAO
Description of the legal entity			
The ARAO is a public service agency that concludes contracts in connection with its activities with the line ministry competent for the Energy Directorate. The ARAO is the mandatory service of general economic interest provider of management of radioactive waste generated in the territory of Slovenia. Its task is to takeover, transport, and carry out pre-treatment, treatment, conditioning, and storage of radioactive waste generated in industry, research and medicine. The ARAO is authorised to manage and carry out long-term monitoring and maintenance of disposal sites of hydrometallurgical tailings and mine waste tailings and repositories for radioactive waste and spent fuel after their closure. By planning and providing long-term, safe and cost-effective solutions for radioactive waste and spent fuel management, including the construction of the LILW repository, it provides infrastructural and professional support to the use of nuclear and radiation technologies in Slovenia. The radioactive waste management as a mandatory service of general economic interest will, when the infrastructure conditions are met, also provide for the final			

disposal of the radioactive waste and spent fuel generated during the operation and decommissioning of the nuclear power plant and for the disposal of radioactive waste from all other industrial activities.

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

ARAO as mandated WMO from Republic of Slovenia will be engaged in Task n°6 – Shared solutions in European countries under Strategic Study WP on “Waste management routes in Europe from cradle to grave (ROUTES)”. Task objectives n°6:

- Describe and assess knowledge on and approaches to sharing technology and facilities between members states.
- Provide an overview of the interest in and experience with sharing technology/facilities in the different steps of waste management.
- Identify gaps and define needs for R&D, strategic priorities and opportunities for collaboration between member states, as applied to challenging wastes as defined in task 1 and LAPs.

The Krško Nuclear Power Plant (Krško NPP) is one of the main pillars of the Slovenian power system. The plant is operated by the public company Krško NPP d.o.o. and owned by state-owned Slovenian and Croatian electrical power companies (GEN energija d.o.o. and Hrvatska Elektroprivreda d.d., respectively). In accordance with The Bilateral Slovenian-Croatian Agreement on the Krško NPP, both countries share responsibility for RW and SF management.

In Resolution on the 2016–2025 National Program for Managing Radioactive Waste and Spent Nuclear Fuel (ReNPRRO16-25) in Republic of Slovenia the conceptual idea of shared facilities and regional cooperation in waste management, including the dual-track approach, was clearly implemented. In Slovenia radioactive waste (RW) and spent fuel (SF) management must be implemented in such a way so as to ensure modern principles of RW and SF management. Especially relevant principles for the task objectives are:

- The principles of international cooperation
Slovenia is aware of the responsibility and opportunity presented at the regional and global levels to safely and sustainably resolve issues related to radioactive waste and spent fuel management together with other countries. In its actions, account should be taken of the principles adopted in this policy and regional and international agreements. National responsibility for radioactive waste and spent fuel management shall be considered in parallel with active participation in international regional efforts to make progress towards joint regional programmes for disposal.
- The principle of seeking a joint solution
Slovenia is aware of the responsibility for the management of radioactive waste and spent fuel and its disposal and shall, in accordance with The Bilateral Slovenian-Croatian Agreement on the Krško NPP, strive to ensure an effective joint solution for the decommissioning and disposal of radioactive waste and spent fuel from the Krško NPP with Republic of Croatia.

For long-term spent fuel management, a dual-track strategy has been adopted as a reasonable solution in the present situation. The dual-track approach in Slovenian strategy includes both first, the option of multinational disposal is kept open, and second, the basic reference conceptual scenario for national geological disposal is included.

With regard to disposal and sharing of facilities, the ARAO participates at the EU level in two programmes which address the possibility of building a multinational/regional repository for spent fuel and high-level waste (ERDO-WG and IGD-TP) and is also involved in the work of the International Framework for Nuclear Energy Cooperation (IFNEC).

Due to special status of the Krško NPP, ARAO has gained lots of experience in sharing of facilities during sitting and construction permit approval process for possible joint Slovenian and Croatian LILW repository (negotiations in progress) and construction of joint dry storage facility for SF in Krško NPP.

ARAO has gained a lot of experience also in sharing of potential regional/multinational disposal facilities through cooperation with other WMO and stakeholders (IAEA, OECD/NEA, WNA, IFNEC, ERDO-WG, Regional Seminar, ...).

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.



3/Bel V

Participant	3	Bel V	Bel V
Description of the legal entity Bel V is a technical subsidiary of the Federal Agency for Nuclear Control (Belgian Safety Authority). By virtue of its activities and its relations to the FANC, Bel V is the Belgian Technical Safety Organisation. The FANC relies on the technical expertise of Bel V for carrying out inspections in nuclear installations in Belgium. Bel V acts as well as expert for the safety assessments of nuclear projects and participates actively in working groups that are organized in the framework of international organizations. Its financial resources are allocated in part to research and development activities.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal WP UMAN: Bel V will act as WP leader. As national TSO, the oversight of uncertainty management approaches and activities carried out by proponents or licensees of waste management facilities is part of Bel V's core business activities. - As WP leader, Bel V will coordinate Task 1 dedicated to WP coordination, interactions with KM WP & integration. - Bel V will contribute to Subtask 2.1 on the generic strategies for managing uncertainties by providing a regulatory perspective on uncertainty management strategies and approaches. - In Subtask 3.5, Bel V will collect and synthesize relevant information on uncertainties associated with spent fuel including regarding the experience gained through its activities in the Belgian national programme. - In Task 4 on uncertainty management options, Bel V will identify regulatory preferences on the management options and contribute to the analysis of options and the identification of needs for future activities that will be synthesised in Task 1. - In Task 5 on the interactions between all categories of actors, Bel V, as coordinator of the WP, will participate in key meetings related to Topics 1 to 4 and the organisation of the seminars and review the deliverables. WP ACED: Bel V will participate in Subtask 2.2 of this WP. In this framework, Bel V will contribute to piloting the new experiment focusing on the evolution of grout cement/CEM I and carbon steel interfaces at 80°C. In the framework of its R&D programme, Bel V has developed knowledge and expertise in this topic, notably by being involved in and co-funding the following PhD's: - PhD on the effect of temperature on geochemistry, microstructure and diffusion at cement/clay interfaces (P. Lalan 2013-2015); - PhD on the development of a coupled experimental, numerical and statistical homogenization approach towards an accurate feedback relationship between porosity and diffusive properties of model cementitious materials in the field of reactive transport modelling (N. Seigneur 2012-2016) Bel V involvement in the previous EC-H2020 SITEX projects (where Bel V coordinated the TSO SRA development) has also contributed to develop expertise in this topic. WP WMR: Bel V will be involved in Task 2 of this WP, devoted to identifying challenging wastes to be collaboratively tackled within the Joint Programme and mapping and share understanding at EU level of practical issues on waste management routes. As a TSO Bel V oversights safety aspects related to radioactive waste management in Belgium and has thus developed knowledge and experience on existing and missing waste management routes. Moreover, Bel V is involved in the management of safety issues on waste management (e.g. drums affected by ASR gel formation, bitumen drums) that would be worth to share in the framework of this WP.			

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.



4/BGE

Participant	4	Bundesgesellschaft für Endlagerung	BGE
Description of the legal entity BGE is the federal company for radioactive waste disposal, implementer and German waste management organization. The BGE is entrusted with the task of implementing site selection procedures for a final repository, particularly for heat-generating radioactive waste. Additionally, the BGE is operator of the Asse II shaft mine, the Konrad final repository and the Morsleben final repository.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal WP HITEC: BGE intends to develop a time dependent anisotropic THM model for argillaceous rock which incorporates strength and stiffness anisotropy, a time-dependent deformation, a dependency of permeability on irreversible strains, a hydro-mechanical coupling for saturated and/or unsaturated conditions and a thermo-mechanical coupling able to predict the thermally induced opening of fractures in claystone. The planned contribution of BGE focuses on the Task 2 related question "How good are the current THM models in representing the stress changes at repository relevant conditions?" by the constitutive modelling of THM behaviour of COX and Opalinus Clay within an open source process level code. The aim is to close existing gaps in regard to the hydro-mechanical coupling with respect to the temperature effects and increase the understanding of the relationships between involved phenomena. WP GAS: BGE envisages in collaboration with UFZ to develop a TH ² M constitutive material model for bentonite which takes into account the two phase flow formulation and the pathway dilation process and incorporate some of the state of the art THM formulation for bentonite actually developed in the scope of the European project BEACON. The results will provide a better understanding of the consequences of gas migration in terms of demonstrating the barrier integrity. WP UMAN: As Task Lead BGE will develop and distribute a questionnaire in order to identify the different actors and collect information about their roles and interests. Also BGE will be in charge of the writing of the deliverable. BGE will contribute to the compilation and review of uncertainty management options, provide an input regarding the options considered in the German programme (considering in particular the construction, operation, and closure of a repository mine). BGE will organize and participate in the workshops, provide an input on the pros and cons from the viewpoint of the German WMO, contribute to the analysis of options, to the identification of needs for future activities and to the writing of the deliverable. WP KM – State-of-Knowledge: BGE will provide the WP Lead. Together with the other participants specifications for the development of a knowledge platform will be elaborated and a "prototype" platform will be set up on the basis of these developed specifications. This platform will be hosted by BGE.			

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

5/CEA

Participant	5	Commissariat à l'Energie Atomique et aux Energies Alternatives	CEA
Description of the legal entity			
The French Alternative Energies and Atomic Energy Commission (CEA) is a key player in research, development and innovation in four main areas: defence and security, low carbon energies (nuclear and renewable energies), technological research for industry, fundamental research in the physical sciences and life sciences. CEA represents 16,000 permanent staff, spread among 9 research centers in France. Drawing on its widely acknowledged expertise, the CEA actively participates in collaborative projects with a large number of academic and industrial partners. Amongst its missions, CEA (Nuclear Energy Division) is working on the optimization of the current nuclear industry. In this framework, CEA is carrying out research for the management of radioactive wastes and spent fuel.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal			
CEA is involved in 5 work packages of the Joint Programme. Regarding Cement-Organics-Radionuclide-Interactions (WP CORI) and Fundamental Understanding of radionuclide mobility (WP Future), CEA will provide dedicated experiments to study the mobility of the radionuclides of interest in cement and compacted clay rocks, benefiting of its skills in this domain. CEA has developed a large experience on the vitrified wastes, and their long-term behaviour under disposal conditions. Hence, CEA will also contribute to the assessment of chemical evolution of High Level Waste disposal cell by characterizing and modelling long-term interactions in a glass/steel/clay system (WP ACED). Furthermore, CEA has been involved since many years on the characterization of thermo-mechanical behaviour of bentonite, in the framework of European projects and collaboration with Andra. Enriched by this experience, CEA proposes to characterize the thermo-mechanical behaviour of clay host-rocks (WP HITEC). At last, CEA, who has conducted large scope of research on spent nuclear fuel behaviour under dry storage in the framework of 1991 French law, will provide experimental data on the behaviour of spent fuel rod under dry storage in incidental scenario (no tight cladding) (WP Spent fuel).			

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

6/CIEMAT

Participant	6	Centro de investigaciones energéticas, medioambientales y tecnológicas	CIEMAT
Description of the legal entity			
The CIEMAT (Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas) is a public research body assigned to the Ministry of Science, Innovation and Universities, focusing on energy and the environment as well as in many vanguard technologies and in various areas of fundamental research. The mission of the CIEMAT is to contribute to the sustainable development of the country and the quality of life of its citizens, through the generation and application of scientific and technological knowledge. During the last decade, CIEMAT develop a strategy into the institutional project Physico-Chemistry of Actinides and Radioactive waste Management, participating in many projects related to the research on radioactive waste repositories, radionuclide transport processes, spent fuel and have been involved in National R&D Programs financed by ENRESA (the Spanish National Agency for Radioactive Waste Management) and the Nuclear Safety Council, as well as in European Union Programs in both R&D and the EURATOM Treaty. Besides CIEMAT has a wide experience in E&T in Nuclear Technology and Radiation Protection such as preparation and development on an annual basis of the Education and Training Program related to nuclear technology, radiation protection and in all the rest of R & D areas.			

Within the European and international networks dealing with these topics the following projects, among others, in which CIEMAT participated, can be highlighted: CEBAMA, nTOF-ND-ADS, MUSE, PDS-XADS, Red-Impact, SARNET, PHEBEN2, ARTIST, CABRI, ACSEPT, HotLab, SFS, NF-PRO, MIKADO, ACACIAS, EUROPART, ADOPT, ACTAF, FEBEX I, PEBS, CEBAMA, BEACON FEBEX II, NF-PRO, FUNMIG, CROCK, BELBAR, RESEAL II, FORGE, 1st Nuclides, REDUPP, MATISSE, TIARA, ECVET, ENETRAP, DEVCO, ACTINET Thematic Network.

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

CIEMAT will contribute to RD&D Work Packages:

Mechanistic understanding of gas transport in clay materials (GAS)

WP GAS -Task 2.2 “Advection (displacement vs. dilation)” is dedicated to improving the understanding of advective gas transport regimes in clay materials.

CIEMAT will focus on the identification of the phenomena that govern gas flow behaviour and the determination of the range of actual conditions (gas pressure, stress/deformation, saturation) at which each gas transport regime occurs on EBS buffer material. The group began to carry out this type of tests in 1998 and has continued them improving the control and analysis conditions. Different barrier materials have been tested in the context of different projects. Close relationship with UPC (TLP) modellers will address the initial experimental work, which is expected to provide valuable data sets to validate the models and to define the future experiments.

Influence of temperature on clay-based material behaviour (HITEC)

Task 1.2 State of the art. CIEMAT will be responsible for this task since it has been involved in projects related with the effect of temperature on barriers for more than 20 years. The group recently participated in the related project PEBS.

Task 3.1 Assessment of the impact of high temperatures over long time periods on the clay buffer properties, including materials coming from large-scale in situ tests and from specific laboratory tests. The group has participated as leading organisation in the dismantling and postmortem analysis of in situ tests (FEBEX, EB) and of laboratory TH tests with FEBEX and MX-80 bentonites, two of the materials included in the proposal. Task 3.2 Determination of parameters at temperatures >100°C. CIEMAT will determine the water retention curve of two bentonites with a methodology previously tested in the FEBEX-DP project that will be fine-tuned for high temperature.

Task 3.3 Small-scale experiments simulating the conditions of the barrier in a repository. The group has performed this kind of tests since 1992, continuously improving the control and analysis conditions. Different barrier materials have been tested in the context of different projects.

Assessment of Chemical Evolution of ILW and HLW Disposal Cells (ACED)

Subtask T1.5: Analysis of experiments and numerical model studies on interfaces, which is included in Task 1: Establishing the state of the art (SOTA) & integration.

As a part of the main objective of ACED is “to improve methodologies to obtain multi-scale quantitative models for the chemical model at cell disposal scale based on existing and new experimental data and process knowledge”. For that is proposed “compile and integrate the process level knowledge and description of reactivity at the interfaces between materials relevant for ILW and HLW disposal cells”. An important basis to do it is “the state-of-the-art scientific knowledge and experimental evidence on chemical processes acting at the interface of 2 materials”. CIEMAT will contribute to the analysis of existing experimental data on relevant processes occurring at the steel/iron-clay (bentonite) materials in the context of HLW, based in its previous experience in the context of NF-PRO, PEBS and FEBEX-family projects. The analysis will include existing work on natural/archaeological analogues that may provide useful information for long-term processes. The final input would be the conceptual model describing processes at the interface that serves to support modelling (Tasks 3 and 4).

Subtask T2.1: Steel/clay material interface reactivity, which is included in Task 2: Interface scale: Reactivity of steel/material interfaces.

A laboratory experimental program for the study of metal-compacted FEBEX bentonite interaction started in august 2006 in CIEMAT, focused on the characterization of geochemical processes occurring in the bentonite barrier and their influence on corrosion of the carbon steel container as in the transitory stage of a DGR. Six identical experimental cells (named FB1 to 6) containing bentonite blocks in contact with Fe powder in order to enhance corrosion phenomena were designed and mounted at CIEMAT. The upper closing of the cells was made by means of a stainless steel plug. Inside this plug there was a deposit in which water circulated at room temperature (25 °C). The bottom part of the cells was a plane stainless steel heater set at a temperature of 100 °C. Then, a temperature gradient is established. The hydration is made through the upper plug of the cell with water taken from a stainless steel pressurized deposit. The cells were instrumented with capacitive-type sensors placed inside the clay at two different levels, at 18 and 74 mm from the heater. Four cells (FB1 to 4) were dismantled after 0.6, 1, 1.6 and 4.5 years under NF-PRO and PEBS projects. Two of these cells are still in operation, one being hydrated with granite water (FB5) and the other one without hydration (FB6). FB5 and 6 will be dismantled and analysed in the context of ACED work package.

Additionally, in 2008, an experiment involving iron and bentonite was designed and assembled in the CIEMAT laboratories to study the diffusion of corrosion products in the buffer material and analyse structural changes in the bentonite, considering a conservative scenario: saturated bentonite, aerobic conditions and high corrosion rates. For that, a block of FEBEX bentonite compacted to a dry density of 1.65 g/cm³ was used for this experiment. Six holes ($\phi=1\text{cm}$) were drilled in the bentonite and filled with a cylindrical stainless-steel sinter surrounded by iron powder. The experiment was assembled in a square cell (120 x 120 mm and 16 mm-high) made out of methacrylate and stainless steel 316L. Hydration of bentonite with granite-type water (Ca-HCO_3) occurred through the sinters. The aim of this experiment is to evaluate the potential alteration of bentonite and the mobility of iron in the most conservative scenario. The corrosion of the metals will be analysed as well.

The value of the experiments is that they will provide useful information on the spatial (by comparison with in situ experiment, e.g. FEBEX-DP) and temporal (as explained above the experiments are the lasts of a series of identical experiments dismantled sequentially after different times of operation) evolution of the mineral alteration and geochemical impact on the bentonite barrier due to the interaction with iron materials. The experiments are set at different hydration and temperature conditions simulating different stages of the repository operation.

The expected outcome of the analysis of long-term interaction tests involving metal and clay as engineered barrier (bentonite) is the assessment of the impact on primary safety functions of EBSs of the metal corrosion products in tests under THC controlled conditions such as Types of corrosion, Corrosion rates, Corrosion products, Fe sorption and mobility, Chemical fronts/mass transport, secondary phase formation.

The results will serve as a base for modelling studies (e.g. Tasks 3 and 4). UDC modelled previous FB experiments and the dismantling of the FB5 and 6 experiments will help to assess the iron/bentonite interaction previous model.

Spent Fuel characterisation and evolution until disposal (SFC):

CIEMAT is coordinating the WP together with NAGRA and Uppsala University due to that CIEMAT will be involved in main coordination activities in task 1.

In task 2 CIEMAT will contribute to the activities: Task 2.1 Compare and benchmark state-of-the art codes for SNF depletion calculations based on the selected assemblies, by Monte Carlo simulations for PWR and BWR assemblies using the EVOLCODE system (MCNP and ORIGEN/ACAB). Performing sensitivity studies and propagate nuclear data uncertainties to define confidence limits based on the present status of nuclear data libraries and identify nuclear data requiring improvement CIEMAT will contribute by Sensitivity analyses and nuclear data uncertainties propagation and identifying fuel irradiation history parameters that influence the source terms and propagate uncertainties of these parameters to the observables. CIEMAT will perform studies on Impact of fuel irradiation history parameters uncertainties on inventory calculations with sensitivity analyses. CIEMAT will perform deliverables related to these activities. Task 2.2 CIEMAT will develop and test a prototype of a combined neutron and gamma-ray monitor based on the

CLYC inorganic scintillator. Task 2.3 CIEMAT will contribute to the activities of 2.3.4 with theoretical calculation of radionuclide inventories and to the activities of 2.3.5 on evaluation of deviations between analytically and numerically determined inventories studied in this subtask. Task 2.4 CIEMAT will contribute to the activities 2.4.2 and 2.4.4. CIEMAT will evaluate “SNF data set package A/B” by using the “sophisticated” code.

In task 3 CIEMAT will estimate key variables in cladding performance like creep, hydrides distribution and hydrides radial reorientation (i.e., embrittlement) with thermo-mechanical FRAPCON code. In addition, simulations will be conducted in a comprehensive frame of uncertainty quantification by using the BEPU (Best Estimate Plus Uncertainties) methodology. Realistic thermal histories will be explored by using the ANSYS-FLUENT package (3D thermo-fluid dynamics code). Furthermore CIEMAT will study the influence of oxygen pressure and temperature in the alteration of the spent nuclear fuel (SNF) and setting. Experiments will be performed with UO₂/doped UO₂, MOX and irradiated fuel in collaboration with NNL. The reaction system to characterize in-situ the fuel will be set under non-active condition and developed to work in the hot-cells. Finally CIEMAT will participate in the subtask 3.3 by modelling of the fuel rod history with FRAPCON-xt from the reactor to the long term dry storage with focus on the stress (causing PCMI that drives PCI) from two major sources: postulated UO₂ swelling due to oxidation in the presence of an oxidizing agent and/or alpha-decay. Additionally, SNF alteration under interim dry storage conditions and degradation effects of the cladding will be investigated experimentally with UO₂/doped UO₂, MOX. Micro indentation measurements, Raman, SEM, micro-XRD will be performed.

In task 4 CIEMAT will lead the activities perform and will contribute by Identification of credible accident scenarios studies and Mechanical analysis. Use of the source terms from Task 2 to evaluate the accidental scenario. Finally Re-criticality modelling for different accident scenarios will be achieved and the identification and quantification of major sources of uncertainties

Cement-Organics-Radionuclide interactions (CORI).

CIEMAT will lead task 4 and it will participate in Task 3 (Organic-Cement Interactions) and Task 4 (Organic-Cement-Radionuclide Interactions). The objective of the work proposed in Task 3 is to provide information on the mobility of organics present in cements, under the conditions of a waste repository. The focus will be brought on the isosaccharinic acid, ISA, as main cellulose degradation product, and superplasticizers (polycarboxylates, PC) and their degradation products. The main materials considered for these studies will be CSH (possibly CASH), CEM I, and CEM V. The possibility of including portlandite and ettringite will be evaluated. The water chemical conditions will be representative for each material and for the cement, two degraded states will be considered.

In Task 4 it will be investigated the role of the presence of organics on radionuclide (RN) retention/migration under cementitious conditions, trying to combine different experimental techniques and thermodynamic sorption modelling. In Task 4, the behavior of ternary systems will be studied by different techniques: batch sorption tests on powdered materials and small consolidated cement blocks, diffusion tests (through-diffusion or in-diffusion) and sorption modelling. The RN of interest for CIEMAT are ⁶³Ni (II); ¹⁵²Eu(III) (as possible homologue of Am(III)) and ²³⁸Pu and ²³³U as redox sensitive elements. Diffusion tests are planned in collaboration with HZDR. The combination of batch sorption and diffusion experiments will be used as a methodology to assess the mobility of RN-organic complexes in cements: therefore, batch data will be used as the basis for design diffusion tests (chemistry, RN concentration, organic concentration). The priority for transport experiments will be for those elements whose retention resulted more affected by the presence of organics.

Fundamental understanding of radionuclide retention (FUTuRE)

CIEMAT will participate in Task 2 (Mobility) and Task 3 (Redox). The main objectives of the work proposed 2 are: 1) to analyse transport mechanisms of RN in compacted/consolidated clays and the dependence of diffusion coefficient as a function of the temperature; 2) to analyse the reversibility of sorption processes in (compacted) clays and to understand which properties of the clay (and RN) may affect mostly the



(ir)reversibility of the retention. 3) To point out the differences between batch/compacted systems. A complete geochemical and mineralogical characterization of different clays will be initially carried out by different techniques. Special consideration will be given to the following radionuclides (RN): Ra (or homologues), Ni, Zn, Ac(IV, VI), Tc and Se.

CIEMAT work-plan in Task 3 aims to identify, and to describe theoretically, the surface mechanisms responsible for the retention of redox sensitive radionuclides (RN) as Se, Tc and U, in systems composed by mixtures of clays and other minerals, especially Fe oxides to relate mineral characteristics and RN reactivity. A bottom-up approach is proposed to describe the retention mechanisms in complex systems, starting from the detailed study of RN sorption in the single systems (batch sorption tests in individual minerals) to more realistic conditions (mixtures, complex materials and compacted samples) to identify new variables and processes as complexity increases. A complete experimental and modelling work is proposed, and experiments will be carried out under controlled redox conditions.

CIEMAT will contribute as well to the two **Strategic Studies Work Packages** such as Waste Management routes in Europe from cradle to grave (ROUTES) and Understanding of uncertainty, risk and safety (UMAN).

Knowledge Management Work Packages

The main tasks of the Knowledge Management and Training Division of CIEMAT in the proposal are related with the Knowledge Management Programme. CIEMAT in collaboration with UPM and supported by ENRESA are yearly delivering a post-graduate course on RWMD since 1989 covering detailed technical questions about the management of both low-and-intermediate-activity wastes and the high-activity level, together with the wastes generated during decommissioning and dismantling of installations, as well as the general and institutional aspects relevant in Spain. CIEMAT has a extensive know-how in E&T in Nuclear Technology and Radiation Protection since the fifties. Particularly, we can result the professionalizing Master programme in Nuclear Engineering and Applications since 1969 and the Radiation Protection Expert course. Also CIEMAT has a wide experience in dissemination of knowledge in RD&D activities of the research centre through both, the social media and the traditional and in crosscutting activities that will provide capacity building, stakeholder engagement, and outreach/communication. International experience on RD&D open platforms developed under UE FP7 projects (Matisse, Tiara, ECVET, ENETRAP...) integrating the capacity building strategy in the R&D projects.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

7/ChRDI

Participant	7	Chornobyl Research and Development Institute	ChRDI
Description of the legal entity			
The Chornobyl Research and Development Institute (ChRDI) is a key scientific organization in the following areas: radiation safety, environmental safety, nuclear and renewable energy, handling of radioactive materials of the nuclear fuel cycle, fundamental and technological research in the field of chemical sciences, physical sciences, environmental sciences. ChRDI has extensive experience in the management of radioactive waste and spent nuclear fuel, including emergency and accidental radioactive materials. Permanent staff of the Institute work in stationary conditions in the city of Kyiv and on the territory of the Chornobyl Exclusion Zone, as well as like mobile emergency personals on radioactive and chemical «dangerous» objects. Based on own experience and recognition of other science and technical organizations, ChRDI actively participates in joint projects and programs with foreign and domestic academic and industrial partners. ChrDI (Department of Nuclear Technology and Radiation Safety) is the main task for safe handling of spent nuclear fuel, monitoring of the state of biological protection, including emergency radioactive materials. In this context, ChRDI conducts research for the management of radioactive waste and spent fuel.			

**Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal**

ChRDI is involved in Spent Fuel Characterization (WP SFC) Subtask 4.2 Consequence Analysis of Postulated Accidents, ChRDI will conduct special studies and provide data for 20 years of research. The results of 20-year studies include: analysis of the status of temporary storage facilities (intermediate storage) in which radioactive waste was contained (dynamics for 20 years) and those where radioactive waste was stored without pre-treatment and conditioning and was placed directly in the reinforced concrete compartments of the near-surface storage (dynamics for 20 years). Analysis of the causes of radiation accidents and their consequences during interim storage of radioactive waste.

The ChRDI also has large experience in handling of radioactive materials, their identification, characterization and transport to the places of disposal.

Important is the experience of the ChRDI when assessment of engineering structures and places of long-term storage of radioactive materials, degradation of the state of multilayer containers and engineer barriers over time and under the influence of ionizing radiation, other external factors (from the moment of the accident at the Chernobyl Nuclear Power Plant).

The ChRDI has Linked Third Parties that perform work in HITEC WP, see section 4.2.

KIPT

The KIPT does not yet participated in the research programs of the European Commission.

KIPT do not have samples that were got before within the framework of joint researches with foreign partners.

Therefore, the fresh samples of bentonite clay will be prepared for tests. But the KIPT has the necessary equipment, tools and specialists to perform WP HITEC Subtask 3.1 and Subtask 3.2

The main characteristic of bentonite clay (swelling pressure) will be investigated at autoclave treatment of samples at 150 °C during the long period of time (3 months as minimum and more). We plan to use saturated and unsaturated samples with various dry densities: from 1400 to 1800 kg/m³. Also, structure and chemical/transport changes in bentonite during heat treatment will be studied.

The maximal parameters of swelling pressure will be determined for each samples and relationship between initial dry density, water content and treatment time will be obtained. Analytical investigations will be carried out to investigate the structure and chemical/transport changes in bentonite during 150 °C heat treatment.

SIIGNASU

The SIIGNASU plans to conduct a series of studies on the influence of temperature on the physical properties of clay, which will be used to prevent the spread of radionuclides from spent nuclear fuel into the environment. The SIIGNASU is planning to study different types of clays, their mixtures with other materials and different thicknesses of layers of clay.

The SIIGNASU has several laboratories for chemical and physical research, equipped with the necessary equipment, devices and tools to perform WP HITEC Subtask 3.1

The temperature of conducting research at 150 °C, the density of materials and their mixtures in the density from 1300 to 1700 kg/m³.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

8/CNRS

Participant	8	Centre Nationale de Recherche Scientifique	CNRS
Description of the legal entity The CNRS (National Centre for Scientific Research) is a government-funded research organization under the administrative authority of French Ministry in charge of research. As the largest fundamental research organization in Europe, CNRS is involved in all fields of knowledge. Interdisciplinary programs and actions offer a gateway into new domains of scientific investigation and enable CNRS to address the needs of society and industry. CNRS is organized in 1053 research units spread throughout France. These units are either intramural or in partnership with universities, other research organizations, or industry. CNRS is involved in research on nuclear waste mainly through four of its ten institutes (IN2P3, INC, INSMI, INSU). Additionally, CNRS has an academic research network SCINEE (Nuclear Science for energy and environment) including French universities and leads a national program on nuclear energy NEEDS (Nuclear Energy Environment Waste Society) with national R&D partners (ANDRA, EDF, ORANO, FRAMATOME, IRSN, BRGM, CEA) including material for nuclear waste and nuclear waste geological disposal. CNRS has specific roles in ACED, DONUT, GAS, HITEC, FUTuRE, CORI, SFC and UMAN. The Hubert Curien Pluridisciplinary Institute (IPHC) is a French Research Institute belonging to both the Nuclear and Particle Physics National Institute (IN2P3) of National Scientific Research Center (CNRS) and the University of Strasbourg. With some 400 employees, IPHC is one of the biggest Institute of Strasbourg University. Founded in 2006, IPHC spans a wide range of scientific disciplines and includes four Departments, namely, the Department of Ecology, Physiology and Ethology, the Department of Subatomic Research, the Department of Analytical Sciences, and the Department of Radiobiology, Hadron Therapy and Molecular Imaging. IPHC is a successful example of an ambitious institute that aims to gather diverse scientific expertise and advanced equipment, and to bring out multidisciplinary research projects contributing at the highest scientific and technological levels to development of basic scientific knowledge and to applications addressing key societal challenges in areas such as energy, health and the environment. CNRS/IN2P3/IPHC has specific roles in FUTuRE. CNRS/IN2P3/Subatech The laboratory SUBATECH is a mixed research unit, operated conjointly by the legal entities CNRS, the IMT-A and the University of Nantes. In EURAD EURAD only personnel of IMT-A (linked third party to CNRS) and of the CNRS contribute. The laboratory is located in Nantes/France on the campus of IMT-A. The laboratory has been ranked “excellent” by the national evaluation commission HCERES. The laboratory produces about 120 papers largely in high impact journals with about 6000 citations per year. About 5 papers per year are on the thematic of EURAD. Principal research orientations are in nuclear physics and in radiochemistry. Nuclear waste management and disposal is a key research subject of this laboratory, supported also by a Chair, financed by industry. The laboratory pilots as well the recent ERASMUS mundus project SARENA, which is the only ERASMUS mundus on nuclear energy in Europe and it offers a strong contribution to teaching in nuclear waste management. CNRS/IN2P3/Subatech has specific roles in ACED, FUTuRE, CORI and UMAN. CNRS/INC/CEMHTI The CEMHTI laboratory (CEMHTI: Conditions extrêmes et Matériaux : Hautes Températures et Irradiations, UPR3079) (Orléans, France) is managed by Catherine Bessada. It has a total of 70 permanent researchers, engineers and technicians. The activities are organized in 4 teams of researches mainly focused on the study of materials and their characterization in extreme conditions of temperature and irradiation. One of these poles called DEFIR (Defects, Impurities Radiotracers: Properties, materials and imaging) is managed by Marie-France Barthe and dedicates its research activities in the field /study of nuclear materials and their behaviour under irradiation. The researchers have good expertise in experimental studies of the irradiation induced damage and the interactions of light elements with defects in different materials (SiC, UO₂, W, Fe based alloys...) by using positron annihilation spectroscopy and ion beam analysis techniques available			



around the different accelerators operated and developed in the “Particle beam Platform” : cyclotron, Pelletron and slow positron beams.

CNRS/INC/CEMHTI has specific roles in SFC.

CNRS/INC/ICSM

The activities of ICSM are mainly devoted to the elaboration and characterization of several kinds of optimized actinide bearing precursors prepared by wet chemistry routes, then to their conversion into the final actinide-based oxides by heating. A particular interest is focused either on the sintering capability of the materials during densification process and also to the evaluation of the chemical durability of the materials when submitted to dissolution/leaching/alteration tests in order to understand their behavior during their reprocessing or in the field of their long-term storage in underground repository site.

In particular, two laboratories have developed new ways of in situ and in operando monitoring of evolving solid/liquid interfaces during dissolution or leaching tests by combining microscopy and spectroscopy based techniques.

CNRS/INC/ICSM has specific roles in SFC.

CNRS/INC/IC2MP

The Institute of Chemistry of Poitiers: Materials and Natural Resources (IC2MP) is a multidisciplinary research institute that specializes in the study of materials, the natural environment, and reactions. The Institute particularly focuses on the synthesis, decontamination and exploitation of natural resources. The Institute is composed of a total of ~250 persons including a staff of 100 researchers (75 faculty members from the University of Poitiers and 25 CNRS), 50 Engineers & Technician staff, ~80 PhD students and ~20 postdoctoral researchers.

CNRS/INC/IC2MP has specific roles in FUTuRE and GAS.

CNRS/INSIS/3SR

Laboratoire 3SR - Sols, Solides, Structures, Risques - conducts cutting edge research in solid mechanics, with application to structural, civil and environmental engineering, as well as energy and health. It is a « Unité Mixte de Recherche » meaning that it is under the administrative and scientific tutelage of three institutions: one national research body CNRS-INSIS, as well as two local universities, l'Université Grenoble Alpes and Grenoble-INP. This research lab is divided into three research teams. The research done in Laboratoire 3SR is in the general field of Solid Mechanics. More specifically, the main domains of the research carried out in Laboratoire 3SR concern:

- Technological and Environmental Risks:
- For surface and sub-surface storage
- For gravity and seismic risk
- For underground collapse (structure-climate interaction)
- Safety of sensitive structures
- The Mechanical Behaviour and Maintenance of:
- Structures and geotechnical engineering works
- Complex materials (granular media, porous media, fibrous and woven materials, reinforced, biological and bio-inspired materials, etc.)

In all these domains are approached by experiments and modelling which are done both at the material scale, as well as at the engineering scale. Experimental work is carried out with the objective of understanding, analysing and informing theoretical and analytical models taking into account physical-mechanical coupling over multiple scales. Laboratoire 3SR has numerous original and relevant experimental installations in the fields of mechanics of materials, geomaterials as well as structures, with some installations being totally unique worldwide.

CNRS/INSIS/3SR has specific roles in HITEC.

CNRS/INSMI/LJAD

The LJAD laboratory is structured around 6 teams: Algebra, Topology and Geometry
Geometry, Analysis and Dynamics, EDP and Numerical Analysis, Numerical Modeling and Fluid Dynamics, Probability and Statistics, Interfaces of Mathematics and Complex Systems. Bringing together 135 researchers and teacher-researchers, 16 administrative staff and research assistance engineers and 74 doctoral and post-doctoral students, the laboratory is also a partner of INRIA, of the CEA (CEA) under the LRC

Fusion of the Doctoral School (EDSFA) and participates in many ANR projects. This project takes place in the LJAD team Partial Differential Equations and Numerical Analysis (around 40 permanent researchers and 20 PhD students) which has developed for a few years a group on geosciences applications including 2 permanent researchers, Konstantin Brenner and Roland Masson, and several doctoral and postdoctoral students.

CNRS/INSMI/LJAD has specific roles in DONUT.

CNRS/INSMI/LMAP

The Porous Media Group of LMAP (University of Pau and Pays de l'Adour (UPPA) & CNRS UMR 5142) is involved in the development and the implementation of advanced mathematical and numerical methods for modeling multi-scales reactive multiphase flow in reservoirs including thermo-hydro-mechanical impacts, pore scale modeling and simulation of complex fluid flows, numerical homogenization. We investigate high-performance parallel processing as a tool to develop a new generation reservoir simulator implemented in the environment of the parallel open-source software DuMuX.

CNRS/INSMI/LMAP has specific roles in DONUT

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

The Hubert Curien Pluridisciplinary Institute (IPHC)

Tasks will be handled by the Radiochemistry IPHC team, which has a long experience in actinide / lanthanide chemistry studies and has developed innovative methodologies to elucidate speciation of actinides and heavy metals at mineral / water interface and effect of organic matter. Main IPHC tasks are as follows. (1) Experimental investigations on surface complexes of uranyl formed at the low concentration level in relevant uranyl-solution-compacted clay systems (COX and Opalinous clay), in presence of phosphate ligands, small organic molecules and competing trace metals (Ni and Fe), by means of ATR-FTIR spectroscopy and complementary techniques (CPM and ESI-MS). (2) ATR-FTIR experiments to investigate sorption reversibility of uranyl sorbed in the uranyl-solution-compacted clay systems (COX and Opalinous clay) and uranyl-solution-hematite systems studied.

These two main tasks match with the subtasks in EURAD proposal entitled “Mobility of Radionuclides in the compacted clay” and “Reversibility of sorption”.

CNRS/IN2P3/Subatech

WP 1 PMO: participation in project coordination, B. Grambow

WP 3 ACED/Task 2.1, 2.2 and 3.1: contribute to the characterization of the interface experiments (glass/steel; steel/clay, cement/steel) using isotopic tracing techniques

WP 4 CORI /task 1.1: coordinator, **1.2** contribution to SOTA, **1.3** preparation of training material, **2.0** study of alpha/ Gamma Radiolytic degradation of Superplasticizers using available irradiation facilities and characterization of degradation products in solution and gas phase and **4.0** characterization of the interactions of organics, radionuclides and cement: The main objective is studying the effect of ISA on the mobility (uptake and transport) of U(VI) in hardened cement pastes: study the diffusion behaviour in HCP samples in presence of ISA for two degradation states, (II and III)

WP 5 FUTURE/Task 2: contribute to the identification / quantification of the uptake processes of elements of interest considering both the “real” (and notably the behaviour of the naturally-occurring elements) and model systems.

WP 6 GAS/Task 2.1: Subatech will perform computational atomistic modelling to investigate the molecular mechanisms of gas sorption in clay-based materials with further extension to a mesoscale and multiscale modelling and will contribute to characterize the nanoporous structure properties and its effect on H₂ sorption (IR/Raman spectroscopy, X-Ray diffraction, QENS, etc.).

WP 9 UMAN/Task 3.1: Subatech is subtask leader to provide a high-level integrated picture of the various types of uncertainties that are potentially relevant for safety.

CNRS-CEMHTI

Several people from CEMHTI will be involved in the present project including researchers, engineers and technicians in the work packages Spent Fuel Characterization and Evolution Until Disposal for the subtasks 1.2, 1.3, and 3.2. Marie-France Barthe will be in charge of the scientific work performed in the project and Pierre Desgardin will be involved for positron annihilation spectroscopy and with Thierry Sauvage for helium implantations and characterization using CEMHTI accelerators. The aim is to provide new insights in the He behaviour in simulated spent fuel.



CNRS-ICSM In particular, two laboratories have developed new ways of in situ and in operando monitoring of evolving solid/liquid interfaces during dissolution or leaching tests by combining microscopy and spectroscopy based techniques.

CNRS-IC2MP The work envisaged in FUTUR WP, devoted to the experimental analysis of water and anion diffusion in partially saturated clay media, perfectly the fit in the scope of the priorities of the research thematic developed and the IC2MP regarding the understanding of reactivity of natural media in relation with the exploitation of natural resources.

The work envisaged in GAS WP is devoted to the experimental study of the micro-structural and mineralogical changes of claystones in relation with self-sealing and gas migration on the one hand, and to the micro-macro upscaling and development and implementation of a numerical HM model accounting for gas migration and self-sealing. It fits in the scope of the priorities of the research thematic developed and the IC2MP regarding the understanding of the microstructure of clays and clayey rocks as well as upscaling of their hydro-mechanical properties.

CNRS-3SR

Laboratoire 3SR has been working for many years on the theme of deep repository of radioactive wastes, both on the characterization of host rocks (several sites in Europe) and on modelling the mechanical behaviour and couplings. Taking into account multiple couplings is one of its research axes. It incorporates imaging skills (X-ray tomography, neutron CT, image correlation DIC) to describe and quantify physical processes. It develops its own modelling tools, notably using multi-scale approaches, to move from behaviour on the scale of the microstructure of the material to behaviour on the macroscopic scale and then that of the engineer, taking into account the phenomena of failure.

CRNS-LMAP

Since several years, our research interests encompass computational models for porous media flow, transport and deformation phenomena, model coupling and decoupling as well as advanced discretization and solution techniques. Moreover, we are involved in several third-party funded research projects. The group has the experience of numerical simulation of gas migration in the framework of nuclear waste disposal. Indeed, the group was a member from 2002 to 2015 of the French research group MoMaS (Mathematical Modeling and Numerical Simulation for Nuclear Waste Management Problems) and is also part of the French research group MaNu (Mathematics for Nuclear energy). Moreover, from 2009 to 2013, we were involved in the FORGE (Fate Of Repository GasEs) European project (<http://www.bgs.ac.uk/forge/home.html>). A homemade C++ upscaling code and a finite-volume method implemented in the DuMu^x framework were coupled to study gas migration through engineered and geological barriers for a deep repository of radioactive waste. Since 2012, we have been interested in the coupling between multiphase flow and geochemistry. In the context of the environment DuMu^x, we have developed and implemented a sequential coupling approach solving firstly a fully implicit two-phase flow problem and then a reactive transport problem. Several strategies including sequential iterative approach (SIA) and direct substitution approach (DSA) have been implemented in a high performance computing framework and tested for the resolution of the reactive transport problem. The accuracy and effectiveness of these approaches have been undertaken through numerical investigation for two and three dimensional spaces tests. However, sequential approaches introduce operator splitting errors and some questions about the coupling between all the physical processes have also to be studied to corroborate if some very coupled phenomena can be solved sequentially or if they need to be treated implicitly.

Consequently, in view of our above-mentioned competencies, we propose to focus on the two following subtasks:

- Development and implementation of a parallel fully-coupled, fully implicit method to solve a non-isothermal reactive multiphase multicomponent flow to achieve improved stability. In comparison with sequential strategies, it will allow the use of larger time steps and secondly, the errors of mass conservation due to the operator splitting will be erased.

Development and implementation of an efficient sequential numerical algorithm for coupling multiphase multicomponent flow and reservoir geomechanics.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.



9/COVRA

Description of the legal entity

COVRA is a national radioactive waste management organisation of the Netherlands. COVRA is a state-owned enterprise of which the stocks are held by the Ministry of Finance. It is the only company in the Netherlands that is qualified to collect, treat and store radioactive waste and prepare and implement the final disposal. Its legal form is a 'Naamloze Vennootschap' (public limited company).

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

- DONUT is WP on the development and improvement of numerical methods and tools for modelling of coupled processes. COVRA has just finished its safety case in 2017, in which the safety assessment uses numerical methods and tools for modelling of coupled processes to describe a disposal facility in Boom Clay. COVRA will prepare benchmarks for the evaluation of the methods and numerical tools described considering their relevance in the scope of multi-physical assessment from the point of view of the implementer. Specifically COVRA plans to develop a benchmark for numerical models with steep chemical gradients across solid interfaces. This contribution can be of help with the evaluation of the efficiency and computational cost of different numerical models/solvers for models with a steep chemical gradient across interfaces between solid materials.
- Assessment of Chemical Evolution of ILW and HLW Disposal Cells (ACED) is the WP to improve methodologies to obtain multi-scale quantitative models for the chemical model at cell disposal scale based on existing and new experimental data and process knowledge and to improve the description of the most relevant processes driving the chemical evolution into robust mathematical frameworks. COVRA is a co-task leader in this WP and made the first assessment of information from existing or currently running experiments from the first questionnaire that was sent around to interested organizations during the pre-project phase and is responsible for the State of the Art regarding relevant processes that influence the long-term chemical evolution in disposal cells for vitrified HLW and for cemented ILW. Both types of processed waste are owned by COVRA which facilitates access to essential details for parameters that can be used for the models. COVRA contributes to relevant sample material, new experimental data to improve the description of relevant processes, writes the conceptual and mathematical models, and executes calculations at waste package scale and disposal cell scale.
- Mechanistic understanding of gas transport in clay materials (GAS) is the WP to improve the mechanistic understanding of gas transport processes in natural and engineered clay materials and to evaluate the gas transport regimes that can be active at the scale of a geological disposal system and their potential impact on barrier integrity and repository performance. COVRA acts as an end-user for this WP and contributes to the conceptualization of gas transport currently treated in COVRA's assessment in natural clay in order to contribute to inform the experimentalists / process-level modellers about the configurations and ranges of conditions that are relevant for disposal systems.
- If only because of the long times scales involves, radioactive waste management involves uncertainty management. Dealing with uncertainties and communicating about them, therefore, forms an integral part of the work COVRA does. The goal of the UMAN work package is to develop a common understanding among the different categories of actors (WMOs, TSOs, REs & Civil Society) on uncertainty management and how it relates to risk & safety. In cases where a common understanding is beyond reach, the objective is to achieve mutual understanding on why views on uncertainties and their management are different for different actors. COVRA will look at the methodological approaches to uncertainty and sensitivity analysis. It will participate in technical meetings, share its experience with uncertainty and sensitivity analysis methods and review the deliverable on this topic .
- The WP WM routes in Europe will describe and compare the different approaches to characterization, treatment and conditioning and to long-term waste management routes, and identify

opportunities for collaboration between MS (member states). It will identify safety-relevant issues and their R&D needs associated with the waste management routes (cradle to grave), including the management routes of legacy and historical waste, taking into account that programmes are at different stages of development, have with different amounts and types of radioactive waste to manage and considering interdependencies between the routes. COVRA will coordinate the task to evaluate the potential for developing and using shared technologies and facilities. COVRA was involved EC project SAPIERR and has coordinated SAPIERR II, both projects concerning sharing facilities. COVRA chairs the ERDO working group that investigates and promotes sharing R&D, technology and facilities.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

10/FTMC

Participant	10	Centre for Physical Sciences and Technology	FTMC
Description of the legal entity			
State research institute acting as TSO in EURAD			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal			
Department of Nuclear Research of FTMC (Engl. CPST) implements the technological possibilities important for public and NPP needs, performs training and expertise in the fields of nuclear physics, nuclear and mass spectroscopy. The activities are mostly concentrated on numerical analysis (MCNP6, MCNPX, SCALE 6.2, GEANT4, OSCAR LIETDOS, THYROID), criticality, radiation shielding safety, nuclide composition analysis of spent nuclear fuel and radioactive waste and experimental measurements of generation of radionuclides (AMS, IRMS, ICP-MS, nuclear spectrometry equipment: HPGe Detectors, Alpha Particle Spectrometer, X-ray spectrometer, FHT 770 T 6 α, β counter, LSC). Further the mechanism of radionuclide transportation through engineering barriers for the surface repository or geological disposal case, evaluation of safety and reliability of radioactive waste management technology is performed in the department. One of the aims - optimization of nuclear facility radioactive waste RW management based on scientifically approved and environmentally – friendly technology, applying grouping and separation of RW by using modeling and experimental research of nuclide content of radioactive waste from NPPs as well as improvement and application of scaling factor (nuclide vector) methods. In this proposal FTMC (Engl. CPST) will contribute to: 1. Spent Fuel properties Characterization until disposal (SFC): FTMC will define and verify procedures to determine the source terms of SNF assemblies with realistic confidence limits and will work on comparing the performance of “sophisticated” and “best-practice industry” codes (SCALE6.2 and MCNP6) based on SKB-50 data. The aim of the task to define, verify and recommend state-of-the-art procedures to determine the source terms of SNF assemblies with realistic uncertainties, further (in the second wave of EURAD) the procedures will be applied for other type reactors (RBMK and VVER) to calculate source terms. 2. Cement-Organics-Radionuclides-Interactions (CORI) work package: will perform overview about the organics degradation and release of soluble organic species (PVC and Cellulose), will perform hydrolytic degradation of PVC/Cellulose and identification of degradation products, will study the competitive effect of Fe(II)/Fe(III) onto radionuclides (Am-243 and Pu-242) sorption in the presence of organics (low molecular weight organic acids / phthalate / adipate) in contact with CEM I/ CEM V cement-based materials (pH 12.5); 3. UMAN - EU cooperation activities explaining the uncertainty, risk and safety of different factors. Work will include assessment of uncertainties related to radiological characterisation of radioactive waste generated during NPP operation and decommissioning activities at the different stages of management programme (impact of predisposal steps). Different reactor waste inventory			

case is specific because of different experience of decommissioning – such analysis of uncertainties relevant to the safety analysis and the safety case will be performed for the first time. The processes cannot be modelled with sufficient precision, or their partial input to the final waste activity cannot be known with adequate accuracy. Therefore general approach is to use the modelling and measurement techniques, complementing each other and therefore reducing the uncertainty and increasing the confidence of activity determination.

4. ROUTES – FTMC will be engage in an activity involving a waste management network in Europe from cradle to grave by touching historical / non-documented waste. FTMC will provide input of Lithuanian situation identify challenging waste streams; describing/comparing waste characterisation approaches; identify WAC's used; disseminating technological waste management solutions for other member states.
5. FTMC will participate in KNOWLEDGE MANAGEMENT activities ensuring access to existing Knowledge (State-of-Knowledge), guiding the development of capability in line with core competencies (Guidance and Training), and improving access to quality tools, resources and communities of practice to share and learn from each other (Dissemination).

This project is in compliance with the EU Council Directive 2011/70 on the safe management of all radioactive waste and spent fuel. In 2015 the Government of the Republic of Lithuania has prepared a National Program for the Development of Radioactive Waste Management. EURAD will help to implement strategic goals of the program.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

11/CV REZ

Participant	11	Centrum vyzkumu Rez	CV REZ
Description of the legal entity			
The research organisation Centrum vyzkumu Rez (CV REZ) was founded on 9th October 2002 as 100% subsidiary company of UJV Rez, a.s. (NRI – <i>Nuclear Research Institute</i>). The main aim of the research organisation is research, development and innovations in the field of power generation (especially nuclear). CV REZ owns unique research infrastructure such as experimental research reactors LVR-15 and LR-0 and technological experimental circuits. Significant modernization of the infrastructure is being realized within years 2012-2017 due to realization of the SUSEN project (realized in the framework of the Operational Programme Research and Development for Innovations of the European Regional Development Fund). As of January 1st, 2016 the company CV REZ had a total of 330 employees. The core activities of CV REZ involve fundamental and applied research on experimental research reactors LVR-15 and LR-0. Another activities are arising from the participation of CV REZ in the international Jules Horowitz Reactor project. No less important are national and international projects (especially H2020 projects). CV REZ is a member of the European Energy Research Alliance (EERA) and since 2010 represents the Czech Republic in the EERA managing body – Executive Committee, thereby participating in the realization of the Strategic Energy Technology Plan (SET-Plan). CV REZ is also a member (and co-founder) of the Technology Platform ‘Sustainable Energy CR’.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal			
Research Centre Rez (CV REZ) will be providing the gamma irradiator Little Cobalt where the superplasticizers or cement paste samples will be irradiated. Moreover the temperature and the emission of the released gasses will be monitored and regularly analysed. Cement pastes will be tested non-destructively before and after the irradiation. Brushed and/or polished fragments of tested samples will be analysed by SEM, LOM or XRD microscopic analyses.			

All measured data and work proceeding will be discussed with the other partners in the work team, e.g. with UJV, CTU or SURAO.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

12/Dekom

Participant	12	Danish Decommissioning	Dekom
Description of the legal entity Danish Decommissioning (DD) is a state-owned company under the Ministry of Higher Education and Science. DD was established in 2003 and has the responsibility of decommissioning the Danish nuclear research facilities, managing waste from other Danish users of radioactive materials, and participating in the process leading to a longterm solution for the Danish RW. DD has the responsibility for safe handling and storage of all Danish RW, except from NORM. Since 2003 it has been part of the official Danish policy to investigate the possibility to find an international solution for 233 kg of spent research fuel; this has been mentioned again in a recent Parliamentary resolution on long term waste management (B 90, May 2018.) B 90 also stresses the importance of DD participating in international research and development projects on RW management (storage and repository). DD has for several years been a member of the ERDO-WG, focusing on both shared predisposal and disposal solutions. See more information on www.dekom.dk			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal Participant in Waste Management Routes Task 6. Since 2003 it has been part of the official Danish policy to investigate the possibility to find an international solution for 233 kg of spent research fuel; this has been mentioned again in a recent Parliamentary resolution on long term waste management (B 90, May 2018.) B 90 also stresses the importance of DD participating in international research and development projects on RW management (storage and repository). DD has for several years been a member of the ERDO-WG, focusing on both shared predisposal and disposal solutions. See more information on www.dekom.dk			

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

13/EEAE

Participant	13	GREEK ATOMIC ENERGY COMMISSION	EEAE
Description of the legal entity Greek Atomic Energy Commission (EEAE) is the competent regulatory authority for the control, regulation and supervision in the fields of nuclear energy, nuclear technology, radiological and nuclear safety and radiation protection. EEAE is operating as a public entity and enjoying full administrative and financial independence in relation to its duties. It operates under and is supervised by the Minister of Education, Research and Religious Affairs. EEAE was initially established by an Act in 1954. The organization has been re-established with a different scheme in 1987. In 2014, with the Law 4310 (Government Gazette Folio No. 258/A/08.12.2014), a separate chapter, chapter E, titled “Nuclear Energy, Technology and Radiation Protection - Greek Atomic Energy Commission” is included. The obsolete framework is replaced by a new operation framework of EEAE. The new framework brings important improvements, regarding, inter alia, EEAE independence, enforcement means, inspectors role and inspection procedures, licensing authority and transparency enhancement.			

The new EEAE operation regime is in line with the international and European requirements for radiation protection and nuclear safety regulatory authorities, enhances the independent and effective regulation of this field and addresses some of the IRRS mission findings.

EEAE organizational structure was published in the form of a Presidential Decree in 1993. At present, a new Presidential Decree on the internal organization of EEAE has been approved by the government and is in the final stage of issuance. Following IAEA IRRS, in 2012, mission findings, the new internal organization of EEAE provides for the operational separation between its regulatory functions and scientific and technical services. EEAE is governed by a seven-member Board.

EEAE employs a sufficient number of about 75 qualified and competent staff to carry out its tasks. Most of EEAE personnel holds a degree of high level education and dispose specialized scientific expertise (M.Sc. and/or Ph.D.). Their continuous training, the participation in EEAE E&T activities and the participation in scientific networks and international fora and activities is encouraged in order to gain the knowledge and experience required for the fulfillment of their tasks.

EEAE financial resources come from the public budget and from licensing fees and radiation protection services. The accounts and fiscal reports of the EEAE are subject to the control of the Audit Council. These data and fiscal reports are published on the EEAE website and submitted to the President of the Hellenic Parliament and the relevant Minister alongside the yearly report and the budget for the coming year.

EEAE implements an integrated management system; in 2013 it was certified in accordance with the requirements of ISO 9001:2008 standard, which incorporates all functions and accreditations of EEAE. In December 2016, the IMS was updated, fulfilling the requirements of the revised ISO 9001:2015. Specific aspects were further identified to be embedded in the integrated management system to respond to the IRRS findings, in line with IAEA safety requirements. An IAEA IRRS mission was conducted in 2012 and follow-up mission in November 2017, where the majority of the recommendations and suggestions identified in 2012 were successfully considered and implemented by EEAE.

EEAE succeeded in participating actively in EC-funded research projects, mainly through FP6 and FP7 (CONRAD, ORAMED, COCAE)

Regarding radioactive waste (RW) management EEAE

- is responsible for the enforcement and implementation of the "national framework" and recommends actions on improvement.
- participates in the formulation and establishment of the "national policy" and ensures compliance and implementation
- implements and maintains the system of authorization, inspections and enforcement for the spent fuel (SF) & RW management practices and facilities; it issues the inspection reports and grants the relevant license;
- participates in the National Committee on Radioactive Waste Management (EEDRA)
- cooperates with EEDRA for the review and updating of the "national program"; it has prepared the 1st "national program"; ensures its proper implementation of the national program.
- maintains the National database for SF & RW, radioactive sources, radioactive materials or nuclear fuels and conducts annually the national inventory of SF & RW management and assess those that may occur in the future.
- approves proposed SF & RW management streams and technical solutions and SF & RW management practices.
- provides education and training in radiation protection to staff involved in the management of SF & RW.
- prepares and submit to the EC the national reports for SF & RW management

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

Task 2: EEAE's main interest on task 2 is to be informed about the best practices in Europe for waste characterization/classification. EEAE has already a limited experience on the subject due to its participation in the characterization of wastes produced by NORM industries during their operation phase, and during their decommissioning. It is also participate to the radiological characterization of wastes produced at a scrap metal recycling industry after the accidental melting of a radioactive source. EEAE also performs the determination of the specific clearance levels to assist these activities.

Task 3: EEAE's main interest on task 3 is to be informed about the best available radio-analytical techniques used for waste characterization and to contribute with its experience on these technique.

Task 5: EEAE will contribute to the analysis of national programmes of other countries with small inventories, in order to identify common aspects and points of interest of the existing and potential disposal options and RW streams. EEAE will contribute to the organization and participation to workshops.

Task 6: Following task 5, EEAE will contribute to the investigation on the common needs, views and attitudes of the EU countries regarding shared solutions of RW management. EEAE will contribute to the organization and participation to workshops.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

14/ENRESA

Participant	14	Empresa Nacional de Residuos Radiactivos S.A., S.M.E., M.P.	ENRESA
Description of the legal entity			
ENRESA is the Spanish radioactive waste management agency, with considerable experience in research and technological activities related to radioactive waste disposal and management of large industrial facilities and research programmes. ENRESA is a public company founded in 1985 by the Spanish Government for the management of radioactive wastes, including: • Design, construction and operation of facilities for the disposal of low-level waste (LLW), interim storage and final disposal of spent fuel, vitrified high-level waste and intermediate-level waste (SF/HLW/ILW). • Decommissioning of nuclear facilities, including nuclear power plants (NPP). • Drafting the R&D plans to cover the needs of the concepts and technical solutions for managing the radioactive wastes and SF in Spain. • Managing the Fund to cover the previous activities.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal			
WP DONUT: ENRESA, together with others WMO and one TSO, will prepare benchmarks from the point of view of the implementers and evaluators (task 5). These organisations and their partners participate in most of other work-packages, and the work will be carried out in close cooperation with the linked WPs and the RE involved in this task. The prepared benchmarks will help to quantify how numerical methods developed in DONUT are relevant regarding current used methods, and to compare tools in which these methods are implemented. In order to make the benchmarks relevant for a large community they will address coupled processes representative in different kind host rocks (e.g. clay, crystalline rocks, salt).			
WP Spent Fuel Evolution: ENRESA will participate in the definition and verification of procedures to determine the source terms of SNF assemblies with realistic confident limits (task 2.4) and in particular in subtask 2.4.2. that considers the use of "state-of-the-art" codes. ENRESA, through subcontractor ENUSA as linked third party will also participate in subtask 2.2.2 "Nuclide inventory by radiochemical analysis of a set of BWR SNF samples".			
WP HITEC. ENRESA will participate in Tasks 1 (subtask 1.2. State-of-the-art) and 4 (Subtask 4.1 – Guidance for safety case development and repository optimization) of this WP.			

WP UMAN: ENRESA will participate in Subtask 3.2 “Uncertainties on waste inventory and on the impact of predisposal steps”, Subtask 4.3. “Preferences of the different actors on uncertainty management options”. Experience in developing design and performing safety assessment to obtain site, construction and operation licenses of near surface disposal facility currently in operation in Spain that include uncertainty management will contribute to the WP.

KM WPs. ENRESA is not directly involved in these WPs, nevertheless ENRESA may contribute to their development.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

15/FZJ

Participant	15	Forschungszentrum Jülich	JUELICH
Description of the legal entity			
Forschungszentrum Jülich (JUELICH) makes a vital contribution to solving major challenges facing society in the fields of information, energy, and bioeconomy. It focuses on the future of information technologies and information processing, complex processes in the human brain, the transformation of the energy system, and a sustainable bioeconomy. Forschungszentrum Jülich develops simulation and data sciences as a key research method and makes use of large, often unique, scientific infrastructures. Its work spans a range of topics and disciplines and it exploits synergies between the research areas. With some 5,600 employees, Jülich – a member of the Helmholtz Association – is one of Europe's large research centres. The work program within EURAD will be performed in the Institute for Energy and Climate Research – Nuclear Waste Management and Reactor Safety (IEK-6), making use of the knowledge acquired during the last 50 years on safety issues regarding nuclear waste management and reactor safety. Institute for Energy and Climate Research – Nuclear Waste Management (IEK-6) contributes to the Helmholtz program NUSAFE and focuses on topics related to the safe management of nuclear waste and international safeguards as well as reactor safety. The safe management of radioactive waste and its final disposal in a deep geological repository is one of the grand challenges of our times and an integral part of the German “Energiewende”. The related research is multidisciplinary – while IEK-6 research mainly considers nuclear aspects, it addresses the behavior of radionuclides and the relevant waste form materials by combining radio-, geo- and materials chemistry aspects and by integrating experiment and simulation. Research covers the complete chain from waste generation to waste disposal including in particular: (1) Research in support of the long-term safety for deep geological disposal with a focus on repository near-field incl. waste forms, barrier materials and in particular secondary alteration phases (source term), (2) Research on unresolved issues prior to waste disposal e.g. pre-disposal: waste treatment, conditioning, decontamination/hydrometallurgical separation chemistry, with a strong emphasis on special radioactive wastes for which up to now no management solutions have been developed and (3) Research on international safeguards, incl. scientific coordination of the German IAEA Safeguards Support Program and qualification for IAEA Network of Analytical Laboratories. IEK-6 operates radiochemistry laboratories and is strongly linked to the Ernst Ruska-Centre, ER-C, to the Helmholtz Nanofacility with atom probe tomography, to the Jülich Supercomputer Centre, JSC, and the Central Institute for Engineering, Electronics and Analytics, ZEA. Future research will focus on reactive mass transport phenomena at chemically perturbed interfaces within a repository, the further development of solutions for radioactive special wastes and of analytical methods for nuclear safeguards and security applications.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal			
JUELICH (IEK-6) will contribute to EURAD on several levels. Within WP FUTURE, JUELICH-IEK-6 will serve as the WP Coordinator and also contribute to the technical RD&D. In WP ACED, JUELICH-IEK-6 will			

serve as co-task leader and perform RD&D. In WPs CORI and DONUT, JUELICH-IEK-6 will contribute to the RD&D program.

Additional activities are related to the Strategic Study ROUTES. Given the high level of technical expertise at JUELICH-IEK-6 in all the fields relevant for the proposed work in EURAD, and the broad experience in coordinating national and international RD&D, JUELICH-IEK-6 is fully able to carry out the work proposed within EURAD.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

16/GRS

Participant	16	Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH	GRS
Description of the legal entity			
The Gesellschaft für Anlagen- und Reaktorsicherheit (GRS gGmbH) is a non-profit organization which deals with technical-scientific research and provides expertise. The company administers interdisciplinary knowledge, progressive methods and qualified data.			
GRS was established as a business in January 1977. The headquarters are in Cologne, other locations include: Berlin, Braunschweig and Garching nearby Munich. Currently, there are approximately 450 employees at GRS, 350 of whom work in the technical-scientific sector. GRS is financed by contracts and the present annual volume of contracts is worth 53 million €.			
In the working field “Waste Management”, GRS is the only institution in Germany with comprehensive interdisciplinary expertise in this wide range of tasks. GRS has the relevant knowledge and experience in the field of disposal of radioactive and chemotoxic waste as well as in the assessment of safety-related questions. The instruments and methods necessary for a safety-analytical assessment have been developed and qualified within the framework of research activities over many years. The participation in committees and co-operation activities, as well as the presentation of the work in international scientific forums ensures the required state of the art in science and technology about expertise and development of procedures.			
In the Cologne division of GRS, the department of Waste Management Safety supports the authorities and ministry with expertise as Technical Support Organization (TSO).			
In the Braunschweig division of GRS, the Repository Safety Research department carries out research and develops methods that are essential to the verification of the long-term safety disposal of radioactive and toxic chemical wastes in geological formations. The division is divided into two departments: the Long-Term Safety Analysis department and the Process Analysis department, working in conjunction with an on premises geo-scientific lab. The competence fields “Waste Disposal”, “Assessment of Long-term Safety”, “Geochemical Research”, “Research in Underground Laboratories” and “Geochemical and Geotechnical Laboratory” are mainly oriented towards safety analyses and geosciences as a Research Entity (RE). Priority is given to the development of methods and instruments for the performance of safety analyses and experimental research on the examination of waste disposal concepts and the provision of data and models that are relevant regarding safety in the long term.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal			
GRS is participating in the work packages DONUT and ROUTES as TSO. GRS is also participating in the work packages DONUT, FUTURE, GAS and UMAN as RE. The general competencies of GRS are given in the description of the organisation.			

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

17/IAE

Participant	17	Ignalinos Atomine Elektrine	IAE
Description of the legal entity			
The state enterprise Ignalina Nuclear Power Plant - <i>Ignalinos Atomine Elektrine</i> (IAE) is carrying out the decommissioning of NPP, construction and operation of storage facilities and repositories for VLLW, LILW, SF (including DGR construction). It includes the operation of key systems that ensure nuclear, radiation and fire protection, as well as physical safety at the INPP, the unloading of spent nuclear fuel from power units and its transportation to the Interim Spent Fuel Storage Facility, equipment and building decontamination and dismantling, and radioactive waste treatment and storage. The INPP decommissioning is set to be completed by 2038.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal			
IAE is mainly involved in WP10-ROUTES and more specifically Task 2.1 and Task 4.1.			

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

18/INCT

Participant	18	Instytut Chemii i Techniki Jadrowej	INCT (ICHTJ)
Description of the legal entity			
The Institute of Nuclear Chemistry and Technology is the most recognised institution in Poland in the fields of nuclear chemistry, radiochemistry, radiation chemistry, nuclear chemical engineering and technology. The other fields of the INCT's expertise include application of nuclear methods in material engineering and process engineering, radioanalytical techniques, design and production of measurement instruments based on nuclear techniques, environmental research, radiobiology and radioprotection. The results of research performed at the INCT have already been implemented in various branches of the national economy, particularly in industry, medicine, environmental protection and agriculture. With nine electron accelerators in operation and with a staff experienced in the field of electron beam application, the INCT is one of the most advanced centres of science and technology in this domain. The Institute has four pilot plants equipped with six electron accelerators: for radiation sterilization of medical devices and tissue grafts; for radiation modification of polymers; for removal of SO₂ and NO_x from flue gases and for food hygienisation. The Institute trains international atomic energy agency's fellows and plays a leading role in agency regional projects. Because of its achievements, the INCT has been nominated "the IAEA's collaborating centre in radiation technology and industrial dosimetry". Its expertise and infrastructure was the basis for participation in several EURATOM, FP7 and Horizon2020 grants. The organization is preparing to play a role of TSO in the Polish nuclear energy programme, offering the expertise in: – Radioprotection and biological dosimetry; – Radioactive waste treatment and disposal; – Coolant and fuel chemistry; – Novel nuclear fuel cycles (including GENIV reactors) – front and back end; – Materials for present and novel reactor systems; – Environmental monitoring of nuclear facilities; – Measurement and control devices for NPPs and nuclear laboratories; – Education and training of the staff; – Public information;			

- Collaborative projects with stakeholders offering interaction between “the technical and the social” approaches.

The INCT works in a consortium of Polish institutions developing the project of the selection of a site for a new near-surface repository for low and intermediate radioactive waste and on the scenario of closing up present repository in Rozan.

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

As an organization with the mandate of the Ministry of Energy, the Institute of Nuclear Chemistry and Technology represents the Ministry and Polish stakeholders in the tasks of this proposal. The INCT will mainly work in Strategic Study WP “Waste management routes in Europe from cradle to grave (ROUTES)” providing all necessary information in the national context of radioactive waste management. The INCT will contribute to elaboration of this strategy collecting the existing state-of-the arts methods for characterization, treatment and disposal, especially for problematic waste and identifying future requirements of implemented technologies.

As a mandated actor the INCT will disseminate the project results among stakeholders in Poland; evaluate the possibilities of implementation of the studied methods in the program of development of new RW repositories in Poland.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

19/IRSN

Participant	19	Institut de Radioprotection et de Sûreté Nucléaire	IRSN
Description of the legal entity			
The IRSN is a French public establishment of an industrial and commercial nature placed under the joint authority of the Ministries of the Environment, Health, Industry, Research and Defence. The IRSN’s field of expertise covers all of the risks related to ionising rays used within industry or medicine, or even natural radiation rays. More precisely, the IRSN carries out missions relating to analysis and research in the following fields: the safety of nuclear installations, including those relating to defence; the safety of the transport of radioactive and fissile materials; the protection of man and the environment against ionising rays; the protection and control of nuclear materials and products likely to be used in the manufacture of weapons and the protection of installations and transport against acts of malevolence (theft or misappropriation of nuclear materials, or even sabotage). The research activities, most often carried out within the framework of international programmes, allows IRSN to maintain and develop its expertise. IRSN was involved in or coordinated several EC FP projects on waste safety (EVEREST, SPA, NFPRO, BENIPA, PAMINA, MICADO, FORGE, SITEX, JOPRAD).			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal			
• ACED WP: IRSN will participate (as task leader) in the task 2. The objective of the task 2 is to provide geochemical and coupled reactive transport models for assessing chemical evolution at steel/clay material and steel/cement material interfaces in terms of corrosion rates, geochemical alterations and physical alterations. These models will provide the bases of the up-scaling to waste package (Task 3) and near-field (Task 4) modelling. IRSN will work on a new in situ collaborative experiment (BACUCE) in the URL of Tournemire to study the interface between ambient temperature and 80°C between grout cement/CEM I and carbon steel cylinder until three years of interaction (with Mines Paris Tech, SUBATECH and ZAG). One of the focus points is on the influence of an imperfect contact.			

The BACUCE experiment started in 2017 to study the steel corrosion in contact with a cementitious environment (CEM I and grout cement) in a temperature range between 14°C and 80°C under the influence or no of bacterial activity and the influence of the interface quality. The first experiments were started in laboratory. New experiments will be start in in situ conditions in October 2018 at ambient temperature and 2019 at 80°C.

The objectives of IRSN in ACED WP are: i/ to identify the corrosion speed of C-steel in alkaline and low alkaline environment and the influence of heterogeneities; ii/ to provide robust data for chemical model of the type of corrosion products and mineralogical evolution of cement materials with respect to temperature and spatial heterogeneity; iii/ to calibrate and refine the corrosion rates of steel under slightly alkaline conditions with respect to temperature and heterogeneities.

- GAS WP: IRSN will participate in the work towards main objectives of this WP:

- ✓ *To improve the mechanistic understanding of gas transport processes in natural and engineered clay materials, their couplings with the mechanical behaviour and their impact on the properties of these materials;*

IRSN will use its Lattice Boltzmann Model to study pore scale diffusion close to saturation with/without sorption to complete experimental results and deliver an interpretation basis with a strong link to the microstructure of materials. This work will also benefit from the previous work on development of 3D automatic segmentation mineral phases and pores in imaging data.

The IRSN's Smoothed Particle Hydrodynamics code takes advantage of 3D images of material microstructure and is able to treat the mechanical deformation of the solid phase interacting with a two phase flow. It will serve to simulate small scale experiments conducted to better understand the relation between the microstructure and creation of dilatant pathways of gas in water saturated argillite.

New gas injection in existing mock-up experiments will be performed on bentonite mixtures presenting an initial heterogeneous structural distribution, induced by the installation process, in order to investigate the effect of structural heterogeneities on gas transport processes. The samples will be subjected to hydraulic and gas loadings, both asymmetric to mimic real saturation scenario of shaft sealing systems: rapid increase of water pressure on top and independent control of lateral hydraulic boundary conditions and bottom gas pressure increase. In parallel a complementary cell in PMMA will be used to perform a microstructural analysis of the mixture at initial state and during gas /water injections by X-ray micro-tomography.

- ✓ *To evaluate the gas transport regimes that can be active at the scale of a geological disposal system and their potential impact on barrier integrity and repository performance.*

Based on previous experience in development of codes and simulations of gas migration within repository (participation in numerical benchmark in EC project FORGE), IRSN will construct, implement and use an extended 2-phase flow model for simulation of scenarios to be proposed within this project with the aim of increasing the predictively of numerical simulations and reducing the gap between experimental data and ad-hoc parameters fits.

- DONUT WP: IRSN will participate in the task 2.

The goal of this task is to design and implement efficient numerical algorithms taking advantage of the latest research achievements for solving complex coupled problems. IRSN will participate to this task in developing numerical model aiming at improving physical representations of gas migration in porous media. This work will be focused on processes usually neglected in these models, such as hysteresis on relative permeability and retention curve, gas entry pressure in 2-phase-flow formula, hydro-mechanical behavior of interfaces at seals. The relevant processes among these will be implemented in THGas representations at large scales.

- UMAN WP: In the Task 2 related to Strategies, approaches and tools, IRSN will by notably share their experience with uncertainty and sensitivity analysis methods (subtask 2.3).

In the Task 3 of Characterization and significance of uncertainties for different categories of actors, IRSN will collect and synthesize relevant information on uncertainties associated with the site and geosphere. IRSN will notably have the ground to share the French experience related to the siting phase for geological and near-surface disposal projects (subtask 3.3).

For the Task 5 on Interactions between all categories of actors, in the subtask 5.1 of Preparation, support and reporting of pluralistic analyses, IRSN will be leader of Topic 2 related to Pluralistic analysis of uncertainty pictures. Thanks to the two hats profiles -both researcher and expert in safety assessments- of the IRSN participants as well as their experience in terms of dialog with Civil Society (through the French disposal project of Cigéo and through the SITEX European projects), IRSN will coordinate the development of materials to be discussed in two seminars and will lead the development of deliverable 5.2. IRSN will also take part to Topic 4 related to the Methods for a pluralistic assessment of uncertainties, contributing to the development of proposals of methods for a pluralistic assessment of uncertainties and to the development of deliverable 5.4.

- ROUTES WP:

IRSN will lead and coordinate the WP and will participate to the tasks 1, 2, 3, 4 and 6.

In this WP, IRSN will exchange on views, practices and radioactive waste management options available or not and bring the French experience. IRSN will share its feedback of safety relevant issues on waste management not only for disposal but also for pre-disposal including characterisation, treatment, conditioning and storage. Moreover, IRSN is involved in the assessment of the retrieval and conditioning processes for legacy waste which are of interest for a lot of countries involved in ROUTES WP.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

20/IST-LPSR

Participant	20	Instituto Superior Técnico – Laboratório de Proteção e Segurança Radiológica	IST-LPSR
Description of the legal entity Instituto Superior Técnico (IST) is the School of Engineering of the University of Lisboa and aims to contribute to the development of society, promoting and sharing excellence in higher education in the fields of Architecture, Engineering, Science and Technology. Técnico offers Bachelor, Master and PhD programmes, lifelong training and develops Research, Development and Innovation (RD&I) activities, which are essential to provide an education based on the top international standards. Until 2012, the former Instituto Tecnológico e Nuclear (ITN) was a State laboratory that operated the Portuguese Research Reactor, the RW storage facility, the Radiation Protection and Safety Laboratory and provided support to the Government in the fields of Radiation Protection including RW Management. In 2012, ITN was extinguished by Decree-Law n. 29/2012, of February 9 th and incorporated into IST. IST assumed all the responsibilities in the field of Radiation Protection and Nuclear Safety once attributed to ITN, including all human resources and infrastructures. As such, IST operates at its <i>Campus Tecnológico e Nuclear</i> the Portuguese Research Reactor, the Radiation Protection and Safety Laboratory, and the only RW Management facility in Portugal, a surface type facility for storage of very low, low and intermediate level wastes (Decree-Law n. 156/2013, of November 5 th). In summary, IST acts as WMO and TSO and RE, respectively, waste management organization, technical support organization and research entity. Moreover, the Radiation Protection and Safety Laboratory of IST (IST-LPSR) performs all the activities related to radiation protection and safety, namely, national metrology of ionizing radiation, individual monitoring, environmental monitoring including radioanalytical techniques for the measurement of natural and artificial radionuclides in environmental samples, foodstuff, feedstuff, construction materials, water for human consumption radon in water and in dwellings, safety assessment of radiological facilities, transport of radioactive material, RW management and storage facility, as well as providing education and training and emergency preparedness and response in the field.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal Portugal is a western European nation with 10.6 M inhabitants (approx.) facing the Atlantic Ocean with terrestrial borders with Spain only. Uranium ore extraction ceased in 2000 and all former U exploration sites have been or are presently being remediated, as there are no further plans to resume this activity. There are no			



nuclear power plants in the country although there is a 1 MW pool-type research reactor operated by IST, in transition to decommissioning since September 2017. In 2006 the research reactor was converted from high-enriched Uranium (HEU) to low-enriched Uranium (LEU) to improve proliferation resistance, in the framework of an agreement with the United States of America (USA) and the International Atomic Energy Agency (IAEA). All HEU was returned to the USA and at present there is no spent fuel (SF) at the reactor facility or anywhere else in the country. As a consequence, the radioactive waste (RW) generated in Portugal consists mainly of materials from past U and Ra mining and milling activities, spent and/or disused sealed sources, smoke detectors, lightning rods, contaminated scrap metal, depleted U from aircraft counterweights, materials contaminated with unsealed sources produced from the applications of ionizing radiation in the fields of Medicine, Industry and Research. The RW is of the very low, low and intermediate level waste types (VLLW, LLW and ILW) and is stored in a surface facility operated since the 1960s at IST's *Campus Tecnológico e Nuclear*.

The first report of Portugal on the implementation of the Joint Convention of the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management was presented at the International Atomic Energy Agency (IAEA) in May 2012 and periodically updated since.

Following the publication of Decree-Law n. 156/2013, of November 5th, that transposes Council Directive 2011/70/EURATOM into national law, IST prepares an inventory of the RW stored at its facility on an annual basis. RW records registered after the year 2000 are reliable but there is a strong uncertainty relative to the waste collected before, considered as legacy waste that requires characterization and classification.

Prior to the publication of the Ministerial Ordinance 44/2015, of February 20th, adopting clearance and exclusion levels, all radioactive material with no further use, including materials that activated the radiation detection portals at the entrance of scrap metal yards, steel and iron melting facilities, landfills for dangerous materials, etc, were collected and brought to the RW storage facility at IST.

Very recently, the first National Programme for the Management of Spent Fuel and Radioactive Waste (2015-2019) was approved by the Government and published in the official journal on the 7th of September of 2017, following the strategic environmental assessment and public consultation.

The first National Program specifically considers the following activities (among other): the characterization and identification of legacy waste, eventual preparation of exclusion processes for waste that no longer require storage at such a facility, restoration of enough room for waste of concern, and the improvement of the overall inventory of radioactive waste.

Task n°2 - Identify challenging wastes to be collaboratively tackled within the Joint Programme - Mapping and shared understanding at EU level of practical issues on waste management routes

IST-LPSR will provide data on RW stored at the storage facility at IST, its classification, and on the identification of routes for disposal RW. Portugal is a country with a first programme on the Safe Management of RW (2015-2019) will benefit from the outcomes of the project.

Task n°3 - Description and comparison of radioactive waste characterisation approaches

IST-LPSR would like to benefit from the experience and knowledge on characterization of legacy RW with the aim to identify key radionuclides of concern and improve the inventory of its historic RW.

Task n°4 – Identification of WAC used in EU Member States for different disposal alternatives in order to inform development of WAC in countries without WAC/facilities

In Portugal there are no established WAC for the treatment and disposal of RW. IST-LPSR expects to improve its knowledge on this matter by sharing its limited experience on RW management balanced with the experience and the know-how from other advanced European member states.

Task n°5 - RWM solutions for small amounts of wastes

The RW generated in Portugal consists mainly of materials from produced from the applications of ionizing radiation in the fields of Medicine, Industry and Research, as there are no nuclear power plants in the country. On the other hand, Portugal is a country with its first programme on the Safe Management of RW (2015-2019). IST-LPSR will improve its knowledge on existing and potential disposal options and solutions for small amounts of radioactive waste.

Task n°6 – Shared solutions in European countries

IST-LPSR expects to learn from the possibilities for sharing technology and facilities available to European member states.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

21/IST-ID

Participant	21	Associação do Instituto Superior técnico para a Investigação e Desenvolvimento	IST-ID
Description of the legal entity Associação do Instituto Superior técnico para a Investigação e Desenvolvimento (IST-ID) IST-ID, the Association of Instituto Superior Técnico for R&D (http://www.ist-id.pt) is a private not-for-profit institution for which Instituto Superior Técnico (IST) is one of the founding associates. IST is part of the Universidade de Lisboa, and it is the largest and most reputed school of engineering, Science and Technology (S&T) in Portugal. Its mission is to provide top quality higher education in the areas of Engineering, S&T and Architecture, as well as developing RD&I activities that meet the highest international standards. IST-ID is the host institution of Centro de Ciências e Tecnologias Nucleares (C²TN) where the proposed R&D activity will be carried out. Under agreements between IST and IST-ID, IST makes available the majority of facilities, infrastructures and services, where IST-ID R&D activities are carried out. Researchers from the Radiological Protection and Safety Group (GPSR) of C²TN, mainly, will be involved in the project but collaborations with other C²TN research groups are envisaged. They are members of the EU Research Platforms MELODI, EURADOS, Alliance, NERIS, IGD-TP and EURAMET and are involved in IAEA and NEA within radioactive waste management activities.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal Portugal produces radioactive wastes from UMM, health and industry sectors, research, training and education, and from the operation, since 1961, of the Portuguese 1 MGW swimming pool research reactor (RPI) located at CTN, Campus of Loures of the Instituto Superior Técnico. Main categories of wastes produced are NORM, VLLW, LLW and ILW. Radwaste R&D activities in the Campus, started in the 90's, with: Radium and uranium industry tailings remediation; liquid effluents treatment from the chemical process with traditional and innovative methodologies (ion-exchange, filtration, co-precipitation, membranes and electrochemical processes, production and test of new molecules to encapsulate radwastes for safer disposal, etc.); characterization and evaluation of treatment methodologies for wastes from nuclear medicine and research; and implementation of safes methodologies to handle, dismantling and conditioning of sealed sources for long-term storage and disposal. Also R&D has been implemented to developing a specific Portuguese methodology for suitable places to host a near-surface repository with the identification of specific geomaterials with adequate properties to be used as engineering barriers. IST-ID has also participated in R&D projects focusing models application to waste management, actinide science, and studies contributing to the development, public acceptance and implementation of geological repositories. IST-ID has also been involved in specific E&T projects/activities to ensure knowledge is passed to future generations and a new pool of highly trained researches and technical personnel will be available in the future. All these activities have been carried within the objectives of the EU concerning safe and reliable solutions for radwaste management and the objectives of IGD-TP and the IAEA related to safe and reliable solutions for radioactive waste today and in the future energy market. The work is in tune with the National Framework Programme on Radioactive Waste, Decree-Law n. 156/2013, of November 5th, (Council Directive 2011/70/EURATOM), IAEA Joint Convention Articles and NEA research recommendations. IST-ID is firmly engaged in pursuing the R&D efforts need to fulfil the vision, agenda and objectives of EURAD.			

IST-ID will be actively involved in WP9-ROUTES:

- **Task n°2 - Identify challenging wastes to be collaboratively tackled within the Joint Programme - Mapping and shared understanding at EU level of practical issues on waste management routes** (subtask 2.2)

IST-ID will identify R&D needs in Portugal and will collaborate with other partners needs as well in providing data on RW treatment technologies used, will identify disposal routes and how to achieve them, will contribute to reports content and questionnaires and will present work in the progress meetings, workshops and conferences.

- **Task n°3 - Description and comparison of radioactive waste characterisation approaches**

IST-ID will contribute with information and share experiences and R&D data on collection and treatment of data related to key radionuclides (^3H ; ^{14}C ; $^{99\text{m}}\text{Tc}$, iodine isotopes, etc.); Characterization and segregation of legacy waste from the different radioactive waste streams (from medical, research and industrial facilities as well as NORM. IST-ID will contribute to reports, questionnaires and will present work in progress meetings, workshops and conferences (subtask 3.1 & 3.2).

- **Task n°5 - RWM solutions for small amounts of wastes**

IST-ID will support JSI with conceptual model developed for long-term interim storage for decay at surface in terms of radwaste small inventories, contributing to reports, questionnaires and presenting work in progress meetings, workshops and conferences (subtask 5.1).

- **Task n°6 – Shared solutions in European countries**

IST-ID will contribute to the identification of gaps, needs and opportunities in R&D towards shared radwaste approaches and solutions by contributing to reports, questionnaires and presenting work in progress meetings, workshops and conferences (subtask 6.3).

IST-ID will also contribute to the continuation of:

- E&T of students in radwaste treatment technologies and management strategies through the implementation of the national and international Master's programmes (MPSR/IST and PETRUS/ENEN) and to increase competence maintenance, education and training (CMET)
- Promoting **application of Learning Outcomes (knowledge, skills and competencies) to ensure a future radioactive waste management work force highly knowledgeable and prepared for the new challenges**
- Production of written materials such as books, papers, oral presentations, posters and other divulgation materials for schools, experts and public towards a better comprehension of safe solutions for radwaste such as GD.
- Better interaction with public and other stakeholders, in matters of common European solutions for radwaste management, mainly, GD.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

22/JSI

Participant	22	Jožef Stefan Institute	JSI
Description of the legal entity Jožef Stefan Institute (www.ijs.si) is the leading Slovenian scientific research institute, covering a broad spectrum of basic and applied research. The staff of more than 900 specializes in natural sciences, life sciences, and engineering. The main areas include production and control technologies, information, communication and knowledge technologies, biotechnologies, new materials, environmental technologies, nanotechnologies, and nuclear engineering. JSI accumulates and disseminates knowledge through the pursuit of research, development, and education at the highest international level of excellence. This project will be supported by the Reactor Engineering Division (http://r4.ijs.si), Reactor Physics Division (http://f8.ijs.si) and Department of environmental sciences (www.environment.si).			

JSI also acts as a Technical and scientific support organization (TSO) to the Slovenian nuclear regulatory authority.

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

JSI is involved in 6 work packages of the Joint Programme, with all of the falling into the scope of its regular research and TSO activities.

- ACED: in-situ monitoring of corrosion of steels in the ongoing experiments and potentially in the new experiments proposed by IRSN (NE2-2/1) to assist at the identification of corrosion type, rate and corrosion products. The test fields at three hydroelectric dams on Drava River in order to get reliable samples of concrete in different locations of saturated zone of the dams. Laboratory investigation of samples in terms of microstructure characteristics Support by linked third party ZAG is foreseen.
- CORI: JSI will study degradation products of organic compounds after irradiation in research reactor by gamma radiation for different times and fluxes. In addition, sorption and diffusion of organic compounds in cementitious environment will be studied.
- SFC: Contribute to the theoretical study of SNF source terms and to definition and verification procedures to determine the source terms of SNF assemblies with realistic confidence limits.
- ROUTES: technical data on different radioactive waste types will be provided for Slovenia and all input information of different waste management routes will be collected and analysed. involved in the interaction with civil society is planned. Support by linked third party EIMV is foreseen.
- UMAN: contribution to common understanding among the different categories of actors on uncertainty management for RWM and contribution to analyses and mitigation procedures on activities related to risk & safety. Support by linked third party EIMV is foreseen.
- KM: Contributions to State of knowledge and guidance, with emphasis on early-stage of RWM programmes. Support by linked third party EIMV is foreseen

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

23/JRC

Participant	23	European Commission, DG Joint Research Centre	JRC
Description of the legal entity			
The Directorate General-Joint Research Centre is the European Commission's science and knowledge service. Its mission is to support EU policies with independent evidence throughout the whole policy cycle. Its work has a direct impact on the lives of citizens by contributing with its research outcomes to a healthy and safe environment, secure energy supplies, sustainable mobility and consumer health and safety. The JRC hosts specialist laboratories and unique research facilities and is home to thousands of scientists working to support EU policy. The JRC has ten Directorates and is located across five EU Member States (Belgium, Germany, Italy, the Netherlands and Spain). The Directorate involved in this project is Directorate G – Nuclear Safety and Security within which the JRC's nuclear work programme, funded by the EURATOM Research and Training Programme, is carried out. It contributes to the scientific foundation for the protection of the European citizen against risks associated with the handling and storage of highly radioactive material, and scientific and technical support for the conception, development, implementation and monitoring of community policies related to nuclear energy. Research and policy support activities of Directorate G contribute towards achieving effective safety and safeguards systems for the nuclear fuel cycle, to enhance nuclear security then contributing to achieving the goal of low carbon energy production. The research programmes are carried out at the JRC sites in Germany (Karlsruhe), Belgium (Geel), The Netherlands (Petten) and Italy (Ispra) and consist of research, knowledge management and training activities on nuclear safety and security. They are performed in collaboration and/or in support to the EU Member States and relevant international organizations. Today the Directorate G is one of the leading nuclear research establishments for nuclear science and technology and a unique provider of nuclear data measurements.			

Typical research and policy support activities are experimental and modelling studies covering nuclear reactor and fuel cycle safety, including current and innovative nuclear energy systems. Fundamental properties, irradiation effects and behaviour under normal and accident conditions of nuclear fuels and structural materials are studied. The activities cover also studies of structural integrity and functioning of nuclear components, emergency preparedness and radioactivity environmental monitoring, nuclear waste management and decommissioning, as well as the study of non-energy technological and medical applications of radionuclides. A dedicated functional entity is devoted to the management and dissemination of knowledge and to facilitate open access to JRC nuclear facilities including training and education.

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

The work to be performed by JRC is divided into three parts. The first part deals with the quantification of radionuclide inventory, the second part with spent fuel rod stability under predisposal conditions and the last part with knowledge management.

JRC-Geel will act as the co-ordinator of the task 2: Fuel properties characterisation and related uncertainty analysis. The main contribution is on the development of innovative non-destructive analysis (NDA) methods and the improvement of existing ones to characterise SNF. JRC-Geel, in collaboration with JRC-Ispira, will develop a detection system to determine the neutron output of a SNF pellet; design and construct a system to define the nuclide inventory of a SNF pellet by NDA applying Neutron Resonance Transmission Analysis (NRTA) and investigate the potential of new radiation resistant neutron detectors. They will also produce a report describing the performance of existing and innovative NDA systems for SNF characterisation, which is the main deliverable of subtask 2.2. JRC-Geel/Ispira will also assist in defining correlation schemes between experimental observables from NDA measurements and contribute to the definition of recommended state-of-the-art procedures to determine the main source terms (decay heat, neutron and gamma-ray emission rate, reactivity) of a SNF assembly.

Within subtask 3.1 "Thermo-mechanical-chemical properties of the SNF rods and cladding", JRC-Karlsruhe (JRC-Karlsruhe) will concentrate its experimental work on quantifying the effects of hydrogen load, hydride distribution and re-orientation as well as mechanical loading to create a knowledge base to evaluate the integrity of spent nuclear fuel rods affected by thermo-mechanical conditions as well as fuel/cladding chemical interaction after discharge from reactor but before final disposal. Additionally, the modification of the fuels mechanical and elastic properties due to alpha-damage formation and associated radiogenic helium production will impact the ensemble cladding/fuel and also determine the magnitude of the fuel fragmentation during impact tests.

In respect to the objectives in subtask 3.1 JRC-Karlsruhe will perform two bending and one impact tests on pre-treated and non-treated spent UO_2 and MOX fuels. Five ring compression tests will be performed after different treatments followed by characterisation of the compressed irradiated cladding. In respect to the alpha-damage studies ^{238}Pu -doped UO_2 samples will be conditioned and thereafter followed by post-characterisation of the alpha-damaged ^{238}Pu - UO_2 samples by regular XRD and Vicker's hardness measurements complemented by TEM analyses.

The JRC-Karlsruhe experimental programme fits the task 3.1 objectives as it is the only part where real irradiated spent fuel rods are tested and the outcome used to benchmark the non-irradiated rod experiments in this task.

The JRC is has a leading role in the knowledge management programme, providing the knowledge management (KM) programme coordinator in the overall EURAD Programme Management Office (PMO), but also contributing to the organization of work within the three KM workpackages. The role of the KM programme coordinator in the PMO includes ensuring that the KM programme is evolving in line with the overall agreed upon objectives and workplan; communicating the progress of the individual KM workpackages to the PMO; keeping the KM workpackages informed about the overall EURAD coordination work and decisions; managing the fund with financial resources used for meetings, workshops, training events, training motilities, external experts in addition to the in-kind contributions within EURAD and the development and maintenance the knowledge platform, etc. The contributions within the individual KM workpackages includes development of initial proposal and follow-up of the knowledge platform population strategy and time

schedule, managing and reviewing the knowledge platform population process, managing the process for updating the PLANDIS Guide and development of the subsequent detailed guidance, contributing to the management of training events, establishment of on-line training material, and the training mobility programme.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

24/KIT

Participant	24	Karlsruhe Institute of Technology	KIT
Description of the legal entity			
Karlsruhe Institute of Technology (KIT) is one of the biggest science and engineering research institutions in Europe and funded jointly by the Federal Republic of Germany and the State of Baden-Wuerttemberg. Its research and development program is embedded in the superordinate program structure of the Helmholtz Association of National Research Centers. KIT was established by the merger of the Forschungszentrum Karlsruhe GmbH and the Universität Karlsruhe (TH) on October 01, 2009. KIT combines the tasks of a university of the state of Baden-Württemberg with those of a research center of the Helmholtz Association in the areas of research, teaching, and innovation. In research and education, KIT assumes responsibility for contributing to the sustainable solution of the grand challenges that face the society, industry, and the environment. Project Management Agency Karlsruhe (KIT-PTKA): Since 1971 the project management agency KIT-PTKA is a service provider, partner, and codesigner of various customers of public organisations with a view to promote scientific research, technical development, and dissemination of research results in the field of nuclear waste management, environment and energy, water technology, production and services. Approximately 2000 projects/a are supervised by KIT-PTKA with a total volume of 135 Mio. EUR/a. In the competence area of nuclear waste management, KIT-PTKA is an agency of the Federal Ministry of Economics and Energy (BMWi) and supervises technical and administrative R&D projects in the fields of "Disposal of highly radioactive waste" and "Nuclear Safety Research". In 2017 ~ 50 Mio. EUR were invested by the BMWi to carry out R&D work in ~ 75 projects. Institute of Nuclear Waste Disposal (KIT-INE): The Institute for Nuclear Waste Disposal (INE) at KIT is strongly focusing on safety research for radioactive waste disposal by investigation of geochemical processes relevant for assessing long-term behavior of waste forms and (geo-)technical and natural barriers. The research contributes to the demonstration of safety within the disposal Safety Case for all types of host rock under consideration. Since several years, INE is one of the driving organizations developing of scientific knowledge which feeds the geochemically based long-term safety assessment for radioactive waste disposal. The competence of INE covers, amongst others, interactions of waste forms and barrier materials in disposal systems, basic radionuclide thermodynamics, the behavior of long-lived radionuclides in the geosphere, radionuclide transport properties in all host rocks considered in Europe, isotope-geochemistry and hydrology. In the area of the nuclear waste disposal Safety Case, it provides support in various national advisory bodies and interacts within several international collaborations.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal			
Project Management Agency Karlsruhe (KIT-PTKA):			



In its role as a management agency, PTKA will not participate in individual work packages in the form of scientific activities. Rather, PTKA has the task of integrating relevant LTPs into the development of scientific content and implementing the corresponding legal link. Furthermore, PTKA will ensure that all administrative requirements in connection with the implementation of joint programming at national level are met at organisational level.

Institute of Nuclear Waste Disposal (KIT-INE):

KIT-INE will contribute to EURAD on several levels. Within CORI, KIT-INE will serve as the WP Coordinator and also contribute to the technical RD&D. In SFC, KIT-INE will serve as co-task leader and perform RD&D. In FUTURE, KIT-INE will contribute to the RD&D program. Additional activities of KIT-INE within EURAD are related to the Strategic Study UMAN and contributing to the Knowledge Management program.

Given the high level of technical expertise at KIT-INE in all the fields relevant for the proposed work in EURAD, and the broad experience in coordinating national and international RD&D, KIT-INE is fully able to carry out the work proposed within EURAD.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

25/LEI

Participant	25	Lietuvos Energetikos Institutas	LEI
Description of the legal entity			
Lithuanian Energy Institute (LEI) is a state scientific research organization with about 250 employees. LEI carries out fundamental and applied research in various fields related to radioactive waste and spent nuclear fuel (SNF) management, heat transfer, hydro and gas dynamics, alternative energy sources, materials science. LEI laboratories are participating in broad of international projects (COST, EUREKA, FP5, FP6, FP7, H2020, IAEA, Phare, etc.). Since 1994 the LEI Nuclear Engineering Laboratory (NEL) has been actively involved in the analysis of the radioactive waste management problems at Ignalina NPP covering planning and decommissioning of nuclear power plant, designing storage, treatment and disposal facilities, evaluating environmental impact of nuclear facilities and post closure safety of repositories. Implementing the research on SNF and long-lived intermediate level waste disposal in Lithuania, the researchers of LEI NEL with the assistance of experts from Sweden and other countries proposed the concept of deep geological repository in crystalline and clay rocks in Lithuania, and generic repository safety assessment was initiated. The concept on disposal and the safety assessment are constantly being updated taking into account international experience and thermal, groundwater flow, mechanical and chemical properties of a possible repository site.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal			
LEI will contribute to five RD&D (“Mechanistic understanding of gas transport in clay materials”, “Influence of temperature on clay-based material behaviour”, “Assessment of chemical evolution of ILW and HLW disposal cells”, “Spent fuel characterisation and evolution until disposal”, “Development and improvement of numerical methods and tools for modelling coupled processes”), two Strategic Studies (“Waste Management routes in Europe from cradle to grave”, “Understanding of uncertainty, risk and safety”) and Knowledge Management Work Packages.			

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

26/MTA EK



Participant	26	Centre for Energy Research, Hungarian Academy of Sciences	MTA EK
Description of the legal entity Hungarian Academy of Sciences Centre for Energy Research was established in 2012 by a merger of two Institutes: KFKI Atomic Energy Research Institute and MTA Isotope Institute. MTA EK is mainly active in the field of basic and applied research related to nuclear energy. The activities of the Centre started in the 1950's. The main research areas of MTA EK are reactor physics, thermal hydraulics, fuel behaviour studies, and material sciences, health physics, environmental physics, nuclear electronics and chemistry. MTA EK is the chief technical consultant of NPP Paks and key player in the power-upgrade, safety, life extension and maintenance activity of the utility. At the same time MTA EK also serves as a technical support organisation (TSO) to the nuclear safety authority in Hungary. The Centre operates the 10 MW Budapest Research Reactor, providing the scientific community of Europe (see Budapest Neutron Centre for details) with research possibility for neutron physics and applications. The Centre has acquired important experience with VVER-type reactors, both in experimental and in analytical fields. MTA EK has been contributing to many EURATOM research programs and member of several expert associations. The Centre is the co-founder of V4G4 Centre for Excellence which organizes the research for the next generation gas cooled fast reactor. MTA EK is the coordinator of the National Nuclear Research Program focusing on radiation ageing of reactor structural materials, spent fuels and radioactive waste management and advanced modelling and simulation of nuclear reactor physics.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal The work programme within EURAD-1 will be performed under Radioactive Waste and Decommissioning platform of MTA EK involving Fuel and Reactor Materials, Nuclear Security and Environmental Physics Departments and as LTP the Social Organization for Radioecological Cleanliness. RD&D is focused on spent fuels, RN mobility in clay, conditioning and deep geological disposal of radioactive waste. Environmental Physics and Nuclear Security Departments are interested in FUTURE and ACED WP's: - in FUTuRE Subtask 2.1-Mobility of radionuclides in compacted clay with following plan: MTA EK will carry out diffusion experiments on host rock samples with radiotracers (Eu, U, Ra, Se) assuming different perturbation effects and microscopic investigations of the diffusion front (inactive Se) and in FUTuRE Subtask 2.3- Reversibility of sorption; with plan: MTA EK will carry out test uptake experiments (Ni) involving thin sections for transferability of sorption phenomena, TEM identification of irreversibly formed phases on micro/nanoscale in natural rock sample, study of sorption reversibility using isotope exchange experiments (Ni, Ra) and modelling, experiments and modelling of competition of metal sorption in clay systems. In ACED Subtask 2.1-Steel/clay material interface reactivity; MTA will set up new experiment with KO-033 steel – plate and/or cylinder placed in contact with the Boda claystone formation between ambient temperature and 80°C. In ACED Subtask 2.2-Steel/cement material interface reactivity; MTA will set up new experiments with steel (KO33) – plate and/or cylinder emplaced with Portland concrete or other cementitious mixture from ambient temperature to 80°C. In ACED Subtask 3.1 – <i>Experimental analysis</i>; MTA EK will carry out different experiments in order to study the chemical evolution of a system borosilicate glass/steel/Boda-claystone formation (BCF). They focus on the understanding of the secondary phase formation (SEM, TEM, XRD, XPS methods). In ACED Subtask 3.2- Modelling of chemical evolution of HLW waste package scale;			

Using previous datasets, and the results from the planned experiments in subtask 3.1, MTA EK use GEMs, an advance sorption model (2SPNE CE/SC) and the GoldSim 8.02 software, which is suitable to model a complex system taking into account various conditions and mechanisms.

Fuel and Reactor Materials Department is interested in SFC WP,

in Subtask 3.1-Thermo-mechanical-chemical properties of the SNF rods and cladding;

Creep tests will be performed with pre-hydrated and pre-treated at high temperatures Zr1%Nb samples.

Hydride reorientation will be studied with pre-hydrated samples in mechanical tests at different temperatures and with different mechanical loads. Post-test investigation of the samples will be carried out with optical and scanning electron microscopy.

in Subtask 3.3- Pellet-cladding interaction under conditions of extended storage, transport and handling of SNF rods;

Cladding samples will be pre-treated in order to simulate the typical conditions for dry storage. Several samples will be charged with hydrogen, other samples will be treated in high temperature inert gas. Mandrel tests will be carried out to simulate crack propagation in cladding.

Through our LTP (Social Organization for Radioecological Cleanliness (SORC)) we are interested in DONUT WP.

In Task 2.- Numerical methods for high performance computing of coupled processes;

SORC will develop modules with numerical algorithms adapted to the resolution of multiphysic coupled problem on GPU-CPU Server platforms.

The lists of projects and publications indicate the experiences of MTA EK in spent fuel studies, the radionuclides transport in clay-rich rock systems and the conditioning of HLW. Our staff and equipment is suitable to serve the initiated program of EURAD-1.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

27/NAGRA

Participant	27	National Cooperative for the Disposal of Radioactive Waste in Switzerland	Nagra
Description of the legal entity Nagra (the Swiss national cooperative for the disposal of radioactive waste) is responsible for the safe management of all types of radioactive waste arising in Switzerland. Since it was founded by the Swiss electricity utilities and the government in 1972, Nagra has developed into an internationally recognised know-how centre in the field of nuclear waste management. Nagra's activities span the areas of development of disposal concepts, regional studies, field investigations and site characterisation, performance assessment, design of deep geological repositories as well as design, construction and operation of underground research facilities. Through operation of the Grimsel test site (GTS) and participation in the Mont Terri URL, Nagra's scientists have been and are involved in the planning, implementation and interpretation of research, development & demonstration programmes during the past 20 years addressing all major aspects of underground disposal of radioactive waste. Nagra's work is supported by an effective quality management system that is certified in accordance with ISO 9001.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal <u>WP HITEC</u> Coordination of the Subtask 4.1: Guidance for safety case development and repository optimization, contribution to the SOTA, coordination of the THM URL FE experiment modelling benchmark. As an implementor and owner of the FE experiment Nagra is well placed to perform these tasks.			
<u>WP Gas</u> Technical coordination of Task 2 "Barrier integrity", including the elaboration of a detailed scope of work, FEP-screening, elaboration of a state-of-the-art report. Technical coordination of sub-task 2.1 ("Gas-induced			

impacts on barrier integrity"), emphasising an integrated laboratory programme for investigating the evolution of damage of clay-rich geomaterials when subjected to excessive water/gas pressures.

WP Uncertainty Management multi-Actor Network (UMAN)

Nagra will lead Subtask 4.2 "Compilation and review of [...] information on [...] management options" and actively provide input from the Swiss program to other tasks. Nagra has been dealing with uncertainty management through its safety analysis for several decades.

WP SFC

Since a large part of the Swiss HLW inventory to be disposed of consists of spent nuclear fuel (SNF, also high burn-up), Nagra has developed significant expertise in this domain in the last decades to ensure the optimization of the loading of disposal canisters and plan for the final disposal including the operational and post-closure safety assessment.

As a consequence Nagra will coordinate the following subtasks:

- 1.2 – State-of-the-art and Gap analysis
- 4.1 – Accident scenario for fuel under dry interim storage conditions

Moreover, Nagra will contribute to the following subtasks with activities and know-how:

- 1.3 – Training materials
- 2.1 – Theoretical study of SNF source terms
- 2.3 – Determine the inventory of activation and fission products in cladding material
- 3.1 – Thermo-mechanical-chemical properties of the SNF rods and cladding
- 4.2 – Consequence analysis of postulated accidents

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

28/NCSRD

Participant	28	National Centre for Scientific Research « Demokritos »	NCSRD
Description of the legal entity The National Centre for Scientific Research "Demokritos" (NCSRD) was founded in July 1961 as a Research Centre for Nuclear Research, Demokritos. Today it is the largest multidisciplinary Research Centre of Greece with approximately 180 Researchers in tenured and tenure-track positions and over 500 Research Personnel working in projects funded mainly by grants from State Funds, the European Union and Private Industries. It is governed by the Board of Directors and is supervised by the General Secretariat of Research and Technology, which is in the Ministry of Education, Research and Religious Affairs of Greece. The Centre consists of five independent Institutes focusing on different scientific fields: 1) Institute of Nuclear & Radiological Sciences and Technology, Energy & Safety (INRASTES); 2) Institute of Nuclear and Particle Physics (INPP); 3) Institute of Nanoscience and Nanotechnology (INN); 4) Institute of Biosciences & Applications (IBA); 5) Institute of Informatics & Telecommunications (IIT). The NCSRD is a mandated RE in EURAD-RWMD. The INRASTES operates: 1) the Greek research reactor (GRR-1) by the Research Reactor Laboratory; 2) the centralized facility in Greece for interim storage of radioactive waste and sources by the Radioactive Waste & Material Laboratory (RWML). Furthermore, INRASTES possesses Laboratories who performing research and technological development in 1) sorption, multiphase flow, heat & mass transfer in porous materials; 2) reliability and safety of complex technological systems; 3) radioecology and radiation protection; 4) materials characterization by X-ray scattering, X-ray fluorescence spectroscopy, Positron Annihilation Lifetime Spectroscopy, Scanning and Transmission Electron microscopy in collaboration with the INN, mechanical testing, optical and thermal properties measurement in collaboration with the INN; 5) nuclear and radiation techniques (prompt gamma neutron activation analysis, gamma spectrometry, RBS, NRA, NAA in collaboration with the TANDEM accelerator laboratory/ INPP).			



The RWML research and development activities are related to radioactive waste and materials management as well as to the decommissioning of nuclear facilities. The main activity is the development of techniques as well as the elaboration and performance of studies for radiological characterization of waste (including historical waste) and facilities by destructive and non-destructive techniques. Furthermore, RWML elaborates studies for the safe storage of radioactive waste at the NCSR D and provides services to the laboratories of the Centre as well as to hospitals, the Industry, companies and individuals.

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

The NCSR D is a multidisciplinary Research Centre of Greece with infrastructure and technical equipment relevant to the proposed work. Furthermore, it is the main producer of radioactive waste in Greece and operates the centralized facility in the country for interim storage of radioactive waste and sources. Greece is a small inventory member state (SIMS) without NPP but possesses a research reactor and other applications of radioactive isotopes. The radioactive waste is producing in the same way, but in much smaller amounts. Furthermore, the disposal solutions have not been determined yet. The profile of the NCSR D matches the tasks of the proposal in the following way:

Task n°2 - Identify challenging wastes to be collaboratively tackled within the Joint Programme - Mapping and shared understanding at EU level of practical issues on waste management routes

The NCSR D will provide data about radioactive waste and sources kept at the centralized storage facility of the centre as well as about the waste that will arise from the future dismantling of facilities. NCSR D will contribute in the analysis of the challenges encountered with small programmes including practical issues on waste management routes for challenging wastes. DMT (TLP) will support the NCSR D as well as the other SIMS and collect the information from Task2 for the work in Task5.

Task n°3 - Description and comparison of radwaste characterisation approaches

The NCSR D will provide experience and knowledge on characterisation of radioactive waste from the Greek Research reactor and the other research facilities of the Centre. Furthermore, key radionuclides of concern and inventories in selected radioactive waste will be provided. DMT (LTP) will present the techniques and procedures used for characterisation of raw legacy/ historical wastes in SIMS including the case of NCSR D.

Task n°4 – Identification of WAC used in EU Member States for different disposal alternatives in order to inform development of WAC in countries without WAC/facilities

Since Greece is a country without WAC for treatment and disposal of radioactive waste, the NCSR D will be observer in the workshops of the Subtask 4.2 – Sharing experience on waste management with/without WAC available and Subtask 4.3 – R&D needs and opportunities of collaboration, in order to gain knowledge from the experience and the knowhow of other countries in Europe and understand the future needs for R&D as well as the possibility of collaboration.

Task n°5 - RWM solutions for small amounts of wastes

NCSR D will summarize the knowledge for existing and potential disposal options for small amounts of radioactive waste in a report (deliverable 5.1) where further needs of R&D on this issue will also be listed. Furthermore, NCSR D will support the preparation of the second report (deliverable 5.2) where the suitable predisposal routes for small amounts of waste will be determined, even without WAC for disposal. NCSR D will organize the first workshop of this task. DMT (LTP) will take over the management of the Task and give information about disposal options appropriate for SIMS like the use of old mines, tunnels, bunkers, caverns, deep shafts and boreholes (some 100 m). Furthermore, DMT will collect the necessary information for the work in Task5 from the other Tasks of the WP.

Task n°6 – Shared solutions in European countries

DMT (LTP) will participate in this Task instead of NCSRD and contribute by describing examples of sharing facilities in Germany as well as by providing feedback. DMT will share the information from the work in this Task with NCSRD.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

29/NES

Participant	29	Nuclear Engineering Seibersdorf GmbH	NES
Description of the legal entity			
Radioactive waste management organization of Austria			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal			
- Identify challenging wastes to be collaboratively tackled within the Joint Programme - Mapping and shared understanding at EU level of practical issues on waste management routes (Strategic WP ROUTES Task 2) - Collection and analysis of existing work on categorization and classification of radioactive waste regarding disposal options, identification of waste for which there is not yet a complete management plan in each Member State, identification of waste management routes for pre-disposal steps → provide national relevant input data; analyze the challenges encountered with small waste programs (Strategic WP ROUTES Task 2.1) - Understanding at EU level of the practical issues on waste management routes for challenging waste → Establish and share synthesis on practical issues on waste management routes for challenging wastes (Strategic WP ROUTES Task 2.2) - RWM solutions for small amount of wastes (Strategic WP ROUTES Task 5) - Collecting and analyzing actual existing knowledge about disposal options for SIMS → NES is contributing the subtask regarding long-term interim storage on surface for decay, participating in two workshops (Strategic WP ROUTES Task 5.1) - Describe the necessary predisposal routes for the disposal options of subtask 5.1 → NES will organize the workshop and write the report with partners (Strategic WP ROUTES Task 5.2) - Shared solutions in European countries (Strategic WP ROUTES Task 6) - State of the art on shared development and use of technologies and facilities → State of the art on shared development and use of technologies and facilities (Strategic WP ROUTES Task 6.1) : Case studies on shared development and use of technologies and facilities → Provide input and participate in workshop (Strategic WP ROUTES Task 6.2) - Assess the feasibility of developing further European shared solutions for waste management from cradle to grave → Provide input and participate in workshop (Strategic WP ROUTES Task 6.3)			
Nuclear Engineering Seibersdorf GmbH is the only WMO in Austria. NES has a profound knowledge of radioactive waste management, and can carry out all necessary predisposal steps on its premises.			

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

30/NNF

Participant	30	Národný jadrový fond	NJF
Description of the legal entity			
National nuclear fund (NJF) was established in 2006 as a state fund for accumulation and management of resources for back end of nuclear facilities life cycle (which replaced the State Fund for the Decommissioning of Nuclear Energy Facilities and the Treatment of Spent Nuclear Fuel and Radioactive			

Waste existing from 1995). Its role is to ensure sufficient acquisition sources for decommissioning of nuclear installations and for construction of deep geological repository in Slovak Republic and supervise accounting of decommissioning and waste management projects and their consistence with National Policy and Program.

Board of supervisors of the Nuclear Fund except of account control insure the evaluation, updating and continuous performance of tasks resulting from the National Policy and Program for the Management of Spent Nuclear Fuel and Radioactive Waste in cooperation with other central state administration bodies, license holders and other stakeholders.

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

NJF will take part of the task No. 6 Shared solutions in European countries providing input, feedback and participate in workshop. NJF is responsible for evaluation and updating of National Policy and Program for the Management of Spent Nuclear Fuel and Radioactive Waste, where one of the considered alternative along with national deep geological disposal is international repository. In near future, NJF will reassess recent national policy of SNF management according current national and international experiences in sharing of waste management solutions.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

31/NRG

Participant	31	Nuclear Research and Consultancy Group	NRG
Description of the legal entity			
NRG has been the lead organisation for research in nuclear technology and in geological disposal in the Netherlands for over 30 years. NRG operates the HFR research reactor, a Hot Cell Laboratory, a Waste Storage Facility and various other nuclear facilities. NRG has almost 500, employees, more than about 100 employees work The Research, Consultancy and Services departments of NRG. NRG has been studying disposal options since the 1970's. NRG had a key role in the recently completed research program into disposal in Boom clay in The Netherlands, (https://covra.nl/en/downloads/operating-info) and provides the Dutch authorities with advice on various topics concerning radioactive waste disposal and radiation protection in general.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal			
NRG contributes to the Workpackages ACED, DONUT, ROUTES and UMAN. As a TSO, NRG main activities are in the field of safety cases, safety studies and (total system) performance assessments IUMAN). This requires to be a knowledgeable and active user of the models developed and laboratory tests results in the research work packages (such as ACED), and to be able to understand and link the models to system performance models (DONUT)			

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

32/ONDRAF/NIRAS

Participant	32	Organisme National des déchets Radioactifs des matières Fissiles enrichies	ONDRAF/NIRAS
Description of the legal entity			
ONDRAF/NIRAS, the Belgian Agency for radioactive waste and enriched fissile materials, is a public agency established by law (08.08.80, modified by law of 11.01.91; royal decree of 30.03.81, modified by royal decree of 16.10.91 and 04.04.2003). In the meantime, several laws and royal decrees were voted for specific tasks of the agency.			

The mission of ONDRAF/NIRAS is to protect man and the environment, for the present and the future, against the potential hazards arising from radioactive waste, without thereby imposing any excessive obligations on future generations. Its competences cover transport, processing, conditioning, interim storage and final disposal of radioactive waste and spent fuel, as well as the decommissioning of nuclear facilities. The agency is also competent for technical research and RD&D in the field of radwaste management, especially with regard to disposal and the optimisation of current practices. Since 1997, the agency is also entrusted by law with the inventory of all nuclear liabilities on the Belgian territory.

The policy pursued so far is to have its industrial tasks performed by subcontractors as far as transportation is concerned and by Belgoprocess, a 100 % subsidiary of ONDRAF/NIRAS, for the activities with regards to the treatment, conditioning and storage of waste awaiting disposal. Concerning the long-term management of radioactive waste, ONDRAF/NIRAS has the monopoly in Belgium. In this respect, it defines the RD&D needs, steers the RD&D projects and integrates the RD&D results. For the R&D in the field of final disposal of waste the Belgian research centre on nuclear energy SCK•CEN is one of its major contractors. The Belgian Underground Research Laboratory HADES is operated by EURIDICE, a joint Economic Interest Grouping (EIG) of ONDRAF/NIRAS and SCK•CEN.

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

ONDRAF/NIRAS will participate in the R&D WP6 (GAS) and the Strategic Studies WP9 (UMAN) and WP10 (ROUTES). The Linked Third Parties of ONDRAF, ULiège and EURIDICE, will additionally perform tasks in WP7 (HITEC), see section on LTPs for the description of these tasks.

As Lead Participant of WP6 (GAS) ONDRAF/NIRAS tasks notably include the coordination of the work package which entails the follow-up of the R&D programme, fostering interactions between WP6 participants, a task ONDRAF/NIRAS is familiar with considering its mission. ONDRAF/NIRAS will ensure the production, cross reviewing and edition of WP6 deliverables and will also ensure interactions with other WPs. Besides the coordination of the work package, ONDRAF/NIRAS will also participate to Task 4 on the Repository Performance Aspects, providing a WMO perspective, and input from the Belgian programme, about the conceptualisation of gas migration at repository and the assessment of its impact in the context of the Safety Case.

In WP9 (UMAN), ONDRAF/NIRAS will contribute to subtask 2.1 by participating in technical meetings, providing an input regarding the strategies considered in their national programme, collecting information on strategies developed and used in other national programmes, providing written material and reviewing the deliverable. ONDRAF/NIRAS will contribute to subtask 3.1 and will collect and synthesise the views of WMOs on the different types of uncertainties that need to be addressed in a safety case and their evolution. ONDRAF/NIRAS will also contribute to subtask 4.3 in order to provide an input on the pros and cons of different uncertainty management options from the viewpoint of the Belgian WMO and to the identification of needs for future activities.

In WP10 (ROUTES), ONDRAF/NIRAS will lead Task 4 on waste acceptance criteria, a topic it is familiar with considering its legal role as WMO in Belgium. ONDRAF/NIRAS will provide input to the WP based on its perspective on the management of radioactive waste from cradle to grave. As task leader, it will ensure the production, cross reviewing and edition of Task 4 deliverables as well as the interaction with other tasks of WP10.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

33/POSIVA

Participant	33	Posiva Oy	POSIVA
Description of the legal entity			



Posiva Oy from Finland is a nuclear waste management company whose main task is the disposal of the spent fuel of its owners' NPPs. It is jointly owned by Teollisuuden Voima Oy (TVO 60%) and Fortum Power and Heat Ltd (FPH 40%). POSIVA have been carried out a research, development and technical design programme for disposal in ONKALO Underground Rock Characterisation Facility (URCF). Posiva will be in charge of the disposal facility in Olkiluoto, Finland, which construction have been initiated. Posiva's ONKALO offers a unique site for practical learning experiences related to repository characterization and construction of underground facilities. Posiva is currently testing in ONKALO the EBS component emplacement and the early evolution of disposal system in full scale.

POSIVA started operations in 1996 and has over 50 specialists engaged in research, development and technical design for an environmentally acceptable disposal solution. POSIVA's programme brings together the resources of Finnish research institutes, universities and consulting and contracting companies. POSIVA has unique specialization in Europe related to site characterization and underground site specific activities. POSIVA received the Decision in Principle for the site of the geological disposal facility in 2000 and 2002 and a construction license for a geological disposal facility and encapsulation plant in 2015 as the first in the world. As a part of the preparations for the start of the construction and operations, POSIVA has carried out and continues the planning a series of various full-scale tests and demonstrations on encapsulation and disposal technologies. These will be carried out partly in the ONKALO, the Olkiluoto underground rock characterization facility, partly in suitable surface facilities. POSIVA has participated in many EURATOM projects related to geological disposal since 4th framework program. POSIVA's most recent EURATOM projects include ReCoSy, FORGE, MODERN, SecIGD, SecIGD2, REDUPP, LUCOEX, BELBaR, Petrus II, Petrus III, DOPAS (in FP7) and in H2020 MIND and MODERN 2020. In addition, POSIVA is an end user in several other European R&D projects.

POSIVA has gained years of experience in working with and applying R&D results into its underground repository development work. POSIVA has acted as the coordinator of SecIGD and DOPAS projects. In addition, POSIVA has led several work packages in the EURATOM projects with success.

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

Posiva is mainly participating in HITEC WP3 Tasks 3.1 and 3.2 and Task 4. Posiva is providing planning and review support for the Tasks and coordinating the R&D work by Finnish RE organisations. Posiva also follows other scientific work packages like EJP1 GAS and WP: Spent Fuel Characterization and Evolution Until Disposal.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

34/PSI

Participant	34	Paul Scherrer Institute	PSI
The Paul Scherrer Institute (PSI), is the largest research institute for natural and engineering sciences within Switzerland. PSI performs world-class research in three main subject areas: Matter and Material; Energy and the Environment; and Human Health. By conducting fundamental and applied research, PSI works on long-term solutions for major challenges facing society, industry and science. PSI has a unique position in Switzerland with respect to nuclear energy research, due to its heavy infrastructure, namely the Hot Laboratory with so-called "hot cells", well equipped and shielded zones for work and research on radioactive material. Based on this infrastructure, PSI's large facilities (SLS and SINQ) and the know-how of its collaborators, the division is involved in three main topics of research: the safety of currently operating nuclear reactors, related fuel cycles, and long-term safety of deep geological repositories for nuclear wastes of all kind.			
In particular the Laboratory for Waste Management, (LES) is the Swiss competence center for geochemistry and multiscale radionuclide and mass transport in argillaceous rocks and cement and their application to deep geological systems and Swiss radioactive waste repositories. The mission of the LES is to carry out a comprehensive R&D programme in support of Swiss radioactive waste disposal options. Research activities			

within LES are performed on very different spatial and temporal scales to take advantage of all the information which can (potentially) be obtained from such an approach i.e. from the nano scale (molecular spectroscopy), to the micro scale (XAS), to the cm scale (laboratory) and to field and regional scales (Mont Terri Rock Laboratory, St Ursanne, Switzerland). During the last 30 years, LES researchers have been developing state of the art models for the mechanistic description of radionuclides transport and retention in argillaceous rocks. Particular strength of the research labs is the combination of experimental infrastructure with the state-of-the-art coupled reactive transport modelling capabilities covering the simulation scale from atomistic to pore and the field scales. These tools are applied for quantitative prediction of repository in situ conditions over geological time scales.

In the **WP-FUTURE** PSI coordinates Task 2 on Experimental studies on radionuclides mobility in compacted clay, crystalline rocks and reversibility of sorption with strongly sorbing radionuclides, and conduct laboratory studies in this task. Diffusion experiments will be carried out with moderately sorbing tracers (Fe, Ni and evt. Mn) and a strongly sorbing tracer (Eu) in compacted illite and in intact Opalinus Clay. The speciation of the adsorbed metals will be explored using synchrotron-based techniques. This will help to evaluate the current knowledge on surface mobility of these kind of metals. PSI will carry out adsorption/desorption experiments with Ni/Zn on pure clay minerals (illite/montmorillonite) under different specific experimental conditions (pH, presence of competing ligands/metals, variation of equilibrium concentrations and time). The local structure environment of the surface species will be probed by P-EXAFS.

PSI also co-coordinates Task 3 Redox and conduct laboratory studies in this task. Purified reference clays will be prepared to obtain different Fe(III)/Fe(II) ratios (i.e. CBD reduction) or will be altered by sorbing Fe(II) under electrochemically reducing conditions. The sorption of U, and Tc or Se on the different Fe/clay systems will be investigated by combining batch type sorption experiments under different conditions (pH, [RNs], [Fe], Eh), molecular scale speciation using X-ray absorption spectroscopy and sorption modelling.

In the **WP-ACED** PSI coordinates Task 3 on the Modeling of chemical evolution in repositories for HLW and ILW at a scale of individual waste packages (conditioned waste, disposal container, overpack). In this work package, recently developed solid solution models for C-S-H, AFm, and AFt phases will be extended by Fe-uptake, based on wet chemistry and spectroscopic data, using a multi-parameter multi-property optimization method. The resulting internally consistent set of parameters will provide a chemical-thermodynamic basis for improved reactive transport modelling in iron-containing cementitious systems used by the other modelling partners. Further, PSI will carry out simulations on the chemical evolution and gas/water mass balances in waste packages containing metallic and/or organic waste with the GEM-Selektor chemical modelling package and OpenGeoSys-MP-LT, a multi-component two-phase reactive code developed in cooperation with UFZ Leipzig.

In the **WP-DONUT** PSI co-coordinates Task 3 on Scale transition schemes for coupled processes and participate in Task 2 on Numerical methods for high performance computing of coupled processes. While optimized continuum and pore-level codes exist a cross-coupled overarching code is still missing. Therefore PSI will address multi-scale chemo-mechanical couplings by linking numerical methods and open-source software for integrating pore-scale reactive transport models with continuum-scale THM(C) codes.

In the **WP-GAS** PSI participates in the Subtask 2.1 – Experimental and modelling studies of diffusion and retardation of gaseous species in clay rocks. PSI will work jointly with SCK•CEN to perform diffusion experiments on Boom Clay, Opalinus Clay and sand/bentonite mixtures and the experimental results will be supported by pore network modelling. Experiments will be carried out at different degrees of saturation, with different gases. This will allow determining how the effective diffusion coefficient is influenced by desaturation. By using lattice-Boltzmann modelling, the gas partitioning in pores of different sizes will be estimated.

In the **WP-CORI** PSI participates in Task 2, and will perform hydrolytic degradation experiments of aged samples of cellulose and the identification of degradation products.

In the **WP-SFC** PSI co-coordinates Task 2 on Fuel properties characterization and related uncertainty analysis. PSI plans a characterization of inhomogeneous hydrogen distribution due to impact of pellet on

cladding (irradiated samples) with analysis of radial and circumferential hydrogen distribution and quantification in the treated claddings with neutron radiography. Further PSI coordinates and contributes to the Subtask 2.1 – Theoretical study of SNF source terms. PSI plans synchrotron measurements of chemical and structural / crystallographic properties of irradiated doped/undoped fuel at the cladding/pellet interface to determine the bonding /PCI properties.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

35/PURAM

Participant	35	Public Limited Company for Radioactive Waste Management	PURAM
Description of the legal entity			
PURAM is the national radioactive waste management organization in Hungary, a 100% state-owned enterprise that was established by the Government in 1998. PURAM's responsibility is to prepare proposal for the national radioactive waste and spent fuel management policy and national programme as well as for their revision, take care of the final disposal of radioactive waste, interim storage of spent fuel and decommissioning of nuclear facilities.			
PURAM operates the Interim Spent Fuel Storage Facility (Paks), National Radioactive Waste Repository (Bátaapáti) and the Radioactive Waste Treatment and Disposal Facility (Püspökszilág).			
The financial source of PURAM's activities is the Central Nuclear Financial Fund, a segregated state fund within the national budget, which is exclusively earmarked for radioactive waste and spent fuel management purposes that are defined in law.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal			
PURAM is one of the participants in the Knowledge Management Programme, in the Guidance Work Package. Considering Hungary's HLW RWM programme, it is at an early stage of development, with an ongoing site selection process. Nevertheless, PURAM has gained significant knowledge in the site characterisation and licencing of a geological disposal facility, because after 15 years of investigation, in 2010, the Bátaapáti repository for LILW in a granitic formation was successfully put into operation.			
International experience was widely considered during site characterisation, facility design and safety assessment. Also, PURAM as a targeted end-user was involved into the finalisation of the PLANDIS 2015 Guide. This guidance was applied by PURAM for the compilation of Hungary's National Programme for the RWM. The updated version of PLANDIS Guide and the completed PLANDIS 2020 will contain a lot of useful information for PURAM and supports further development and implementation of the Hungarian RWM programme.			

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

36/RATEN

Participant	36	Regia Autonoma Tehnologii pentru Energia Nucleara	RATEN
The Technologies for Nuclear Energy State Owned Company (RATEN) is a strategic Romanian legal entity coordinating the R&D activity in the nuclear energy field, which maintains and develop the scientific and technologic support for the National Nuclear Energy Program. RATEN manages two subsidiaries: Institute for Nuclear Research Pitesti (RATEN ICN) and Center of Technology and Engineering for Nuclear Projects (RATEN CITON). The activities proposed by RATEN under this proposal will be carried out in the Institute for Nuclear Research Pitesti.			
The Institute for Nuclear Research Pitesti (RATEN ICN) is a complex R&D centre created in 1971 to provide the scientific and technical support to the national nuclear energy program. Its activity covers a wide range of nuclear fields such as nuclear safety, radioactive waste, radioprotection, nuclear fuel and materials, reactor physics. Under the Radioactive Waste Management R&D program, RATEN ICN specialists			

developed treatment and conditioning technologies for LLW/ILW, established and applied new methodologies for radioactive waste characterization, in parallel with performance and safety assessments mainly for the future LLW/ILW repository designed mainly to dispose of the radioactive waste generated by Cernavoda NPP but also for geological repository for CANDU spent fuel and long-lived waste. The research activity is founded on a modern and complex infrastructure consisting of TRIGA reactor, Hot Cells Facility, Radioactive Waste Treatment Department, radiochemical laboratories operating modern investigation techniques, and sustained by specialists with large experience in the nuclear field.

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

RATEN will be involved in two R&D work packages, FUTURE and CORI, and two strategic WPs, ROUTES and UMAN.

In **FUTURE WP**, RATEN is involved in Task n°3: Redox. Under this task, RATEN will carry out sorption/desorption experiments, under controlled conditions (O_2 content and Eh) to study the retention mechanisms of Tc on individual clay minerals and on the natural and “model” red clay. The influence of FeII/FeIII ratio in clay minerals, change in redox state and reversibility of sorption/incorporation will be studied. Diffusion and sorption experiments will be carried out on natural red clay samples and on a compacted “model” red clay sample. At the end of these experiments the location of Tc (Re) will be investigated using spectrometric and microscopic techniques. The sorption/desorption tests will be sustained by experimental investigations to characterize the individual minerals (clays and iron oxides) and the natural compacted clay used in experimental programme. The total and redox active Fe content and the location of Fe(II) and Fe(III) in clay minerals and in red clay will be evaluated.

In **CORI WP**, RATEN is involved in Task n°2: Organics-Cement-Interactions and Task n°3: Radionuclide-Organics-Cement-Interactions. Under **CORI Task n°2**, RATEN proposed to investigate the interaction (sorption/desorption) of C-14 bearing organic compounds generated by CANDU spent ion exchange resins degradation with non-degraded and degraded HCP (state II, III and carbonated). The potential competitive effect of Fe on organic compounds sorption will be also investigated.

Under **CORI Task n°3**, RATEN has proposed to investigate the effect of organics generated by spent ion exchange resins degradation on Ni (as divalent radionuclide) mobility in cementitious environments. Ni sorption kinetic and isotherms and the effect of organics on Ni sorption will be investigated by batch sorption/desorption tests. Effect of single organics and cocktails of organics and role of iron on Ni sorption on non-degraded and degraded HCP will be investigated, as well as the effect of Ca.

In the frame of **ROUTS WP**, RATEN will contribute to Taks n°2 and Task n°4. Under Task 2 “*Identify challenging wastes to be tackled in collaborative way within the Joint Program - Mapping and shared understanding at EU level of the practical issues on waste management routes*”, RATEN will provide the current status in Romania regarding the RW classification, describe the waste management routs for institutional radioactive waste and for radioactive waste generated from Cernavoda NPP (in close collaboration with Romanian WMO), and will identify the RW generated in Romania that are not complying the WAC for the foreseen near surface and geological repositories in Romania. Under Task n°4 “*Identification of WAC used in EU Member States for different disposal alternatives in order to inform development of WAC in countries without WAC/facilities*”, RATEN will lead the sub-task 4.1 “*Current use of waste acceptance criteria*” and will organize (together with ONDRAF/NIRAS and GSL) and host a workshop under sub-task 4.2 “*Sharing experience on waste management with/without WAC available*”.

In the frame of **UMAN WP**, RATEN will lead Task n°3 “*Characterization and significance of uncertainties for different categories of actors*” contributing to identification of different types of uncertainties that need to be addressed in a safety case; collection and analysis of relevant information on uncertainties associated with the site and geosphere.

For the R&D work packages, RATEN ICN has quite well equipped laboratories used for sorption and diffusion experiments carried out during site selection and characterisation for Romanian near surface repository. Even in this programme we worked with different geologic materials (mostly clays, limestone and loess), different radionuclides and in different chemical conditions (redox or anoxic conditions were not

involved in this programme), RATEN specialists have the needed background to continue the sorption studies. The experience gained by participating in EURATOM projects on waste management such as CEBAMA, CAST, FORGE, and CARBOWASTE is useful for the experimental activities proposed by RATEN under FUTURE and CORI WPs. Radiochemical laboratories of RATEN ICN allow performing experiments under anoxic and controlled redox conditions. We are doing experiments in anoxic conditions under CEBAMA project to investigate C-14 and Ra-226 sorption on fresh and degraded HCP, and we carried out leaching/corrosion experiments in controlled conditions under CAST project.

The expertise gained participating in CHANCE project, the knowledge in treatment of uncertainty associated with a near surface repository, as well as the good collaboration with Cernavoda NPP, the main waste generator in Romania and ANDR, Romanian WMO, substantiates RATEN involvement in networking work packages.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

37/RWM

Participant	37	Radioactive Waste Management	RWM
Description of the legal entity			
Radioactive Waste Management (RWM) is a wholly-owned subsidiary of the Nuclear Decommissioning Authority (NDA), which is an Executive Non-Departmental Public Body of the Department for Business, Energy and Industrial Strategy (BEIS).			
Our vision is simple: A safer future by managing radioactive waste effectively, to protect people and the environment. All our activity is in support of realising this Vision and is a critical enabler in UK Government Policy, Implementing Geological Disposal. Our Activities support and will eventually fulfil our Mission, to: Deliver a geological disposal facility and provide radioactive waste management solutions.			
In order to fulfil our mission we will deliver through four key activities:			
Key Activity 1: Implement government policy on geological disposal of Higher Activity Waste (HAW) – we are working to develop a GDF for the long term management of higher activity radioactivity waste with a view to providing disposal capability for the UK in line with the Government's 2014 White Paper, Implementing Geological Disposal.			
Key Activity 2: Work proactively with waste producers, planning for and delivering waste management solutions – we provide solutions for our parent organisation, the NDA, its Site Licence Companies and waste producers in the management of radioactive waste. We aim, to help them retrieve, condition and package wastes now, in ways that make them suitable for disposal later.			
Key Activity 3: Deliver a robust Technical Programme, support the GDF programme and waste management – The technical programme will provide designs and safety case capability to support the GDF programme and waste management, and will work with the site characterisation team as potential sites are identified. In preparation, RWM needs to acquire capability in business-critical areas e.g. developing GDF designs, disposal concepts, the making of Development Consent Order applications and other permits, environmental assessments, as well as safety and security cases.			
Key Activity 4: Develop RWM into a high performing delivery organisation – our people are central to our strategy and we need to attract and retain the very best if we are to meet our commitments. RWM needs to be credible both internationally and for the communities we intend to work with, so we plan to build our business to be a high performing delivery organisation. Radioactive waste management is a complex subject, so our vision demands that we employ leaders in this field.			

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

RWM will participate in EURAD Programme Management Office (PMO), two of the R&D WP's (GAS and HITEC) and two of the Strategic Studies (UMAN and to a lesser extent ROUTES).

RWM will support delivery of EURAD PMO. In this role we will primarily provide scientific and technical coordination/integration between the RD&D, Strategic Studies and KM activities (Task 2). We will also support the proposed Bureau and General Assembly in SRA/Roadmap extension/update exercises (Task 3) and help to identify suitable subject matter/theme experts from EURAD colleges. In particular RWM will act to co-ordinate the proposed WMO college and its interactions with the existing IGD-TP.

RWM will act as a member of the project steering committee and as task co-leader in the GAS WP. RWM's involvement will include leading subtask 4.1 conceptualization of gas migration at repository scale. RWM will provide a WMO perspective, and input from the UK programme, about the conceptualisation of gas migration at a disposal facility/repository scale and the assessment of its impact in the context of the Safety Case. Additionally, RWM will co-fund the activities of the British Geological Survey in the GAS WP, noting BGS is the other UK mandated actor and carries expertise in the WP specification.

In HITEC RWM will co-fund work of another mandated actor, BGS, to deliver a matrix of laboratory tests. These tests will evaluate the self-sealing capability of clay based materials under thermal loads. For subtask 2.1 tests will consider the near field, where damage from excavation may exist, and subtask 2.2 will consider the far field, where clay based material is intact. For Task 3 laboratory tests at >100C will be undertaken to evaluate the behaviour and evolution of a range of bentonites in response to thermal load. RWM will share knowledge and expertise arising and prepare a synthesis report regarding the relevance of the findings to RWM. This synthesis will underpin RWM's contribution to Task 4, which consolidates the impacts of the learning from the experiments. RWM will also contribute knowledge from our programme to subtask 1.2 which establishes the state of knowledge.

In UMAN, RWM will contribute to subtask 2.1 (generic strategies for managing uncertainties) by participating in technical meetings, providing input regarding the strategies considered in our national programme, exchanging on the pros and cons of strategies and reviewing the deliverable. We will also contribute towards subtask 2.2 (uncertainty identification, classification and quantification) by participating in technical meetings, providing input regarding the approaches considered in our national programme, providing written material and reviewing the deliverable. Likewise RWM are involved in subtask 2.3 (methodological approaches to uncertainty and sensitivity analysis) and will do this via participation in technical meetings and sharing our experience. RWM will also contribute to subtask 5.1 and 5.2. This will be done via a contribution to the development of materials related to Topics 1 and 2, to be discussed in seminars. We will also contribute to the development of deliverables 5.1 and 5.2.

In the ROUTES WP, RWM will act as an observer/contributor. We have not requested any financial support for this involvement as such activities are already funded elsewhere within our national programme (i.e. within the UK Problematic Waste Integrated Project Team).

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

38/SCK•CEN

Participant	38	Belgian Nuclear Research Center	SCK•CEN
Description of the legal entity			
SCK•CEN (www.sckcen.be) is a foundation of public utility and is one of the largest research institutions in Belgium, with activities dedicated to the development of peaceful applications of radioactivity. Our developments have already resulted in a long list of innovative and forward-looking applications for the medical world, industry and the energy sector. In the course of our work, there are three main research topics:			

- The safety of nuclear installations
- The well-considered management of radioactive waste
- Human and environmental protection against ionising radiation

We offer various services and operate BR2, a Material Test Reactor (MTR) with a very high neutron flux, BR1, a graphite-gas research reactor, GUINEVERE a zero-power-critical-facility, several gamma irradiation facilities, a laboratory for High and Medium Activity and Nuclear analysis, as well as different chemical laboratories. Through the EIG EURIDICE, an economic interest grouping between SCK•CEN and ONDRAF/NIRAS, we run our Underground Research Laboratory HADES. Also noteworthy are our European demonstration programs for PWR dismantling and MYRRHA (Multi-purpose hYbrid Research Reactor for High-tech Applications), an Accelerator Driven System (ADS) under development in Mol.

SCK•CEN began R&D on geological disposal in clay in 1974 and since then has been an active participant in all EC FP's and the R&D programs of ONDRAF-NIRAS, performing R&D on many aspects of near-field and far-field processes including laboratory experiments in its hot and cold dedicated facilities, state-of-the-art multi-scale and coupled modelling, in-situ tests in the HADES URL and performance and safety assessment for both surface and geological disposal concepts. SCK•CEN actively contributes to the Belgian programme for radioactive waste disposal as a main contractor for the Belgian waste management organisation, ONDRAF-NIRAS, in two projects: 1) the surface disposal facility for short-lived low and intermediate level waste in Dessel, and 2) research on a potential geological disposal facility in poorly indurated clay formations. SCK•CEN received the mandate as research entity (RE)-type programme manager by our programme owner.

Also noteworthy is the SCK•CEN Academy for Nuclear Science and Technology (academy.sckcen.be), which has a specific task to foster the transfer of nuclear knowledge, skills and attitudes towards students and professionals who are active in the nuclear field. Following topics are part of the SCK•CEN Academy's mission: 1) guidance for young researchers; 2) organisation of academic courses and customised training for professionals; 3) policy support regarding education and training in nuclear domains; 4) caring for critical-intellectual capacities.

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

SCK•CEN contributes to different tasks in the proposal:

- RD&D work packages: as the largest Belgian nuclear research organization and a major international player in the field of radioactive waste management RD&D, we contribute to different RD&D work packages to a varying degree, reflecting both our own interest and the interest of the Belgian waste management programme in the different studies that will be undertaken. We also coordinate one RD&D WP (Assessment of the Chemical Evolution of a Disposal cell – ACED), for which we have particular interest, because it combines both an experimental programme and coupled process modelling, two items where we score strongly.
- Strategic Studies work packages: within the Strategic Studies work packages we follow up the international progress related to several hot topics, including uncertainty management and dealing with legacy waste. In the first topic there is also a more specific interest in looking at the societal aspects related to uncertainty treatment, while in the second topic there is also an interest because we dispose of several difficult-to-manage waste forms on site given our large nuclear heritage.
- Within the Knowledge Management work packages we coordinate the work package on Training&Mobility, where we use the return of experience from the SCK•CEN Academy.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

39/SKB

Participant	39	Swedish Nuclear Fuel and Waste Management Company	SKB

Description of the legal entity

Svensk Kärnbränslehantering AB (Swedish Nuclear Fuel and Waste Management Company), SKB, is responsible for safe management of all nuclear waste arising in Sweden. Over the past few decades SKB has built and operated an underground final repository (SFR) for final repository for short-lived radioactive waste generated by nuclear power plants, hospitals etc., a central interim storage facility for spent fuel (CLAB) and a specially-built vessel for transportation of the wastes and the spent fuel. SKB has also planned, constructed and is operating an underground research facility – the Äspö Hard Rock Laboratory, a chemical laboratory, a bentonite laboratory and a canister laboratory. These facilities are used to execute essential research, development and demonstration before construction of the spent fuel repository and the encapsulation plant. A license application for the final repository for spent nuclear fuel was submitted in 2011 and an application to extend the SFR facility was submitted in 2014. Reviewing is ongoing. The plan is to start construction of the SF repository around 2022 and the extension of SFR some years later.

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

SKB will participate in the RD&D WP7-HITEC and WP8-SFC, as well as the Strategic Studies WP10 (ROUTES).

WP HITEC

Coordination of the Subtask 3.1– Characterisation of material treated by high temperature. Analyse the chemistry and mineralogy of blocks of the MX80, DepCAN (Milos), Asha505 (Kutch) and Calcigel bentonites from the ABM5 experiment. Provide ABM5 information and samples to other collaborating partners within HITEC.

WP SFC

SKB-UU will be the leader of WP8 SFC, coordinating the scientific and technical content of the WP. SKB-UU will coordinate task 1 (S/T coordination, State-of-the-art and training material) and will contribute to the subtask 2.2 (Develop, improve and demonstrate NDA methods/systems from SNF characterisation)

WP ROUTES

SKB will participate in subtask 2.1 (provide national contribution at exchange meetings) and in subtask 2.2 (Establish and share synthesis on practical issues on waste management routes for challenging wastes), and in task 3.2 (Characterization and segregation of legacy waste)

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

40/SSE Ecocentre

Participant	40	State Specialized Enterprise “Ecocentre”	SSE “Ecocentre”
Description of the legal entity SSE "Ecocentre" successfully operates within the territory of the Exclusion Zone (EZ) during the last 30 years. SSE "Ecocentre" carries out activities in the field of radiation monitoring. SSE "Ecocentre" is responsible for the radiation safety, in particular for the radiation monitoring of the environment media and individual monitoring within the territory of EZ. It has the experience of the investigation of the environment components as well as the development of the program for the radio-ecological monitoring of RAW management and disposal facilities at different stages of their lifecycles. SSE "Ecocentre" takes part in various radioactive waste/materials management programmes (projects) regarding the issues of RAW characterization: Sampling and investigation of all the environmental media. Radioactive waste and contaminated materials characterization in process of their management before disposal.			



SSE "Ecocentre" takes part in the international intercalibration procedures to keep the operational status of its analytical laboratory for RAW characterization at the due level.

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

1. Subtask 1.1 Collection and analysis of existing work and methods on categorization and classification of RWs consistently with disposal options.

Collection and analysis of existing national experience on categorization and classification of RWs consistently with disposal options.

Comparative analyses with the foreign experience, if any.

2. Subtask 2.1 Collection, analysis and comparison of the existing knowledge about techniques and practices for radiological characterization of RW, description and comparison of the different approaches of characterization based on national and international experience, specification of R/D issues and needs.

3. Subtask 2.2 Collection and analysis on applicability of the existing knowledge about characterization of radioactive waste regarding physical, chemical and toxic characteristics.

Collection analysis and processing our own experience on characterization of radioactive waste with regards to operational and accidental waste.

Specification of R/D needs for DTM radionuclides.

4. Subtask 2.3 Collection and analysis of the existing knowledge about techniques & procedures for characterization and segregation of legacy/ historical waste as well as of small amounts of waste

Analysis of national knowledge about techniques & procedures for characterization and segregation of legacy/ historical waste spent (disused) radiation sources as small amounts waste.

Identification of R/D needs and opportunities for collaboration.

The above tasks match SSE "Ecocentre" profile for reasons given below.

According to its company rules SSE "Ecocentre" performs the following kinds of activities with regards to characterization of contaminated objects:

-sampling and measurement of all environmental media of Chernobyl Exclusion Zone;

-characterization of legacy waste from military programmes of the former Soviet Union and radiological accidents;

-establishment of radiological status of radioactively contaminated territories;

-independent party expert activities during investigations with the matter of sources of ionizing radiation;

-participation in Ukrainian and international projects concerned with RAW characterization;

- SSE "Ecocentre" has the long-term experience and knowledge in practical issues of measurement of physicochemical and radiation properties based on up-to-date equipment and methods of examination during characterization of various environmental media as well as radioactive waste.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

41/SSTC NRS

Participant	41	State Enterprise "State Scientific and Technical Center for Nuclear and Radiation Safety", Ukraine	SSTC NRS
Description of the legal entity The State Scientific and Technical Center for Nuclear and Radiation Safety (SSTC NRS) is a Technical Safety Organization (TSO) to the national nuclear regulatory authority of Ukraine since 1992. The SSTC NRS mission is to provide scientific, engineering and expert support to the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) in all areas of its activity to ensure nuclear and radiation safety, protection of public health and safety, and protection of the environment. About 140 researchers and experts in safety-related areas are presently involved in the SSTC NRS scientific and technical activities. SSTC NRS has above 20-year experience in the field of management of radioactive waste (RW) and spent nuclear fuel (SNF). It employs highly qualified experts, possesses advanced methodological, analytical and technical infrastructure and developed capabilities for review of safety-related documentation and development of regulatory documents related to RW and SNF management.			

In addition, the SSTC NRS staff has solid background and practical experience gained during their previous assignments at Ukrainian RW management enterprises, Ukrainian NPPs (including Chornobyl NPP), in research and design institutes, as well as in technical support organizations in the nuclear industry.

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

RD&D WP SFC:

Evaluation of the isotope composition and decay heat of spent fuel for different assembly types (VVER-440/1000, VVR-M, RBMK-1000) depending on the burnup and cooling time for the most conservative simulation conditions. Evaluation of the multiplication properties of spent nuclear fuel depending on operating/storage conditions and with a certain isotopic composition.

SS WP UMAN:

Providing regulatory perspective on uncertainty management strategies and approaches, contributing to the compilation and review of information on strategies developed in the national programmes.

Collect and synthesize relevant information on uncertainties associated with spent fuel (including that regarding experience gained in the national programmes).

Uncertainty management options for addressing uncertainties throughout a geological disposal programme.

SS WP - ROUTES:

Share experience and knowledge on waste management routes. Identify safety-relevant issues and their R&D needs associated with the waste management routes, including legacy and historical waste. Describe and compare different approaches to characterisation, treatment and conditioning and long-term waste management routes.

KM WP:

WP 1 – Development of quality assurance (QA) documentation (QA Plan and set of Guidelines) for Knowledge Platform (KP) in order to ensure compliance of functionality, characteristics, approaches and content of the KP with established quality requirements.

Coordination of the development/ update of SoK content in compliance with the implementation schedule approved by the General Assembly and the QA process.

WP 2 – Providing suggestions on updating the PLANDIS Guide in consistency with EURAD Roadmap and with account of the TSOs' needs (PLANMAN Guide).

WP 3 – Participation in development and implementation of training courses in the field of safe RW management. Organization of obtaining feedback response from the mobility programme.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

42/STUBA

Participant	42	Slovak University of Technology in Bratislava	STUBA
Description of the legal entity Slovak University of Technology in Bratislava (hereinafter referred to as "STUBA") is an educational and scientific institution. At present, it consists of seven faculties. All the faculties provide a study in accredited study programmes within the complex system of a bachelor, master and PhD. study. Faculties realise credit system compatible with the European credit transfer system enabling mutual mobility of students within European Union member countries and a larger European space. In the area of scientific and research activities the STU successfully joins European Union programmes. STU is a public university and offers education mainly in technical, technological, technical-economical, technical-information and technicalartistic fields of study. International cooperation is a significant area based on interactive contact with educational as well as scientific-research institutions of the countries all over the world. First of all, it is			

focused on solution of the joint projects within the EU framework and other international programmes, mobility of students, ect.

Institute of Nuclear and Physical Engineering (STUBA-INPE) at Faculty of Electrical Engineering and Information Technology of Slovak University of technology is focusing on research of operation and decommissioning of NPPs, material science, nuclear fuel cycle and decommissioning of NPPs and radiation protection.

STUBA-INPE staff is based on 10 professors in physics, nuclear power engineering and material science. There are actually 50 employers (scientific or research workers) and about 20 PhD students.

This institute is also a base for activity of Slovak Nuclear Society (SNUS) and the Slovak Centre for operation and Decommissioning of Nuclear Facilities. STUBA-INPE has a long tradition in the NDS investigation of RPV materials by use of Positron Annihilation Spectroscopy and Mossbauer spectroscopy.

The partner role to the project: research organisation.

The partner contribution to the project: performance of R&D work mainly in field of development of proper methodology for mapping of radioactive material behaviour during its decommissioning, transport and long term storage. Knowledge management in dismantling, decommissioning and geological disposal characterisation is one of the main task in education and research at the University level.

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

STUBA will contribute in characterization of actual state of art, mapping and development of activities in decommissioning of Slovak nuclear facilities and knowledge management including organization of seminars for graduate and PhD students

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

43/SURAO

Participant	43	Sprava ulozist radioaktivnich odpadu	SURAO
Description of the legal entity The Radioactive Waste Repository Authority (SURAO) is a Czech state organisation and its activities and management are regulated by Article 113 of Act 263/2016 (the Atomic Act). SURAO's mission is to ensure the safe disposal of existing and future radioactive waste in compliance with the requirements of nuclear safety and human and environmental protection. SURAO's most important responsibilities include the operation of 3 low- and intermediate-level radioactive waste repositories. SURAO also coordinates the considerable work necessary regarding the development and construction of a deep geological repository for high-level radioactive waste and spent nuclear fuel, the commencement of operation of which is planned in 2065 according to the Policy of Radioactive Waste Management as approved by the Government of the Czech Republic and for which a Strategic Environmental Assessment (SEA) was granted last year as part of the Nuclear Action Plan covering the next few decades.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal SURAO is involved in 6 EURAD RD&D work packages as well as in two Strategic Study WPs; SURAO also leads the KM Guidance WP (WP 12). WP HITEC: SURAO and its LTPs (CTU, CU and UJV Rez) have been involved for many years in the characterisation and modelling of the thermo-mechanical behaviour of bentonite both through Czech and wider European projects. All the previous research experiments were limited to a temperature of 95°C. SURAO and its LTPs propose to conduct the characterisation and to model the thermo-mechanical behaviour of bentonite at temperatures in excess of 100°C. WP CORI: SURAO will work with the following LTPs: UJV Rez and the Czech Technical University (CTU). Experimental work will focus on the degradation of concrete organic additives and ion-exchange resins and the migration of radionuclides and their complexes.			

WP FUTURE: SURAO, together with the LTP UJV Rez, is interested in attaining a more detailed understanding of radionuclide mobility in crystalline rocks. Determining a fundamental understanding of radionuclide mobility makes up the basic prerequisite for the performance of a credible safety assessment of the future radioactive waste repository.

WP ACED: SURAO will work with the LTP UJV Rez on the analysis and modelling of the thermal, hydrogeological and mechanical processes and their mutual links that occur in deep geological repositories hosted by crystalline rocks in order to obtain a more detailed understanding of their effects on repository long-term safety.

WP DONUT: SURAO and its LTPs (CTU, CU, TUL, UJV Rez) will contribute towards the development of robust and efficient numerical methods for the simulation of thermo-hydro-mechanical (THM) processes in bentonite barriers and host rocks. Development will include the use of parallel computing algorithms for the solving of complex associated issues.

WP GAS: SURAO and its LTPs (UJV Rez and CTU) already have the technical and instrumental infrastructure for the research of gas migration in bentonite materials. The research programme will involve laboratory gas injection tests on bentonite samples using air and hydrogen.

SURAO would like to attend debates in order to be able to determine the deliverables and form conclusions of the both Strategic Study WPs.

SURAO is the leader of the knowledge management Work Package (WP 12) which aims to clarify and justify the priorities of Guides for the pre-disposal and siting processes. It is intended that these Guides will lead to the determination of guidelines for the further development of National Programmes in countries with early-stage ones and which will help in terms of differentiating between them and countries with small programmes. The optimisation and adaptation of such programmes to the coming decades which will be characterised by the digital economy and the development of robotics will provide inspiration with respect to identifying the advantages of a common approach in several areas that meets the challenges of the new public environment, safety requirements and security with concern to the final disposal projects adopted in countries with early-stage programmes. The collection of positive arguments for decision-makers employing *inter alia* recommendations/conclusions from SITEX and IGD-TP - the outputs will be very useful for developing Summer schools and the exchange of researchers throughout the European Research Area thus improving mutual communication, reducing costs via the sharing of knowledge and experience, etc.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

44/SURO

Participant	44	Statni ustav radiacni ochrany, vvi (National Radiation Protection Institute)	SURO
Description of the legal entity			
SURO is a non-profit research institution and mandated TSO in radiation protection and nuclear safety. SURO was founded by State Office for Nuclear Safety (SUJB) in 1995. The mission of SURO is focused on research in the field of radiation protection, emergency preparedness and nuclear safety, including radioactive waste management, providing SUJB with research, expertise, methodologies, supervision, legislative support and consultation activities. SURO operates the main part of Czech National Radiation Monitoring Network including independent monitoring of nuclear power plants and radioactive waste disposal sites. SURO is an accredited laboratory in radioactivity measurements. SURO is engaged in training and tutoring in the field of nuclear safety and radiation protection, hosting IAEA trainees (based on signed Memorandum between IAEA and SURO) and cooperating with ENSTTI. With respect to the statutory request (new Atomic law, 263/2016), the Research Centre Rez (CV REZ) has agreed with SUJB on building of an independent technical and expert support in the area of nuclear safety, including RWM, inside the SURO. Due to this decision, human and material resources of CV REZ TSO			

group have gradually started to be transferred from CV REZ into SURO to ensure a high level of competent and independent expertise in all basic areas related to the evaluation of nuclear safety. This process has started in January 2017 based on signed Agreement between CV REZ and SURO.

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

SURO is engaged in both Strategic studies Workpackages and in Knowledge programme.

ROUTES - (T2, T4, T5, T6), UMAN (T4):

SURO including TSO team transferred from CV REZ can provide an experience with more than 60 years of national nuclear energy development, including RWM programme establishment and implementation and identification of relevant research needs, in particular in radwaste disposal. SURO team can also provide experience with different kind of waste. Concerning research reactors operation when a certain part of generated liquid and solid waste was put in stores without proper documentation; thus, they have been missing information about their origin, amount, and radiochemical composition. These wastes were contaminated mostly by fission products, but also by transuranium elements. To remove those waste, procedures for their characterisation, retrieval, and re-processing in line with waste acceptance requirements for their disposal have been developed. These activities were accompanied by the assessment of the environmental pollution, esp. monitoring of underground water, airborne measurements; dose risks of involved personnel, and the effectiveness of applied procedures. This knowledge will be completed by experience from both national and international RWM programmes establishment, in particular for countries with small amount of radwaste with different disposal solution.

Due to a large international experience in RWM, expert team can contribute to the shared solutions for RWM.

Based on experience gathered within national RWM programme development and knowledge obtained at international level, SURO team can contribute to the identification and characterisation of different actors across necessary phases of disposal programme with respect to the management of different types of uncertainties and their management options.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

45/TNO

Participant	45	TNO (Alwina Hoving, Jasper Griffioen)	TNO
Description of the legal entity The Netherlands organisation for applied scientific research TNO (TNO) is an internationally oriented knowledge organisation for private industry, government and governmental organisations. It is active in technical, earth, environmental, life, societal and behavioural sciences and has a staff of c. 3,500. The unit Geological Survey of the Netherlands TNO is nationally responsible for all geoscientific data and groundwater monitoring information. As such TNO-GSN is the national information provider on subsurface data, including the 3D groundwater information products REGIS, GeoTop and webservices such as Groundwater Tools. It has built up leading experience in the development of environmental databases. TNO has several laboratories among which a geochemical laboratory, that is shared with Utrecht University and knowledge organisation Deltares. The laboratory comprises analytical and experimental facilities for environmental geochemical and also sedimentological, stratigraphical, paleontological, and petrological applications. In addition, the laboratories comprise electron microscopic and advanced mass spectrometric facilities. TNO has extensive expertise in environmental geochemical characterisation of the subsurface both within the framework of its responsibility as geological survey and for individual purposes. TNO has over 30 years of experience in supporting industries and authorities in groundwater and subsurface management where environmental issues aimed at a sustainable use and environmentally responsible management of groundwater and other subsurface resources become addressed. All kinds of risk assessment studies of anthropogenic, subsurface activities have been performed by TNO: Carbon Capture and Storage, oil and gas production, geothermal energy production, high temperature - aquifer			



thermal energy storage, storage in salt caverns, etc. It has also been strongly involved in the Dutch, national research programs on disposal of radioactive waste among which the last OPERA program.

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

TNO will contribute to WP FUTuRE (Fundamental understanding of radionuclide retention). Here, we will participate in Subtask 1.2 where we will contribute to the preparation of the State-of-the-art report and update with our focus on redox reactivity. We will also contribute to Task 3 where we will carry out the geochemical and mineralogical characterization of various model clay minerals, including the electrochemical redox reactivity and we will carry out batch experiments to assess the redox reactivity of model clay minerals towards Se as a radionuclide. This fits well in the overarching goal of task 3 “Redox”, which is to contribute to a better understanding of the coupled sorption and electron transfer interface reactions governing the retention of redox-sensitive radionuclides on Fe(II)/Fe(III) bearing minerals so as to improve the capacity to model, and thus predict, the fate of these elements within the safety assessment of radioactive waste storage.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

46/TS Enercon

Participant	46	TS Enercon Ltd.	TSE
Description of the legal entity			
TS Enercon Ltd. is a Budapest-based engineering and consulting organization specializing in radioactive waste and spent fuel management issues, safety and reliability of fuel cycle facilities, design of fuel storage methodologies both for nuclear power plants and research reactors, radioactive waste management, storage and disposal technologies. TS Enercon carries out safety assessments, safety cases, and feasibility studies for both nuclear and radioactive waste management installations.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal			
TS Enercon Ltd. is participating in DONUT WP, since it has experience in modelling of contaminant migration in various media. Modelling of coupled processes is important for the safety assessments of the Hungarian radioactive waste and spent fuel disposal program, therefore it is essential to be involved in activities that aim to improve modelling tools.			
Uncertainties in safety cases as the sensitivity analyses are important to understand as well. Experiences in the field of inventory uncertainties are planned to be shared, further developed in the strategic study aiming to examine uncertainties.			
Experience regarding management of historic waste and development of WAC is planned to be shared in the strategic study for the radioactive waste management.			

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

47/TUS

Participant	47	TECHNICAL UNIVERSITY OF SOFIA	TUS
Description of the legal entity			
Technical University of Sofia (TUS) in Bulgaria is the biggest higher technical educational and research complex in the fields of thermal-, nuclear- and electrical power engineering, computer science and technologies, communications, etc. with close contacts and cooperation with governmental energy institutions and nuclear regulatory body. TUS has national role for the distribution of safety engineering knowledge and analysis, and for development of the Energy and Nuclear Energy Research Area in Bulgaria. The Research and Development Sector (R&DS) of TUS organizes, administrates and services of the research activities of TUS.			

The Safety and Environmental Engineering Laboratory (SE&EL) by the Electrical Power Department at TUS, has significant experience regarding VVER safety analysis and studies, Environmental Impact Assessment of NPPs with caution to the radwaste management, ASTEC benchmark calculations, post-test analysis, etc. In these activities the team of SE&EL often works together with involved experts from Kozloduy NPP plc, Bulgarian Academy of Science and other institutes and companies. TUS, in particular SE&EL has an experience in the nuclear and severe accident research in the frame of 5FP Projects - PHEBEN2 and RMPS; 6FP Projects - SARNET, COVERS and NEPTUNO; 7FP Projects SARNET2, NEWLANCER, ASAMPSA-E and ARCADIA. Since 2002 TUS was participant in the PHEBUS FP Programme. TUS, in particular SE&EL was initiator for preparation and implementation joint with CEA and KIT (then FZK) teams different experiments (2003-2006) for VVER conditions in experimental program PLINIUS - COLIMA tests, and in LACOMERA platform – COMET-1 (MCCI), DISCO-L2 (DCH) and LIVE-L1 tests, etc.

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

The profile of TUS shows relevant level of expertise and matches the tasks in the proposal, and namely TUS' main tasks in the WPs tasks are:

WP SFC:

T2: To contribute in Subtasks 2.4.1 and 2.4.2 – TUS joint with JSI is responsible to define the big SNF data set packages A to C, collect the relevant information, standardize it and make it ready-to-use for the other partners, and to lead the evaluation of results of both code categories (best practice industry and sophisticated) used.

T3: To contribute in Subtasks 3.1 with modelling work, numerical simulations and analysis for evolution studies of SNF rods. To lead the preparation of D 3.1.9 Development of a numerical tool for the evolution studies of SNF rods.

T4: To contribute in Subtasks:

- ST 4.1 with listing, grouping, ranking and prioritization of internal and external hazards (natural disasters and human factors) which can cause accidents and emergency conditions during extended storage, transport and emplacement of the SNF; Study and description of potential accident scenarios and ranking of the most probable and worst 1-3 scenarios related to the transport and long-term dry interim storage of SNF; Participation in the development of an engineering methodology capable of assessing the scenarios. To lead the preparation of D 4.1.1 Identification and description of potential accident scenarios.
- ST4.2 with numerical simulations and consequence analysis of postulated accidents and expert assessment of criticality safety for accident scenarios (fuel release). Participation in the criticality safety analysis for different loading schemes for transport/storage casks.

WP DONUT:

T4: To contribute with generalised review on the developed and proposed benchmarks for the evaluation of numerical tools and methods for coupled processes; evaluations of the efficiency and applicability of new algorithms by strong non-linearity and non-monotonic systems, and sensitivity analysis of large-scale mathematical models for conditions of pre-disposal and of geological repositories.

WP ROUTES:

T2: To contribute in Subtasks 2.1, 2.2, 2.4 and 2.5 with providing national data on radioactive waste categorisation/classification, check and complete synthesis on practical issues on waste management routes for challenging waste, and participation in T2 exchange meetings.

T3: To contribute in Subtask 3.1 with collection, analysis and comparison of the existing knowledge about techniques and practices for characterisation of RWs and identification of the needs for future R&D concerning Bulgaria, and to participate in information exchange for Subtasks 3.2 and 3.3.

T4: To provide input and participate in workshops of the WP.

WP UMAN:

T2: To contribute in Subtasks 2.2 to the compilation, assessment and improvement of approaches for the ranking, selection and prioritisation of uncertainties, reviewing the deliverable, and participating in technical meetings.

T4: To contribute in Subtasks 4.2 to the compilation and review of uncertainty management options, provide an input regarding the options considered in the Bulgarian programme, and to the writing of D4.2.

T5: To contribute in Subtasks 5.2 to the development of materials related to Topic 2 for seminars 2 and 3, and to the development of D5.2. TUS will be responsible for the practical organisation of seminar 2 and preparation of the minutes.

In addition to the above tasks:

TUS could host some project/WPs meetings in Bulgaria.

TUS, on the basis of his experience in previous EC projects, could organize issue of dissemination materials of EURAD project with high quality and good competitive price.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

48/UCY

Participant	48	University of Cyprus	UCY
Description of the legal entity			
The University of Cyprus (UCY) has been established under the University Law 144/1989. UCY is a public corporate body and is operating subject to the provision of its Law, Regulations, Rules and Internal Guidelines. The main objectives of the University are twofold: the promotion of scholarship and education through teaching and research, and the enhancement of the cultural, social and economic development of Cyprus.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal			
The Radioanalytical-Environmental Chemistry Lab of UCY is the only Lab in Cyprus, which activities include research related to the chemical behaviour of radionuclides in the environment and particularly their interaction with inorganic and organic surfaces present in natural systems. Moreover, the Radioanalytical-Environmental Chemistry Lab of UCY is in close collaboration with the local radiation protection authorities and supports (when needed) governmental labs dealing with radiation/radionuclide measurements.			

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

49/UHelsinki

Participant	49	University of Helsinki	UH
The University of Helsinki , established in 1640, is the most versatile research university in Finland. It includes eleven faculties. The University has ca. 31 000 students and 7 800 employees. (https://www.helsinki.fi/en/university/the-university-of-helsinki-in-brief).			
High-level research is carried out at the departments of the faculties and departmentally affiliated research stations, as well as at independent research institutes. In 2017, the University of Helsinki placed 56th in the Shanghai Ranking, 90th in the Times Higher Education World University Ranking and 102th in the QS World University Ranking and 81th in the Taiwan (NTU) ranking.			
The University lays special emphasis on the quality of education and research. The University monitors the research quality by organising research assessment exercises using international peer review process approximately every six years. The University of Helsinki is a member of the League of the European Research Universities (LERU).			
The Research Funding Services of the University of Helsinki was established in 1994 with an aim to provide centralised research administration and management services for the researchers of the University. The unit is part of the Research Services, which is one of the six sectors of the University Services. In the previous EU's Framework Programmes the unit has gained valuable experience from providing support services to over 800 projects, out of which to 240 FP7 and currently over 140 Horizon 2020 funded projects.			
The Department of Chemistry is the leading hub of chemistry teaching and research in Finland. The research carried out at the department is highly valued internationally, and it is divided into three research programmes: Materials Chemistry , Molecular Science , and Synthesis and Analysis . The molecular research unit of the Department of Chemistry combines many complementary molecular and methodological approaches, both experimental and theoretical . The main directions of experimental studies are exhaled human air monitoring, photochemistry, low-temperature chemistry, fundamental reaction studies, gas kinetics, solid phase and surface reactions, and combustion chemistry. We actively develop infrared optical frequency			

combs, precision laser spectroscopy and mass spectrometric techniques, to name a few. In parallel to experimental techniques, we develop and employ a multitude of theoretical and computational methods.

The radiochemistry research is a part of molecular science research programme. The radiochemistry research is focused on four areas, the largest one of them being study on behaviour of radionuclides in the geosphere in reference to final disposal of spent nuclear fuel. Another are related to nuclear waste is the development of inorganic ion exchangers for the selective removal of radionuclides from nuclear waste effluents. Third area is radiopharmaceutical chemistry and fourth environmental radioactivity. The Disposal of nuclear waste team is based at the Department of Chemistry on the Kumpula Science campus. The research is focused on providing realistic parameters for safety analysis of the final disposal of nuclear waste and improving the understanding of chemical and physical processes of elements in geomaterials. The team provides a wide range of services from structure characterization to transport modelling.

Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal

EURAD-1 FUTURE: Sample characterisation by C-14 PMMA autoradiography, XRD, SSA and X-μCT.

Sorption and matrix diffusion experiments with ²²⁶Ra on pure minerals and rock samples and interpretation of the results from sorption and matrix diffusion experiments.

EURAD-1 HITEC: Batch type tests to follow bentonite mass loss and characterization of the clay properties in micro or nanoscale after the heat treatment. Determination of the rheological (flow) properties as a function of temperature (20 – 150 °C) of sol, sol-gel, gel and colloidal phases.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

50/UKRI-BGS

Participant	50	British Geological Survey – United Kingdom Research and Innovation	BGS-UKRI
Description of the legal entity The British Geological Survey (BGS) is an applied geoscience research centre that is housed in UK Research and Innovation (UKRI) and affiliated to the Natural Environment Research Council (NERC). It is a world leading geological survey that provides a core science mission to inform government of science related to the subsurface and its interfaces and also undertakes applied research for solutions to earth and environmental processes, both in the UK and globally. It is funded directly by UKRI as well as through research grants and via private sector contracts. BGS has an annual budget of approximately £60 million and employs 650 people. It has two main sites, a head office in Keyworth near Nottingham and the Lyell Centre, which is a joint collaboration with Heriot Watt University in Edinburgh. BGS works with more than 150 private sector organisations as well as having close links with 40 universities and sponsors approximately 100 PhD students each year.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal BGS contribution will be within work package: Mechanistic understanding of gas transport in clay materials (GAS) . Within this, BGS in partnership with ONDRAF/NIRAS will co-lead subtask 1.2 State-of-the-art (SOTA) , producing a SOTA report based on the state of knowledge before EURAD-1. This will be available by month 12. BGS will contribute to subtask 2.1 Diffusion and retardation which focuses on diffusion and gas adsorption experiments. Specifically BGS, specifically will perform and model experiments on clay simulants to investigate the impact of mineralogy on the diffusion coefficient. A series of tests will be performed providing reference values for different mineral combinations, yielding data of interest to multiple end-users. This main body of experimental work be undertaken between month 6 and month 36 with reporting following this.			

BGS will lead **subtask 2.2 Advection** performing experiments to identify the governing processes for natural and engineered materials and on simulant materials to explore the dependency of transport mechanisms to petro-physical properties. Pathway imaging techniques will also be used. Finally, observations will also be up-scaled to include in-situ measurements of gas migration at a repository-relevant scale using the Lasgit facility at the Äspö URL managed by SKB.

Experiments will run from month 6 to month 48 with reporting to follow.

BGS, in partnership with CNRS (GeoResources – Nancy and IC2MP – Poitiers) will contribute to **Subtask 3.1 Gas induced impacts on barrier integrity** undertaking phenomenological experiments using a direct shear rig for water/gas injection experiments. Shear fractures will be created within the apparatus while tensile fractures will be created externally. Quantitative textural information of all fracture surfaces will be determined prior, and after, detailed experimental work by BGS. This will be undertaken between month 6 and month 24.

Under **subtask 3.2 Pathway closure and sealing processes**, BGS, in partnership with CNRS will extend the experimental work in subtask 3.1 beyond the shut-in phase to visualise at pore scale the complex HM-C interactions, which are associated with the self-sealing process.

BGS will contribute to meetings, reporting and dissemination throughout the lifetime of the project.

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

51/VTT

Participant	51	Teknologian tutkimuskeskus VTT (VTT Technical Research Centre of Finland Ltd)	VTT
Description of the legal entity VTT Group is the largest public applied research activity in Northern Europe with a staff of 2600 and turnover of M€ 279. VTT has 75 years of experience in addressing the needs of industry and the knowledge-based society. Over the years, VTT has participated in more than 1000 European R&D Framework Programme projects, within various thematic programmes. VTT is currently involved in over 10 H2020 Euratom projects and is an active member of IGD-TP. VTT has partnership agreements and works in close cooperation with both the waste management producers and repository operators (Fortum, TVO, Fennovoima, Posiva) and the Finnish Nuclear Regulatory Authority (STUK). VTT is a multi-technological research organisation providing high-end technology solutions and innovation services.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal VTT is a mandated actor, reporting to the Ministry Economic Affairs and Employment within the Finnish government. VTT (Erika Holt), together with Posiva and University of Helsinki, coordinate the Finland partners' involvement in EURAD.			
Regarding specific WPs identified in the 1 st wave, VTT participates to the following: - WP HITEC: Coordinator (Markus Olin). - WP ACED: Task 4 leader (Pauliina Rajjala, Markku Leivo) - WP SFC: Contributor (Silja Häkkinen) - WP UMAN: Contributor (Marja Ylönen, Rafael Popper)			
VTT also has the coordinator role for the Finnish Research Program on Nuclear Waste Management (ongoing KYT2018, in planning KYT2022), where there may be complimentary domestic R&D compared to EURAD. http://kyt2018.vtt.fi/en/			



For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

52/VUJE

Participant	52	VUJE, a.s.	VUJE
Description of the legal entity			
VUJE a.s. is an engineering company that performs design, supply, implementation, research and training activities, particularly in the field of nuclear and conventional power generation.			
Description of main tasks in the proposal, with an explanation of how its profile matches the tasks in the proposal			
VUJE, a.s. shall be involved in Task No. 3 “Description and comparison of radwaste characterisation approaches”. Its profile matches the following subtasks:			
- Identification of characterisation techniques for radioactive waste (selected in Task 2); - Comparison of the characterisation methods applied for the same radioactive waste in different countries; - Analysis of the existing approaches and identification of the knowledge gaps; - Recommendations for the future R&D to eliminate knowledge gaps; - Recommendations for characterisation approaches for countries with non-developed waste management concept.			

For full details on profile of the persons who will be primarily responsible for carrying out the proposed research and/or innovation activities and of any significant infrastructure/items of technical equipment, relevant to the proposed work, see Proposal Part B Section 4.

2.6.2. Third Parties involved in the project

1/ Andra

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	Y
Andra plans to get support from a subcontractor for its work under WP1 – Programme Management and more specifically under: - task 3 - Extension/update of the Roadmap/SRA; - task 4 - Identification of Experts; - task 5 - Internal communication/meetings and - Task 6 – Dissemination.	
Does the participant envisage that part of its work is performed by linked third parties	Y
BRGM is a public institute and acts as the French Geological Survey. It embraces activities in the field of applied Earth Sciences, e.g. geology, hydrology, hydrogeology, geochemistry, geophysics, biotechnologies, hydrometallurgy, and analytical chemistry. For 20 years, BRGM cooperates with Andra in the framework of a scientific partnership. Thanks to this partnership and its implication in many EU projects, BRGM has acquired internationally renowned experience in several fields including coupled geochemistry-transport modelling, validation of the concepts of storages, transfers of pollutants in the environment, performances of the barriers and durability of materials of the artificial barriers. Within EURAD, BRGM, as a linked third party of Andra, will be involved in	

- WP3 DONUT
 - o BRGM is the WP leader of DONUT and contribute to task 1 Coordination
 - o Task 2 - BRGM will 1) develop numerical schemes to include advective transport in reactive transport codes dealing with the presence of a charged diffuse layer in the porosity; 2) develop a Poisson-Nernst-Planck model in Openfoam and 3) make available a toolbox to the community to help in the interpretation of laboratory studies (e.g. in-situ experiment running in Underground Research Laboratories) with state-of-the-art reactive transport codes capabilities.
 - o Task 3 – BRGM will apply pore-scale and micro-continuum models to pore-scale data sets to derive Darcy-scale properties of electrochemical transport.
 - o Task 4 - BRGM will investigate advanced techniques to take into account uncertainties from coupled process in nuclear waste disposal : development of surrogates in the time-space-parametric (such as polynomial chaos expansions (PCEs)), use of adapted method to sensitivity analysis with dependent parameters (estimation of a posteriori distributions in order to minimize the difference between observations and simulations)
- WP5 FUTURE
 - o Task 2 – Mobility: Task 2.3: BRGM will contribute as follows: Fine characterization of U-bearing phases/surfaces in clay-rocks and of radionuclides (or their stable isotopes counterpart). Adsorption processes on clay minerals surface using wet chemistry and spectroscopic, diffractometric and microscopic techniques. Unravelling of retention mechanisms from site localization as a function of chemical conditions and linking to the reversibility or irreversibility of the processes and thus the type of thermokinetic description that should be considered (surface adsorption, incorporation, co-precipitation etc.). Modelling of reversible adsorption processes using electrostatic surface complexation models adapted to the specificities of clay minerals surfaces.
 - o Task 3 - Redox reactivity of radionuclides on mineral surfaces: BRGM is the leader of this task. BRGM will prepare and provide sample to the partners: an anionic, a cationic clay, and an iron oxide of interest for the partners. These samples will be provided in various Fe oxidation states (various Fe(II)/Fe(III) ratio and different structural location of Fe). The abundance and structural location of Fe(II) and Fe(III) will be determined using a combination of methods: Mossbauer spectrometry and chemical methods for macroscopic average Fe oxidation state, transmission electron, and diffractometric methods (powder X-ray diffraction and synchrotron techniques) to determine the crystal chemistry of the samples.
- WP7 HITEC:
 - o Task 3.2: [Andra (BRGM)] will measure swelling pressure during the hydration of a bentonite (Kunipia-G or MX-80) at temperatures between 100 and 150°C with solutions of different compositions (cations and ionic strength) using an oedometer cell suitable for X-ray tomography acquisition to visualize in situ the evolution of the microstructure evolution. Swelling experiments will be simulated accounting for both mechanical compaction, temperature changes, water flow and chemical effects. A comparison of modelling approaches will be made with the Charles University hypoplastic model for swelling clays.
- WP3 CORI :
 - o Task 2 Organic degradation –BRGM will perform g-radiolytic/hydrolytic degradation of Superplasticizer/PVC or IER with identification of degradation products by complementary work with ISTO
- WP2 ACED:
 - o Task 3.2 - modelling the selected reference experiments studied in subtask 3.1 and the evolution of a HLW waste package for vitrified waste consisting of a glass core encapsulated in an iron/steel canister and in contact with a cement or cement/clay backfill.

It will involve testing and comparing different conceptual models including different features (description of heterogeneities, e.g. voids) and processes, and/or waste alteration models and/or different corrosion models and/or degradation of concrete materials models and/or different reactive transport codes (PhreeqC, Hytec, Crunch, OpenGeoSys-GEM, etc.). o Task 3.3 - modelling the long-term chemical evolution of ILW waste packages and to provide upscaled effective parameters for usage in disposal cell scale reactive transport models. investigate the chemical evolution considering different scenarios and different processes. This task will involve testing and comparing different models, including different features and processes, like waste alteration models, corrosion models or concrete degradation models with different reactive transport codes. The choice of scenarios and processes has to be coordinated with task 4 in order to avoid inconsistencies between waste package and disposal cell scale. The planned scenarios are related to intermediate storage of waste packages (important for definition of initial state at emplacement), after emplacement the evolution under fully liquid saturated conditions and the evolution under partially saturated conditions.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

2/ ARAO

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

3/ BEL V

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

4/ BGE

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

5/ CEA

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
EDF (<i>Electricité de France</i>) group is the world's leading electricity company and global leader for low-carbon energy production. Particularly well established in Europe, especially France, the United Kingdom, Italy and Belgium, as well as North and South America, the Group covers all businesses spanning the electricity value chain – from generation to distribution and including energy transmission and trading activities – to continuously balance supply and demand. The R&D Division is made up of 13 technical departments. Their skills cover all the Group's field of activities: renewable energies and storage, networks, nuclear generation, thermal, hydropower, energy management, environment. EDF and CEA are	

linked through a cooperation agreement, which includes research activities on radioactive waste and spent fuel management, and on the behaviour of engineered/natural barriers in disposal. The tasks performed by the third party concern thermo-mechanical modelling of clay rocks. EDF will contribute to the development of numerical methods for high performance computing of coupled processes (WP DONUT), to numerical modeling of gas induced damage and self-sealing of barrier (WP GAS), and to the benchmark exercise on THM modelling of effect of temperature in near and far field using the code_Aster. EDF launched a glass/steel/cement buffer/clay experiment in April 2018. In the framework of WP ACED, EDF will provide characterization of this experiment at various time steps, in collaboration with CEA. This experiment is complementary to the long-term glass/steel/clay experiment, proposed by CEA. Since a long-time, ORANO Cycle (previously AREVA-NC) has been the industrial partner of CEA in the development of innovative processes and technologies for the nuclear fuel cycle, from the mine to the treatment of spent fuel. ORANO Cycle develops solutions for the management of radioactive wastes produced by spent nuclear fuel treatment operations. The most famous one is the vitrification process developed for the confinement of high-level wastes. In parallel, ORANO Cycle develops also new conditioning processes for ILW. In the framework of EURAD, ORANO Cycle will contribute to the WP ROUTES by sharing its experience on methodologies of characterization of radioactive wastes and waste conditioning. ORANO is particularly involved in the task dedicated to the development of shared solutions in European countries for the management of radioactive wastes.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

6/ CIEMAT

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
Third Party: The Spanish National Research Council (CSIC) is a public institution dedicated to research in Spain. Belonging to the Spanish Ministry of Science, Innovation and Universities through the Secretary of State for Universities, Research, Development and Innovation, its main objective is to develop and promote research that will help bring about scientific and technological progress, and it is prepared to collaborate with Spanish and foreign entities in order to achieve this aim. The Institute for Construction Sciences “Eduardo Torroja” (IETcc) belongs to CSIC. Its mission is to develop research and technology in the construction field infrastructures and its materials. The IETcc is specialized in: physic-chemistry of cement and concrete, raw materials, sustainability, nanotechnology and multifunctional building materials, structural engineering, risk and safety of structures, roads, building energy saving, environment, durability, circular economy and life cycle analyses. Link of the participant to the third party: CSIC and CIEMAT subscribed a framework agreement entitled “Convenio marco de colaboración entre el centros de investigaciones energéticas medioambientales y tecnológicas y el consejo superior de investigaciones científicas” and since June 1989 with ref. UCA1989010008 that establishes the will and conditions for continuous collaboration in the research in all the fields of CIEMAT R&D including nuclear technology. The framework agreement is every 4 years updating and both institutions have used this agreement to collaborate in a number of projects on research programs cooperation, nuclear advice and	

management, personal exchange and training in different areas of nuclear research including topics on waste management.

- Tasks to be performed by the third party:

1.- Cement-Organics-Radionuclides-Interactions (CORI). Within this WP, CSIC will contribute in Task n°3 - Organics-Cement-Interactions. CSIC will study the interactions that take place between different organic species (tentatively ISA, Acetate, EDTA and carboxylic acid) when they are incorporated (individually and combined) into HCP (CEM V, with pH < 12.5 and alkali-free as possible) through different transport mechanisms (adsorption, natural diffusion and electrically-driven diffusion). In addition to the plain cement, twin samples with an extra addition of Fe will be incorporated when casting to decipher the role of iron.

2.- Assessment of chemical evolution of ILW and HLW disposal cell. T2: Steel Concrete Interface: The CSIC contribution consist in the study the chemical evolution of the steel corrosion phenomena due to the interaction with the concrete in variable environmental conditions: Concrete pH, type of aggressive ion, T^a, moisture content and oxygenation level) will be under the focus of research. The main objective is to obtain reliable kinetic and microstructural data of the relevant parameters causing steel corrosion and further instability in the concrete that allow to understand the phenomena occurring at the interface and contribute to the modelling of the long-term service life of the repository.

Third Party: Universidad Politécnica de Cataluña (UPC) is a public university created in March 1971, aims to offer high-quality training and education leading to prestigious degrees, diplomas and courses. Regarding research and technology. The research group of the Geotechnical Engineering and Geosciences Division of the Department of the Department of Civil and Environmental Engineering has developed an advanced state-of-the-art in-house computer code (CODE_BRIGHT) able to perform coupled thermo-hydro-mechanical (THM) analyses. The code also incorporates constitutive laws appropriate for the description of the behaviour of the types of material involved in nuclear waste disposal. The group has an advanced laboratory to perform THM tests on materials often used in radioactive waste disposal such as bentonite and argillaceous rock. The group has also access to facilities such as ESEM (environmental electron microscope) and MIP (mercury intrusion porosimeter) to determine microscopic features of the materials.

- Link of the participant to the third party: UPC and CIEMAT subscribed a framework agreement entitled “Convenio marco de colaboración entre el centros de investigaciones energéticas medioambientales y tecnológicas (CIEMAT) y la universidad politécnica de Cataluña (UPC)” since February 2018 with ref.8266/2018 that establishes the will and conditions for continuous collaboration in the research in all the fields of CIEMAT R&D including nuclear technology. CIEMAT and UPC are using this agreement to collaborate in the nuclear research including topics on radiological protection, waste management, environment protection, computational studies, materials studies and fission & fusion Energy. In addition CIEMAT and UPC are members of the CEIDEN Spanish nuclear platform for nuclear research where they collaborate on the definition and development of research projects on nuclear technologies including aspects of the nuclear waste management.

- Tasks to be performed by the third party:

1.- Mechanistic understanding of gas transport in clay materials (GAS) into the Modelling of experimental work by CIEMAT will be developed by UPC team. The main effort will be devoted to the modelling of laboratory data sets in order to interpret the results and offer directions for future experimental work. The focus will be on the identification and quantification of the phenomena that govern gas flow behaviour. Heterogeneity will be introduced via consistent random and auto-correlated distributions of properties or parameters that will be coupled between them. A special type of finite element formulation will be used that allows the simulation of discrete gas flow paths embedded in a continuum. The information and expertise gathered during the performance of the modelling work will be put into operation in the final synthesis of the results and in the evaluation of the scientific achievements.

2.- Influence of temperature on clay-based material behaviour (HITEC) UPC will make available a recently developed advanced stress-strain law for clay rocks which includes non-linearity and plasticity before peak strength, softening after peak, anisotropy of stiffness and strength, creep (visco-elastic and visco-plastic) and permeability variation due to damage and self-sealing. The law will be further developed by introducing thermo-plasticity. Another key development will be the simulation fracture generation due to overpressure and/or temperature and their propagation. A non-local formulation has proved capable of predicting the development and propagation of discontinuities under isothermal conditions. The formulation will be generalised to include specific thermal effects taking into account the variation of permeability in the discontinuity.

Third Party: Universidad Autónoma de Madrid (UAM) hosts one of the largest scientific communities in Spain whose research meets international standards which is recognized as “Campus de Excelencia” that incorporates highly qualified research groups from the Spanish National Research Council (CSIC).

- Link of the participant to the third party: UAM and CIEMAT subscribed a framework agreement “Convenio de colaboración entre la Junta de energía nuclear (CIEMAT) y la Universidad Autónoma de Madrid” since October 1985 with ref. 25/84 that establishes the will and conditions for continuous collaboration in the research in all the fields of CIEMAT R&D including nuclear technology. The framework agreement is still valid and CIEMAT and UAM have used this agreement to collaborate in a number of projects on different areas of nuclear research including topics on waste management.
- Tasks to be performed by the third party: 2.- Influence of temperature on clay-based material behaviour (HITEC) into the Task 3.1 UAM will focus on the post mortem analyses of the laboratory-scale thermo-hydraulic cells performed by CIEMAT in Task 3.3, mainly concerning mineralogical changes that could explain the macroscopic changes observed. The research group involved, belonging to the Department of Geology and Geochemistry in the Faculty of Sciences, is devoted to the study of geochemical reactions in the clay-waste system. The group has expertise, acquired during at least 20 years, in mineralogy and geochemistry of clay minerals (sheet silicates, oxides, zeolites, salts...). In this field they manage the main techniques used for materials characterization, including XRD, surface analysis and electron and optical microscopy.

Third Party: IDOM Nuclear Services is an area of IDOM Consulting, Engineering and Architecture company. Its experience in the nuclear sector has its origins in the early nuclear generation projects in Spain in the late 70s and 80s. IDOM NS develops projects where effective protection measures are integrated at all stages of the life cycle of nuclear fuel and radioactive waste: Ageing Management, Operation Consultancy, Engineering, Accident Evaluation, Project Management, Advanced Analysis, Decommissioning.

- Link of the participant to the third party: IDOM and CIEMAT have subscribed a framework agreement since April 2011 that establishes the will and conditions for continuous collaboration in all activities related to the Nuclear field. The framework agreement is removable and still valid and both institutions are using such agreement to collaborate in a number of projects on different areas of nuclear research including topics on waste management and training. In addition CIEMAT and UPM are members of the CEIDEN Spanish nuclear platform for nuclear research where they collaborate on the definition and development of research projects on nuclear technologies including aspects of the nuclear waste management.
- Tasks to be performed by the third party: Spent Fuel characterisation and evolution until disposal (SFC) IDOM will identify the main BWR and PWR fuel data that would affect the evolution of accidents, in order to understand the relationship between the data used in the fuel characterisation task and the accident analysis during storage, transport and fuel management. This activity (included in Subtask 4.2) contributes to the main goal of the WP helping to understand fuel behaviour under normal and postulated accident scenarios.



Third Party: Technical University of Madrid, (UPM) is the largest Spanish technological university as well as a renowned European institution. With two recognitions as Campus of International Excellence, it is outstanding in its research activity together with its training of highly-qualified professionals, competitive at an international level. More than 2,400 researchers carry out their activity at the UPM, which is committed to transforming this knowledge into advances applied to the production sector.

- Link of the participant to the third party: UPM and CIEMAT has been collaborating under the framework agreement entitled “Convenio de cooperación científica entre la Junta de energía nuclear (CIEMAT) y la Universidad politécnica de Madrid” since November 1983 still valid that establishes the will and conditions for continuous collaboration in the research in all the fields of CIEMAT R&D including nuclear technology. The framework agreement is still valid and CIEMAT and UPM have used this agreement to collaborate in a number of projects on different areas of nuclear research including topics on waste management. In addition CIEMAT and UPM are members of the CEIDEN Spanish nuclear platform for nuclear research where they collaborate on the definition and development of research projects on nuclear technologies including aspects of the nuclear waste management.

- Tasks to be performed by the third party:

1.- Spent Fuel characterisation and evolution until disposal (SFC) UPM group plans experiments on unirradiated cold-worked stress-relieved Zirlo™ cladding samples according to the following activities such as experimental reproduction on unirradiated cladding of the hydride geometry observed in spent fuel cladding, after discharge, drying, transport and long-term dry interim storage. Mechanical testing of pre-hydrided samples. It is proposed to perform ring compression (RCT) and three-point bending (TPB) tests on unirradiated pre-hydrided samples before and after the simulated drying treatment at three temperatures: 20°C (worst case), 135°C (representative of long term dry interim storage) and 300°C (representative of operation conditions). 3. Analysis of failure mechanisms of unirradiated pre-hydrided cladding to elucidate the fracture micro-mechanisms. The fracture surfaces of broken samples after the ring compression and three-point bending tests will be studied by means of a scanning electron microscope (SEM). The three tasks are the ones that UPM group is going to perform in subtask 3.1 (Thermo-mechanical-chemical properties of the SNF rods and cladding) and therefore its profile matches perfectly the tasks defined in the proposal.

2.- Knowledge Management Work Package, UPM will provide educational materials and lectures developed by professors and teachers experts into the nuclear field.

Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners ⁴ (Article 14a of the General Model Grant Agreement)?	N

7/ ChRDI

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N

⁴ International Partner' is any legal entity established in a non-associated third country which is not eligible for funding under Article 10 of the Rules for Participation Regulation No 1290/2013.

Does the participant envisage that part of its work is performed by linked third parties	Y
1. National Science Center Kharkov Institute of Physics and Technology, (NSC KIPT, PIC Number: 969818320, information about NSC KIPT on site: http://www.kipt.kharkov.ua/en). The Kharkov Institute of Physics and Technology conducts scientific research in the field of nuclear physics and solid state physics. And also is one of the most active participants in scientific and research work in the field of nuclear fuel cycle. <u>Tasks to be performed by the third party:</u> NSC KIPT - WP7- HITEC. NSC KIPT will contribute to work package: Task 3.1 Assessment of the impact of high temperatures over long time periods on the clay buffer properties, from specific laboratory tests. Task 3.2 Measurement/processes at high temperature + process modelling. Using data from T3.1 and T3.2, we will be able to develop the model to simulate material behaviour for temperatures more than 150 °C. Bentonite clay MX 80 will be used for reserach tests. The scientific institutes of Ukraine did not yet participate in the research programs of the European Commission. We do not have samples that were got before within the framework of joint researches with foreign partners. Therefore, the fresh samples of bentonite clay will be prepared for tests. We plan to use saturated and unsaturated samples with various dry densities: from 1400 to 1800 kg/m³. The maximal parameters of swelling pressure will be determined for each samples and relationship between initial dry density, water content and treatment time will be obtained. Analytical investigations will be carried out to investigate the structure and chemical/transport changes in bentonite during 150C heat treatment. 2. Institution State "Institute of Environmental Geochemistry of the National Academy of Science of Ukraine", (IEG NAS of Ukraine, PIC Number: 953812253, information about IEG NAS of Ukraine on site: http://www.igns.gov.ua/). State Institute "Institute of Environmental Geochemistry of the National Academy of Sciences of Ukraine" (SI "IEG NAS of Ukraine") is a state (a public research organization, PIC: 953812253) nonprofit scientific institution with the rights of a legal entity. SI "IEG NAS of Ukraine" is a leading scientific institution dealing with the problems of radioactive waste management, and ecological and radiation safety. The Institute is subordinated to the National Academy of Sciences of Ukraine as a part of the Nuclear Physics and Energy Department. The Institute staff carries out fundamental and applied research on: • scientific support of nuclear fuel cycle; • geochemistry, radiogeochemistry; • technogenic and environmental safety; • problems of decontamination of territories and equipment; • instrument-making in the sphere of nuclear, radiation and environmental safety. Institute has contributed into development of the scientific basis for long-lived radioactive waste disposal in stable geological formations and technological concepts for creation of barrier materials for ensuring safety of radioactive waste repositories. Since 2004, the Institute participates in the project "Technologies for the disposal of radioactive waste in underground research laboratories". The Institute supported the scientific program of the European Commission project "European Technology Platform - Implementation of the Geological Waste Disposal" and became its member (http://www.igdtp.eu). The Institute was responsible for management many international projects: • CAST project (CARbon-14 Source Term #604779, 7 FP EURATOM) • "Feasibility Study for an Underground Repository for Long-lived Non-heat-generating Radioactive Waste in Ukraine" / EUR 17631, Contract № B7-6340/95/001028/MAR/C3/, 1999. Institute took part in coordinated research projects of IAEA: - "Extrapolation of short term observations to time period's relevant to the isolation of long-lived radioactive waste ", IAEA-TECDOC-1177, IAEA, 2000;	

- “Characterization and performance studies and demonstration in underground research laboratories of swelling clays as engineered barriers of geological disposal”, IAEA-TECDOC-1718, IAEA, Vienna, 2013; Tasks to be performed by the third party: SI "IEG NAS of Ukraine"- have been involved for many years in the characterisation and modelling of the thermo-mechanical behaviour of bentonite both through Ukrainian and IAEA projects. All the previous research experiments were limited to a temperature of 22°C. SI "IEG NAS of Ukraine will contribute to work package 7 - HITEC: Task 3.1 Assessment of the impact of high temperatures over long time periods on the clay buffer properties, from specific laboratory tests, two of the materials included in the proposal. Task 3.2 of the impact of elevated temperature (> 100°C) on geochemical mineralogical properties of a suite of different bentonites.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

8/ CNRS

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
• Université de Poitiers (UPoitiers) Founded in 1431 by Pope Eugene IV, then confirmed by the patent letters of King Charles VII, the University of Poitiers consists from the outset of five faculties: theology, canon law, civil law, medicine and arts (letters). After the Revolution, which suppresses provincial universities, the University of Poitiers is reborn and enriched with new faculties: letters, sciences ... Today, the University of Poitiers, it is 28000 students, 4000 international students from 136 different countries, 3000 staff, 14 faculties, institutes and schools, 1000 professors-researchers, 1100 doctoral students, 37 laboratories, 8 doctoral schools, 2000 national diplomas, 180 PhD thesis defended each year, 500 partner institutions around the world and 1600 professional speakers participating in the teachings . • The Centre National de la Recherche Scientifique (CNRS) will participate in the EURAD WP Gas project via the IC2MP laboratory which is a Joint Research Unit (UMR 7285) between the CNRS and the University of Poitiers (UP). Thus the University of Poitiers is a third party linked to CNRS. Personnel with permanent positions in this project (Rochard Giot, Stephen Hédan, Baptiste Dazas) are employees from the University of Poitiers (UP). The Institute of Chemistry of Poitiers: Materials and Natural Resources (IC2MP) is a multidisciplinary research institute that specializes in the study of materials, the natural environment, and reactions. The Institute particularly focuses on the synthesis, decontamination and exploitation of natural resources. The Institute is composed of a total of ~250 persons including a staff of 100 researchers (75 faculty members from the University of Poitiers and 25 CNRS), 50 Engineers & Technician staff, ~80 PhD students and ~20 postdoctoral researchers. More specifically, they belong to the research tem E2 "HydrASA" of IC2MP laboratory. The IC2MP HydrASA team's scientific objective is the study of multiscale transfers in surface and sub-surface geosystems. The activities of the team are organized into three themes: - o Functioning of reactive geosystems (soils, sedimentary basins, aquifers, hydrothermal systems and more widely alteration systems), - o Properties and reactivity of clay mineral solutions systems - o Spatialization and multi-scale modeling of reactive transfer.	

Reactive geosystems refer to a wide variety of natural objects with very different characteristic dimensions: clay minerals and their aggregates (from nanometers to hundreds of microns), clay soil profiles (from centimeters to tens of meters) and large geological systems (from a hundred meters to a hundred kilometers). The general topic of the team is the understanding and modeling of transfers in reactive geosystems, which is based on two strong cognitive issues: the relationship between the different scales of space brought into play through these objects and the integration large time scales (geological time) in its approaches. More specifically, the team is internationally recognized thanks to its ability to mobilize multiple skills (mineralogical, crystallochemical, microstructural and geomechanical) for the study of clay media and materials.

Link of the participant to the third party: The University of Poitiers is a co-partner together with the CNRS of the Institute of Chemistry of Poitiers: Materials and Natural Resources.

Tasks to be performed by the third party:

It contributes in WP6 GAS: experimental study of the micro-structural and mineralogical changes of claystones in relation with self-sealing and gas migration on the one hand, and to the micro-macro upscaling and development and implementation of a numerical HM model accounting for gas migration and self-sealing. It fits in the scope of the priorities of the research thematic developed and the IC2MP regarding the understanding of the microstructure of clays and clayey rocks as well as upscaling of their hydro-mechanical properties.

- **Université de Montpellier (UMontpellier)**

Since 800 years, the University of Montpellier (UM) has played important scientific and societal challenges. It is composed of 16 faculties, high schools and institutes. The 78 research units are involved in 9 scientific departments, working in the fields of science and technology, medicine, pharmacy, law, economy, sport and management. The university gathers 48,000 students and 4,800 employees (teachers, researchers and administrative). In the field of chemistry, the research activities are structured in the Pôle Chimie Balard composed by four institutes (Institute Charles Gerhardt, Institute of Biomolecules Max Mousseron, Membranes European Institute and Institute of Separative Chemistry). In particular, concerning the activities devoted to nuclear energy, the University of Montpellier is involved in the Institute of Separative Chemistry of Marcoule (ICSM, Joint Research Unit shared with CEA, CNRS and High School of Chemistry of Montpellier - ENSCM). This institute is involved in several aspects dealing with the nuclear fuel cycle (separative chemistry, nuclear materials, spent fuel reprocessing, waste management,...).

- Since ICSM is a Joint Research Unit (UMR in French) between CNRS, CEA, University of Montpellier and ENSCM, several researchers from the University of Montpellier will be involved in the project. The CNRS will solicit from University of Montpellier, i.e. 1 professor: Nicolas Dacheux and 1 assistant professor: Laurent Claparède, will be involved in the project and will particularly contribute to all the tasks included in the WP Spent Fuel Characterization and Evolution until Disposal.

Link of the participant to the third party: The University of Montpellier is a co-partner together with the CNRS, the CEA and the ENSC Montpellier Institute Max Planck Chemical Physics Solids of the Institute for Separative Chemistry in Marcoule.

Tasks to be performed by the third party:

It contributes in WP8 SFC: UMontpellier will be involved in in the WP Spent Fuel characterization and evolution until disposal (Subtask 3.2. Behavior of SNF pellets under interim storage conditions). The main actions proposed by CNRS and University of Montpellier deal with the development of a micro-/macro-dual approach to examine the role of several families of FP on the behavior of UO₂ sintered samples during leaching tests. The proposed action is divided in 3 parts. The first one focuses on the role of lanthanide elements incorporated in the UO₂ ceramic during alteration (especially in terms of chemical durability and surface reactivity modifications). The second one deals with the role of platinum group metals (PGM)

elements (especially as metallic particles) as well as molybdenum present in UO₂. The last aspect will be the role of perovskite type phase on the inventory of the released elements.

- **IMT Atlantique**

The **IMT Atlantique (IMTA)** is leading French engineering school, a public Technical University created on January 1, 2017 through the merger of the École nationale supérieure des mines de Nantes and Telecom Bretagne, administered by the french General Council for the Economy, Industry, Energy and Technologies. Research is organized within thirteen departments of teaching and research : Automation, Computer-Integrated Manufacturing and IT (Nantes), Electronics (Brest), Information Technology (Brest), Image and Data Processing (Brest), Languages and International Culture (Brest), The Logic of Practices, Social and Information Sciences (Brest), Microwaves (Brest; Toulouse), Optics (Brest), Subatomic Physics and Related Technologies (Nantes), Social Science and Management (Nantes), Signals and Communications (Brest), Energy and Environmental Systems (Nantes), Network Systems, Cyber Security and Digital Law.

- All tasks of the LTP IMTA in the EJP EURAD will be performed by the department SUBATECH, which is a Joint Research Unit with the CNRS, the IMT Atlantique and the University of Nantes, headed by Dr. Gines Martinez. Principal research subjects of Subatech are in the area of nuclear physics and radiochemistry. SUBATECH has a staff of about 190 engineers, scientists and technicians, including as well post docs and PhD students. Research on nuclear waste management of relevance for the EJP is conducted by the radiochemistry group which consists of a staff of about 40.

Link of the participant to the third party: IMT Atlantique is a co-partner together with the CNRS and the University of Nantes of the joint research laboratory Subatech.

Tasks to be performed by the third party:

- 1) It contributes in Participation in the WP1 PMO
- 2) WP2 ACED : Participation in Subtask 2.1 on Steel/clay material interface reactivity with the characterization of interface experiments and in the Subtask 2.2 on Steel/cement material interface reactivity IMTA participates in the characterization in existing interface experiments between Portland cement or grout cement in contact with steel in saturated conditions and in the subtask 3 (waste package scale), IMTA will support the CEA in the dismantling and characterization of an ongoing Glass/steel/clay experiment (5 year, 50°C) and it supports SCK.CEN in the dismantling and characterization of a glass/steel/cement system experiment, already ongoing since 30 month.
- 3) In the WP10 UNAM IMTA will contribute to the Subtask 2.3 on Methodological approaches to uncertainty and sensitivity analysis and IMTA is the leader of the task 3.1 Subtask 3.1 on the the identification of the types of uncertainties relevant to the safety analysis and the safety case. IMTA will participate also in task 4.3 on Preferences of the different actors on uncertainty management options

Principal actors of IMTA in its role as LTP are:

-Abdesselam Abdelouas (CNRS/IMT-A, male) is Professor of Radiochemistry and Nuclear Materials at IMT Atlantique, and Head of the Radiochemistry Group at Subatech Laboratory, Nantes. He graduated from the University of Strasbourg, and spent a US DoE-funded Postdoc working on radioactive waste management. He was named an Expert for the European Commission in the field of Education & Training for the nuclear sector. He is also Adjunct Professor at Mody University, India. He is coordinator of the recently accepted ERASMUS mundus project SARENA. He will participate in WPs ACED and GAS

-Bernd Grambow (CNRS/IMT-A, male) is Professor of Excellence at IMT Atlantique, Nantes, holding a Chair on nuclear waste disposal and former director of Subatech laboratory. He received his PhD from the FU Berlin, and held research positions at the Pacific Northwest National Laboratory, Hahn Meitner Institute Berlin, and Forschungszentrum Karlsruhe. He is an expert in radiochemistry, nuclear waste disposal science, geochemical modeling, and radionuclide migration in the environment. He will participate in the PMO and in UMAN.



- **Université de Lorraine (ULorraine)**

The Université de Lorraine (UL) is a large multidisciplinary university, open to international collaboration. With more than 3,700 teaching and research faculty and approximately 60,000 students, including nearly 8,000 foreign students, the Université de Lorraine (UL) is one of France's largest multidisciplinary universities. Its location in the heart of Europe, with borders on three European member states (Germany, Belgium and Luxembourg) offers to UL a privileged position for strong international partnerships. The scientific activity of UL is organized in 60 research laboratories located in 10 scientific centers and 6 research federations covering a wide range of disciplinary fields and topics. In addition, the university houses several technology platforms including large-scale facilities and large measurement instruments, providing research teams with the most efficient equipment. UL is committed to numerous European and international collaborations and exchanges, including multi-partnership projects and initiatives that, in many cases, go beyond European borders. UL is currently engaged in 15 European projects, including the Biomore, Lights, Newores, and EIT Knowledge and Innovation Community Raw Materials (Eurocore, TravelEx), more specifically in the scope of the NEXT program.

- The GeoRessources Laboratory is a Joint Research Unit which brings together Nancy's most important players in the field of Applied Geology having as supervising institutions the University of Lorraine and CNRS. GeoRessources employs a total of 190 personnel and orientates itself around three main research themes:

- o "GeoModels" is a meeting-place for specialists in geometrical, geostatistical and physical-process modelling. The objectives are to forge strong collaborations between experts in digital and experimental simulation and to unite geometrical, inverse, hydrogeochemical and mechanical approaches.
- o "Raw Materials" is a place for interaction and exchange between experts in the exploration, exploitation and treatment of carbon and mineral resources. Geologists, geochemists, metallogenists and mineralogists can interact freely with one another. The 'Raw Materials' mission is to develop models that explore upstream and downstream resource cycles.
- o "GeoSystems" is a synergistic space that hosts experts in underground exploitation for the storage of waste and geothermal energy, as well as specialists in the hazards and risks associated with anthropogenic activity such as mining and excavation. Because the field of resource exploitation is developing like never before, it is essential that specialists from across the different research themes work together in finding new ways to minimize the environmental impact of resource exploitation.

The Geomodels and Geosystems themes conduct interdisciplinary research concerned with the use and management of the surface and sub-surface environment, with a strong focus on the safety of underground structures. Applications address local and national socio-economic issues, including geotechnics, environmental protection, and the surface and sub-surface storage of waste, CO₂ and H₂. The originality of the team's work lies in addressing these issues from the points of view of hydrodynamics and transfer mechanisms, as well as from poro-mechanics and geochemical perspectives.

Scientific goals of the Raw Materials theme concern a better understanding of: i) metals concentrations associated with crustal growth and evolution within the frame of plate tectonics (multimethod approach combining field geology, structural analysis, petrology, geochemistry, geochronology), ii) the processes governing the extraction of metals from rock sources, their transport by fluid phases (speciation, especially through experimental studies, and spectroscopic monitoring, fluid origin), and iii) ore formation (PVTX reconstruction through integrated paleo-fluid studies (microthermometry, Raman, spectroscopy, LA-ICP-MS), thermodynamic and experimental modeling dating of ore stages), the overall data yielding to conceptual and numerical modelling of the genesis of ore deposits within their geologic and geodynamic contexts.

Link of the participant to the third party: The University of Lorraine is a co-partner together with CNRS and the research center CREGU of the GeoRessources laboratory.

Tasks to be performed by the third party:

It contributes in :

- WP2 ACED task 3, UL-GeoRessources, based on its strong experience on solid phase characterisation, proposes to use its platforms to rigorously and finely perform chemical and mineralogical analyses of solid phases coming from the dismantlement of experiments carried out by SCK/CEN on the Glass(SM359)/Steel/Cement. The goal is to highlight mineralogical transformations in the solid phases and at the different interfaces and to follow the chemical gradients along the materials and linked to the geochemical reactivity of the different phases in contact.
- WP6 GAS: UL-GeoRessources will conduct numerical simulations of multiphase fluid transport through deformable nanoporous geomaterials using a lattice-Boltzmann model applied to FIB-SEM images of actual material. Numerical results will be used to upscale effective properties (deformation-dependent saturation curve, relative permeability). Experiments will be also conducted to follow the evolution of damage and self-sealing processes in the argillaceous rock samples during gas injection and after shut-in using a high-resolution X-ray CT scanner.
- WP7 HITEC UL-Georessources will perform mechanical tests on different clay host rocks (Boom Clay, Opalinus Clay, Callovo-Oxfordian clay) to study the propagation of fractures at elevated temperatures (40 °C, 60°C, 80 °C, 100 °C), characterize fracture shape and size at different loading stages and self-sealing process. Tests will be conducted in a transparent triaxial cell under X-ray nano-tomography, on fractured samples (with two bedding orientations) mimicking the damage expected in the near field.

The short- and long-term thermo-mechanical behaviour of 2 claystones (Opalinus Clay, Callovo-Oxfordian claystone) will be investigated at elevated temperatures (40, 60, 80 and 100 °C). Short-term triaxial tests will allow characterising mechanical properties (failure criterion, elastic coefficients). Thermal profiles will be performed before and after TM tests with the optical scanning method to determine the evolution of thermal properties with damage. Long-term triaxial tests under 2 confining pressures (2 and 12 MPa) will allow characterising creep properties. For all tests, ultrasonic velocities and acoustic emissions will be measured to assess the evolution of elastic properties and then micro-cracking damage.

- **Université de Grenoble (UGrenoble)**

University Grenoble Alpes (UGA) is a public university created in January 2016 that aims to offer high-quality training and education leading to prestigious degrees, diplomas and courses. Regarding research and technology. The research group of ISterre laboratory has as a long experience on gas sorption (M. Didier PhD thesis (2012) – supervisor L. Charlet; IDEX innovation grant to L. Truche to study H₂ sorption on clay minerals applied to energy storage), clay minerals crystallography (BET, X-Ray, FIB-TEM, ATG-DTG, infer-red spectroscopy, neutron scattering at ILL), and hydrogen experiments (ATEX lab).

- UGA is a Linked Third Party of CNRS for the participation of its employees in the project within the unit ISterre. ISterre is a Joint Research Unit between UGA, CNRS, as well as USMB, IRD, and IFFSTAR. ISterre: 280 pers. including 108 researchers. Rank 18 in Earth Science (Shanghai). 3 main scientific priorities: 1) Understanding earthquakes, landslides, volcanic eruptions and Earth's Magnetic fields, 2) What is shaping the Earth? And 2) How rocks change as a function of natural and human constraints.

Link of the participant to the third party: The University of Grenoble is a co-partner together with the CNRS and the Grenoble INP of the 3SR laboratory and ISterre.

Tasks to be performed by the third party: It contributes in :

- WP5 FUTURE: Measure hydrogen uptake by clay minerals (e.g. montmorillonite, illite, chlorite, Fe-serpentine) and clayrocks (bentonite, Callovo-Oxfordian claystone and Boom clays) as a function of H₂ partial pressure, temperature, water saturation (relative humidity), and presence of

other gases competing for sorption (CO₂, CH₄, He). H₂ sorption isotherms will be measured over a wide range of pressure (typically from 1 mbar to 100 bar) to study the retention mechanisms and fundamental thermodynamic properties of the retention process (adsorption enthalpy, role of pore size distribution, crystallographic properties of the sorption sites).

- WP6 GAS: 2. Study the desorption processes to evaluate hydrogen mobility and retention mechanisms in clay-rich porous media.

Outcomes: 1) amount of hydrogen trapped in the disposal surroundings, 3) stability or reversibility of H₂ sorption with respect to near and far field perturbations (temperature, water resaturation, secondary minerals formation triggered by iron-clay interactions), and 3) positive and negative feedbacks of hydrogen sorption regarding: i) hydrogen overpressure and associated mechanical stress (in connection with tasks 2.1 and 3.1), ii) propagation of a redox front in the geological media, and iii) radionuclides mobility (in connection with WP FUTURE).

- **Université de Nice-Sophia Antipolis (UNice)**

Université Nice Sophia Antipolis is part of Université Côte d'Azur (UCA) which is a recently created cluster of higher education establishments on the French Riviera that brings together the major players in higher education and research on the Côte d'Azur. Université Côte d'Azur aims to develop a new, 21st-century model for French universities, based on new interactions between disciplines, a new form of coordination between research, teaching, and innovation, and strong partnerships with the private sector and local authorities. In January 2016, Université Côte d'Azur won a prestigious "IDEX" award from the French government for its UCAJEDI project, placing it among the top 10 world-class, comprehensive universities in France.

- The LJAD laboratory is a Joint Research Unit between the CNRS and Université Nice Sophia Antipolis (Laboratoire Dieudonné UMR 7351 CNRS), the mathematical laboratory of UCA, is structured around 6 research teams: Algebra, Topology and Geometry, Analysis and Dynamics, EDP and Numerical Analysis, Numerical Modeling and Fluid Dynamics, Probability and Statistics, Interfaces of Mathematics and Complex Systems. Bringing together 135 researchers and teacher-researchers, 16 administrative staff and research assistance engineers and 74 doctoral and post-doctoral students, the laboratory is also a partner of INRIA, of the CEA (CEA) under the LRC Fusion of the Doctoral School (EDSFA) and participates in many ANR projects. This project takes place in the LJAD team Partial Differential Equations and Numerical Analysis (around 40 permanent researchers and 20 PhD students) which has developed for a few years a group on geosciences applications including 2 permanent researchers, Konstantin Brenner and Roland Masson, and several doctoral and postdoctoral students. CNRS/INSMI/LJAD has specific roles in DONUT.

Link of the participant to the third party: The University of Nice-Sophia Antipolis is a co-partner together with the CNRS and INRIA of the LJAD laboratory.

Tasks to be performed by the third party:

- It contributes in WP4 DONUT to develop an efficient algorithm to couple a nonisothermal compositional liquid gas Darcy flow and a RANS nonisothermal compositional free gas flow. This type of coupled models plays a key role to study the mass and energy exchanges at the interface between the radioactive waste disposal and the ventilation galleries with two main objectives: to improve the modelling of the porous-medium desaturation and to model the variations of relative humidity and temperature in the galleries over a period of say one to two hundred years. A Domain Decomposition Method (DDM) has been developed during the postdoctoral position of Nabil Birgile ended in march 2018 in collaboration with Andra. It has been prototyped on 2D test cases with simple geometry and simple pipe flows with an algebraic turbulent model. The objective is to increase the complexity of the geometry and of the free flow using a code coupling strategy between the porous-medium code COMPASS co-developed by BRGM and LJAD-Inria and the free-flow code CimLib developed by the CFL team of CEMEF Mines ParisTech.



- **Université de Lille (ULille)**

Université de Lille is a public university created in January 2018 as a merging of 3 universities. It aims to offer high-quality training and education leading to prestigious degrees, diplomas and courses with wide disciplinary range.

Regarding research and technology. The research group on numerical analysis and partial differential equations of the Laboratoire Paul Painlevé (LPP, mathematic department) has built a strong expertise in numerical methods that remain accurate in the long time regim for dissipation driven systems, as well as on modeling based on variational principles. The team has a great experience in the certification of the numerical method it designs, thanks to mathematical proofs of stability, convergence and asymptotic behavior.

- LPP is a Joint Research Unit between Université de Lille and CNRS. LPP already experienced contractual collaborations with ANDRA and CEA on the numerical approximation of corrosion models. They particularly focused on the design of schemes implemented on the code CALIPSO which is the ANDRA and CEA reference code for the simulation of the Diffusion Poisson Coupled Model (DPCM) for corrosion.

Link of the participant to the third party: The University of Lille is a co-partner together with the CNRS of the LPP Laboratory.

Tasks to be performed by the third party:

It contributes in WP4 DONUT: Even though the DPCM model is now a well established model for modeling the corrosion process in nuclear repositories, many fundamental questions still remain open. In particular, it is not clear if the model has an energy formulation of generalized gradient flow type as it would be expected in view of the large time scales. Such an energy formulation is key to guarantee the long-time behavior of the model. This motivates the following workplan.

- Task 1: Derivation of the energy, link with the DPCM model, mathematical results of existence of solutions and long-time behaviour of the DPCM model
- Task 2: Development of numerical methods based on the energetic formulation, validation of their energetic stability, study of the long time behavior
- Task 3: Implementation of the new methods in the electrochemical code CALIPSO, validation.
- Task 4: Investigation of the coupling with a reactive-transport model in porous media.

- **Université d'Orléans (UOrléans)**

University of Orleans, a public university, aims to offer high-quality training and education leading to prestigious degrees, diplomas and courses. In this university, the observatory of universe sciences (OSUC) is composed of two main laboratories. Among these, the “Institut des Sciences de la Terre d’Orléans” (ISTO). ISTO is a research laboratory in Earth Sciences, a Joint Research Unit (UMR) depending on three supervisory authorities (the Université d’Orléans, CNRS, BRGM). ISTO is leading two France-scale excellency projects (VOLTAIRE, 2012-2022; PLANEX, 2012-2019), two of the six platforms of one Région-scale excellency project (PIVOTS, Région Centre Val-de-Loire – Europe), the INSU national observatory “SO Tourbières”, and the “Val d’Orléans” site of the national observatory Karst. Our research reaches from Earth’s atmosphere and surface to the upper mantle with studies focusing on exchange processes at mantle-crust and crust-atmosphere interfaces. We are organized in five research teams. Among these, Continental Biogeosystem team has a long expertise in unraveling evolution of climates, ecosystems and human activities from organic matter and fossil molecules (biomarkers) preserved in lacustrine sedimentary archives. This team studies the stability of organic molecules, their sorption on clays and their transformation products under different environmental conditions. ISTO is involved, together with BRGM, in a partnership with ANDRA (CTEC and DRO project), to investigate the degradation of organic molecules in cementitious medias.

Link of the participant to the third party: The University of Orleans is a co-partner together with the CNRS of the CEMHTI laboratory (Extreme Conditions and Materials: High Temperature and Irradiation) located at Orleans and the ISTO laboratory.

Tasks to be performed by the third party:

- It contributes in WP3 CORI – Task 1 to study the effect of gamma irradiation on the degradation of superplasticizers and phthalate in cements and alkaline solutions in partnership with BRGM. The media considered would be alkaline (pH 12.5) in synthetic cement solutions. The various degradation media will be selected so as to form a consistent experience plan considering the following parameters: concentration of the molecule, redox conditions, nature of the alkaline/calc-alkaline cation and dose rate (1 kGy/h and 0.1 kGy/h). Degradation tests will be conducted on both irradiated and non-irradiated molecules and monitored as a function of time, up to 6 months. Analyses will be performed for the initial molecule and their degradation products. Degradation rates will be extracted from the experiments results, together with the production rates of the degradation products. ISTO beneficiaries from a cutting-edge organic geochemistry platform allowing bulk, molecular and isotopic characterization in a wide set of matrices and is able to develop detection and quantification methods adapted to a large range of organic molecules.

Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

9/ COVRA

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
Delft University of Technology (TU Delft) With approximately 23,500 students and 5,200 staff, Delft University of Technology (TU Delft) is the largest university of technology in the Netherlands. The university covers virtually the entire spectrum of engineering sciences, divided across 40 departments in 8 faculties, and it offers an equally broad, high-quality array of degree programmes and unique facilities. The mission of the university is to contribute to solving global challenges by educating new generations of socially responsible engineers and expanding the frontiers of the engineering sciences. Description of the link between COVRA and TU Delft (including scientific and technical scope) COVRA have since 2012 sponsored the Faculty of Civil Engineering and Geosciences at TU Delft for work relating to research and education in the area of radioactive waste management. Several projects have been conducted within this scope of both national and international significance. A memorandum of understanding has been signed recently (between COVRA and TU Delft) to develop the relationship into a long term collaboration, with a focus on the following areas: • Investigation of technical feasibility of constructing a radioactive waste repository in the Netherlands. • Investigation of sub-surface layers (Boom Clay and other clay layers, and salt deposits). • Investigation of multi-physics processes occurring within a radioactive waste repository. • Education. Involvement of the TU-delft in GAS and the tasks to be performed (5-10 lines maximum)	



TU Delft is involved in three subtasks of the workpackage GAS, namely 2.2 (Advection), 3.3 (Model-based interpretation and synthesis of results) and 4.2 (Model assisted assessment of gas induced effects). In these subtasks, TU Delft will numerically investigate (using the FE code LAGAMINE) the effects of natural heterogeneities and induced discontinuities (able to self-seal) on the gas transfer mechanisms. TU Delft will back analyse laboratory experiments in order to feed in the development of a conceptual process model of gas-induced damage evolution and self-sealing processes for damaged or intact host rocks and EBS materials. Validation of this model will take place in a series of prediction-evaluation exercises, covering different loading paths in different geometric configurations. TU Delft will finally apply their numerical approach to a generic repository configuration with different sets of properties, conditions and scenarios. TU Delft will work with other partners in the EURAD project, who will also use the same computer code to harmonise the research efforts, and with partners inside and outside the project (where needed) to select appropriate experimental cases.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

10/ FTMC

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

11/ CV REZ

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

12/ DEKOM

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

13/ EEAE

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

**14/ ENRESA**

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	Y
ENRESA plans to subcontract certain task to ENUSA and UDC. The subcontractors have been selected in accordance with the requirements of Article 13 of the grant agreement. Total budget of ENUSA: 208 750,00 € Total budget of UDC: 229 852,50 € <u>WP SFC</u> ENRESA will subcontract with ENUSA for Task 2: Fuel properties characterization / Develop, improve and demonstrate NDA methods/systems for SNF characterization. The contribution of Enusa to Task 2 will include the nuclide inventory by radiochemical analysis of a set of BWR SNF samples irradiated to an average burn-up of above 40 MWd/kgU, covering a range of initial enrichment and coolant void histories, as well as the modelling with SCALE and estimation of uncertainties. <u>WP ACED:</u> Task 1; State of the art. The contributions of UDC as subcontractor include: Task 1: 1) The compilation of previous modelling studies and 2) The identification of the remaining model uncertainties on the mineralogical alteration at the carbon steel/bentonite interface and 3) The proposal of a revised conceptual and mathematical model for the carbon steel/bentonite interactions which will be useful for other tasks of the WP Task 2: UDC as subcontractor will perform multicomponent geochemical reactive transport models (RTM) under saturated and unsaturated conditions of steel/bentonite laboratory experiments. The models will account for time-varying corrosion rates depending on ambient conditions (T, pH, Eh) and will be based on the revised conceptual and mathematical model of the steel/bentonite interactions identified in Task 1. The main outcomes include: 1) Improving the understanding of the dependence of the corrosion rate and the bentonite mineralogical alterations on thermal, hydrodynamic, solute transport and geochemical conditions; 2) Gaining confidence on RTM of the steel/bentonite interactions; and 3) Reducing the uncertainties of RTM. The outcomes of this task will be most useful for the modelling at the disposal cell scale (Task 4). Task 4 UDC as subcontractor will perform multicomponent geochemical reactive transport models (RTM) of steel/bentonite, bentonite/concrete and concrete/clay interactions for a HLW repository in clay host rock and of steel/bentonite, bentonite/granite interactions for a HLW repository in granitic host rock. The model will be based on the revised conceptual and mathematical model of the steel/bentonite interactions identified in Task 1 and will incorporate the knowledge gained from the laboratory experiments of Task 2. The main outcomes include: 1) Improving the understanding of the geochemical evolution of the repository and the role of thermal, hydrodynamic, solute transport and geochemical conditions; 2) Gaining confidence on RTM; and 3) Reducing the uncertainties of RT <u>WP DONUT</u> Task 4: UDC as subcontractor will contribute with innovative numerical methods for uncertainty and sensitivity analysis for coupled THC models (nonisothermal reactive transport models). The proposed methods include: 1) Adjoint-state methods and 2) Uncertainty quantification (UQ) methods. The main outcome of the UDC contribution is the development of innovative numerical methods for uncertainty and sensitivity analysis for coupled THC models. Task 5: UDC as subcontractor will contribute with benchmark test cases for the evaluation of the numerical tools and methods for coupled processes of relevance for the performance assessment of the engineered barrier of ILW and/or HLW repositories. The main outcomes of the UDC subcontractor contribution include: 1) Evaluation of the methods and tools derived in other tasks and 2) Evaluation of the efficiency of the numerical methods in terms of CPU time, ability to deal with large and complex problems at the disposal scale, comparison of multi-scale approaches and model uncertainties.	

Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

15/ JUELICH

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
Part of the work will be performed by linked third parties, namely: (1) Helmholtz Zentrum Dresden-Rossendorf, HZDR, (2) Helmholtz - Zentrum für Umweltforschung GmbH, UFZ. The link of the participant to the above listed TLP is their membership to the Helmholtz Association of German Research Centers, which was founded in 1995 and is today one of the leading research organizations worldwide. The Helmholtz Association is a registered association of eighteen (18) legally independent research centers, funded by the German Federal Ministry of Education and Research (BMBF). The activities of the Helmholtz Association are governed by its statutes. With its programme-oriented funding (POF) system, in which cross-center research programs compete with one another for funding, the Helmholtz Association performs cutting-edge research in six research fields: Energy, Earth & Environment, Health, Aeronautics, Space and Transport, Matter, and Key Technologies. Further, the Helmholtz Associations enables research using their large-scale devices and infrastructure, cooperating closely with national and international partners. Helmholtz Zentrum Dresden-Rossendorf, HZDR (PIC: 999470541) is a non-profit research organisation and a member of the Helmholtz Association of German Research Centers. It is funded by German Federal and Saxonian Authorities. HZDR is dealing with application-oriented basic research, focused on three major research fields: matter, energy, and health. It has been collaborating with JUELICH in various national and international projects. Within the national program HZDR and JUELICH are interlinked via the research program Nuclear Waste Management, Safety and Radiation Research (NUSAFE). WP CORI: HZDR will study the influence of small- to middle-size organic molecules (EDTA, ISA and gluconate as reference) on the retention of radionuclides (U(IV, VI), Cm(III), Am(III)) by cementitious material (CSH, CASH) by the mean of complexation and batch sorption experiments. WP Spent Fuel: The local structure of the U oxides and of the FP secondary phases will be accurately determined by EXAFS and synchrotron XRD. WP DONUT: HZDR will deliver uncertainty quantifications and probability density functions for a variety on physico-chemical processes within THMC relevant et near and far field of a nuclear waste repository. This will be accompanied by the development of respective robust models. WP FUTURE: HZDR will carry out PET/μCT measurements using fractured samples with conservative and reactive tracers, interferometry/ confocal microscopy measurements of fracture surfaces, and petrographic analysis. In addition. The HZDR will perform sorption experiments, spectroscopy analyses, surface potential analyses, radiography analyses, and data reduction using the smart Kd concept. WP Strategic studies Uncertainties: HZDR will contribute to Subtask 2.2 by coordinating the work, organizing and participating in technical meetings, contributing to the compilation, assessment and improvement of approaches for the characterization and quantification of uncertainties associated with THMC models and leading the writing of the deliverable. KM WP - State-of-Knowledge: The HZDR together with the BGE are responsible for coordinating the EURAD Knowledge Management Platform, which is an Open-source knowledge sharing tool (IT system and associated management procedures) for organising and capturing key sources of knowledge on radioactive waste management.	

Helmholtz - Zentrum für Umweltforschung GmbH, UFZ (PIC: 999994632) The UFZ is one of the world's leading research centres in the field of environmental research, enjoying high social recognition. It demonstrates ways in which a sustainable use of our natural resource base is possible for the benefit of both humankind and the environment. In the energy sector (resources and waste management), the spectrum of topics covered ranges from process modelling and simulation through the development of innovative monitoring strategies to the investigation of socio-economic aspects. The Department of Environmental Informatics (ENVINF) is developing numerical methods and software components for simulating coupled processes in porous media based on the finite element method. In addition, questions of the development of simulation platforms for the treatment of these problems as well as the benchmarking for model and software validation also take up wide space. An integral part of these platforms are workflows and system components for the 3D visualization of complex, heterogeneous data from different sources. In this context, the ENVINF acts as the lead developer and coordinator of OpenGeoSys, the international scientific open source software project. In addition to method and software development, there is a strong relationship to applications in hydrology, geotechnics and energy storage research. WP DONUT (Task 3): The UFZ Team will develop numerical multi-scale scheme for coupled processes able to link different simulators as well as develop and test parallel execution capabilities. WP GAS (Task 3): UFZ together with BGE, BGR will employ and extend the open-source software OpenGeoSys, in which localization can be described using enriched approximation spaces, non-local elasto-plasticity or phase-field models of fracture. Together with existing multi-phase flow and swelling formulations, these models will be used in the modelling tasks described above. Random-field initialization will be used to trigger localization. WP ACED (Task 4): The UFZ team contributes to the methodology comparison and also inter-code benchmarking of reactive multiphase transport process relevant to the ILW at the scale of a waste repository. Together with PSI they will carry out simulations on the chemical evolution and gas/water mass balances in waste packages containing metallic and/or organic waste with the GEM-Selektor chemical modelling package and OpenGeoSys-MP-LT, a multi-component two-phase reactive code developed in cooperation with UFZ Leipzig.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

16/ GRS

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

17/ INPP (IAE)

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

18/ ICHTJ

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

19/ IRSN

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
IRSN envisage that part of its work will be performed by 3 linked third parties : Mutadis, NTW and MINES ParisTech Mutadis is an independent research organisation specialized in the area of the governance of activities entailing risks for people or the environment as well as in the field of ecological, economical & societal Transition. It operates for public and private organizations. Mutadis has a long-standing expertise and field experience regarding interaction between civil society and technological processes (in the context of decision-making, expertise processes and research) in the French, European and international context since 1990. Mutadis had a role of methodological expert and facilitator of interactions with the Public in many research, surveys, and field projects. Mutadis has also developed projects and research regarding the adaptation and transformation of legal and institutional frameworks, in order to create the conditions for a permanent and influential participation of Civil Society Organisations and local communities in the governance of activities associated with risks and impacts on health and environment (notably on the ground of the Aarhus Convention - 1998). In France, Mutadis has been cooperating with IRSN in the field of health, food, environment and work hazards, in order to propose a vision and tools for the governance of expertise processes, and their approaches regarding stakeholders' involvement. Link of the participant to the Third party: Since its creation, Mutadis has developed numerous research projects and partnerships with IRSN in the two last decades. Currently, a research partnership between Mutadis and IRSN, that began in September 2017, focuses in particular on structured dialogue tools facilitating interactions between experts and civil society on the field of Radioactive Waste Management. Mutadis also cooperated closely with IRSN in the context of the European projects SITEX (2012-2013) and SITEX-II (2015-2017) coordinated by IRSN, by providing its expertise, as Work Package leader, on	

governance and understanding of the socio-technical issues involved in the implementation of geological disposal, by developing a specific interaction model enabling meaningful engagement of civil society representatives in the context of RD&D on radioactive waste management and by developing a tool for pluralist dialogue on these issues. Together with IRSN, Mutadis was also partner of the European R&D project JOPRAD and contributed to the development of a participatory framework of governance for consideration by the future EURAD proposal. Mutadis, as a representative of the Civil Society function, is also member of the SITEX.network association that is chaired by IRSN.

Tasks to be performed by the LTP:

- 1- Mutadis will carry out the work in the task 5 of the Strategic Study WP – Uncertainty Management multi-Actor Network (UMAN). The work will consist in gathering views and contributions from a pluralistic stakeholder group on Uncertainty Management. The task will be organised through seminars gathering pluralistic stakeholder groups (task 5.1). Mutadis will also coordinate the contribution of stakeholders from the public and CS experts participating in specific subtasks of Tasks 2 to 4 (task 5.2).
- 2- Mutadis will also lead task 8 of the Programme Management Office (PMO), dedicated to the coordination of CS contribution within EURAD. It will ensure the finalisation of the composition of the CS group involved in EURAD. It will contribute to the organization of a yearly workshop as part of EURAD annual meeting (involving the participation of the CS group, the CS experts together with a panel of WMO, TSO and REs from the different WPs). Mutadis will also ensure the subtask “*Assessment of the experimental model of Interaction between EURAD participants and Civil Society*”.

Nuclear Transparency Watch (NTW) is a European network that promotes a citizen watch on nuclear safety and transparency. The European network Nuclear Transparency Watch has been created in order to promote transparency and vigilance on nuclear safety issues and increase the contribution of civil society in the governance of nuclear activities, raise awareness among policy makers and European society about the need for transparency on nuclear decision-making processes at the local, national and European level. The network was launched in 2013 after a Public Call of Members of the European Parliament from different Political Parties. The action of Nuclear Transparency Watch is regarding most activities of the nuclear cycle: nuclear safety, ageing of NPPs, life-time extension, new build, emergency preparedness and response, post-accident management (including liability issues), radioactive waste management, decommissioning, etc.

Link of the participant to the third party: NTW is member of the SITEX.network association chaired by IRSN, that results from SITEX and SITEX-II European projects, in which civil society experts, members of NTW, collaborated with IRSN as research partners of SITEX II, in order to develop experimental interactions between institutional experts (expertise function) and civil society (society function). Since 2013, NTW also coordinates, together with the DG-ENER of the European Commission, the second phase of the Aarhus Convention & Nuclear (ACN) process where IRSN is involved. The ACN process is regarding the concrete implementation of the Aarhus Convention Principles in the nuclear field in the European Union. It involves the organisation of pluralistic roundtables at European level, gathering concerned stakeholders of European countries (operators, regulators, institutional experts, civil society representatives).

Tasks to be performed by the LTP:

- 1- In the strategic study ROUTES, NTW will be Task 7 leader. It will provide CS experts involved as partners in WP activities, and will gather the contribution from CS larger group. The objectives of this task are NTW will also contribute to the UMAN WP, see MUTADIS task 1..
- 2- NTW will contribute to the task 8 of the Programme Management Office, dedicated to the coordination of CS interactions within EURAD. In order to organize the general session of a annual workshop in the frame of the EURAD Annual meetings, NTW will translate the results of the scientific/technical WPs to the CS group during the session and gather CS views on future EURAD activities. NTW will provide a small team of CS experts dedicated to this task and will work together with representatives from WMOs, TSOs and REs from the different WPs. NTW will also ensure the administrative work related to the invitation and reimbursement of the CS stakeholders.

MINES ParisTech

The graduate school MINES ParisTech (www.mines-paristech.eu) is one of the oldest French higher education institutions in engineering. The Geosciences Department of MINES ParisTech is dedicated to all the research and teaching activities in the field of earth, geo-engineering and environmental sciences. In particular, the Geosciences Department has a great expertise in numerical modelling of hydrogeological and geochemical processes applied to the geological disposal of radioactive wastes. Over the last two decades, IRSN and MINES ParisTech collaborated on the following projects: - Clay/concrete interactions (3 joint publications, co-supervised Ph.D. of P. Lalan –collaboration agreement IRSN /LS 11862) - Concrete carbonation modelling (Post Doc N. Seigneur 2013 – 2016 - collaboration agreement IRSN/LS 20506) - Iron/concrete interactions (2 joint publications, 1 co-supervised Ph.D.) - Study of the oxidizing transient (1 joint publication) - Numerical modelling of these interactions at long term (2 joint publications). All these matters are highly relevant for the study proposed by IRSN (iron/concrete/clay interactions) as part of the WP chemical evolution. In ACED WP, the collaboration between IRSN and MINES ParisTech will be part of task 2 (reactivity at the interface scale) and task 4 (disposal cell scale). The core approach of MINES ParisTech will be reactive transport modelling (RTM) with the HYTEC code. This code is developed in MINES ParisTech in partnership with IRSN since 2000. In task 2, MINES ParisTech will do the RTM of the experiment on steel/concrete interface (IRSN) and of the experiment on steel/bentonite interface (Uni Bern); to discriminate the most relevant reactive pathways, develop a solid solution of Fe-solid phases and provide parameters for up-scaling the temperature and heterogeneity effects. One main outcome will be to provide the bases for up-scaling the RTM to waste package and near-field of HLW disposals. In task 4, MINES ParisTech will do the RTM to assess of sensitivity to heterogeneities and temperature gradient (evolving with time) of the long-term chemical evolution of a reference HLW disposal cell by two-phase reactive transport modelling, partly based on the up-scaling of the modelling of steel/bentonite and steel/cement experiments (task 2). These RTM results will be useful for the more abstracted models and performance assessment of TSO such as IRSN.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

20/ IST-LPSR

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

21/ IST-ID

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

22/ JSI

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y

EIMV

The EIMV – Elektro inštitut Milan Vidmar is the leading Slovenian engineering and scientific research organisation acting in the area of electric power engineering. It has a long tradition in operation and, in 2018, it celebrates its 70th anniversary. The EIMV addresses the issues of generation, transmission and distribution of electricity from the technological, environmental and economic perspective. The experts at the institute prepare feasibility and implementation studies, expert reports, they implement technological, environmental and other analyses, inspect the quality and operation of electric power systems and facilities as required by electric power utilities, ministries and national as well as regional authorities. The staff of EIMV also performs research and analyses in relation to different aspect of ionizing radiation, work on use of nuclear energy, radioactive waste management, emergency preparedness and response, and different applications of nuclear technology. The institute also implements R&D projects in the EURATOM frame (Horizon 2020) and regional levels, which are developed from idea to their realisation.

The EIMV is also one of the Technical Support Organisations (TSOs) licensed by the Slovenian Nuclear Safety Administration (SNSA), the Nuclear Regulatory Authority (NRA) in Slovenia. EIMV provide opinions with regards to specific issues related to radiation and nuclear safety. The EIMV's license covers all related fields linked to nuclear safety and radiation protection of nuclear and radiation facilities and radioactive waste repositories. On the basis of extensive practical experience, the EIMV coordinates preparation of the expert opinion for refuelling and maintenance outage for the Krško NPP (NEK) where it organises the work of authorised institutions involved in the evaluation of implemented works during the outage. EIMV also provides, as the TSO, expert opinions for NEK in specific fields, such as maintenance and changes related to the main and emergency diesel generator, power and auxiliary transformers, cables, high voltage motors, control and protection systems and other equipment in the high voltage switchyard. EIMV likewise performs authorised expert opinions in collaboration with other institutions for activities which combine various topics (e.g. establishment of Emergency Control Room, Dry Storage for Spent Fuel, ...). Lately, EIMV has also been involved in the evaluation of licensing documentation for radioactive waste repository in Slovenia.

EIMV will contribute to several WPs in the EURAD:

In ROUTES the technical data on different radioactive waste types will be provided for Slovenia and all input information of different waste management routes will be collected and analysed. EIMV will be also involved in the interaction with civil society.

In UMAN the contribution to common understanding among the different categories of actors on uncertainty management for RWM will be addressed by EIMV. EIMV will contribute to analyses and mitigation procedures on activities related to risk & safety.

In KM, EIMV will participate mainly in the WP on Guidance where it will contribute to identification of topics for early-stage of RWM programmes and development of guiding documents.

EIMV will also be an organisation, which will be involved in Interaction with Civil society activities, in the SFC WP and in ROUTES WP, but also in the coordination of CS group.

ZAG

Slovenian National Building and Civil Engineering Institute (ZAG) is the leading research and testing institute of its kind in Slovenia. It is a state-owned, independent, impartial and non-profit organization, which fulfils all the requirements of the EEC Council Directive No. 89/106 regarding approval bodies, which carry out the testing and attestation of conformity of construction products. The main activities of ZAG are: research, quality assurance programs, and testing and assessment in the fields of building materials, structures (buildings and infrastructure) and geotechnics. For the last 20 years, ZAG has been involved in development of new highly efficient and sustainable construction materials and structures and infrastructure construction, including building energy efficiency, and has been the leading independent quality control and counselling organization. It has been developing and implementing tools for efficient inspections of structures and infrastructures' asset management, monitoring and safety assessments, evaluation of material degradation processes, and rehabilitation for many decades. ZAG performs comprehensive research of the waste material into the various possibilities for its use in the construction industry. ZAG employs 178 researchers, among them 40 PhD and it has approximately 10 million EUR of turnover. In the field of tasks deriving from the CPR (Construction Product Regulation) it has two independent services: the Certification Service and the Service for Technical Assessments, the latter including also system for issuing Environmental Products declaration. ZAG is involved in the international co-operation in science and technology with institutions from the EU, the USA and other countries. Over the last 10 years ZAG has participated in more than 60 projects funded by the EU (4th - 7th FP, H2020, LIFE, and EIT Raw Materials).

ZAG will contribute in ACED: in task 2 by an in-situ monitoring of corrosion of steels in their ongoing experiments and potentially in the new experiments proposed by IRSN (NE2-2/1) and to assist at the identification of corrosion type, rate and corrosion products. In task 3 ZAG will provide the test fields at three hydroelectric dams on Drava River in order to get reliable samples of concrete in different locations of saturated zone of the dams. Laboratory investigation of samples in terms of microstructure characteristics.

Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

23/ JRC

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N

Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

24/ KIT

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
The link of the participant to the listed LTPs is an: AGREEMENT FOR COLLABORATION ON THE FIELD OF MANAGEMENT AND DISPOSAL OF RADIOACTIVE WASTE Between Karlsruhe Institute of Technology (KIT) and: - University of Potsdam, Am Neuen Palais 10, 14469 Potsdam, represented by the President; Executing Unit: Institute for Chemistry, Apl. Prof. Dr. M. Kumke - Clausthal University of Technology, Adolph-Roemer-Straße 2a, 38678 Clausthal-Zellerfeld, represented by the president; Executing Unit: Institute for disposal research, represented by Prof. Dr. Klaus-Jürgen Röhlig - Johannes Gutenberg-University Mainz, represented by the President, Prof. Dr. Georg Krausch, Saarstr. 21, 55122 Mainz; Executing unit: Institute for Nuclear Chemistry, Contact: Prof. Dr. Tobias Reich - Federal Republic of Germany, represented by the Federal Minister of Economic Affairs and Energy, who in turn is represented by the President of the Bundesanstalt für Materialforschung und -prüfung (BAM), Unter den Eichen 87, 12205 Berlin - Federal Republic of Germany, represented by the Federal Minister of Economic Affairs and Energy, who in turn is represented by the President of the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Stilleweg 2, 30655 Hannover - Amphos 21 Consulting S.L. Passeig de Garcia i Faria 49-51, 1-1. Barcelona E08019 Spain - PreussenElektra GmbH, Tresckowstrasse 5, 30457 Hannover, Germany University of Potsdam: WP CORI The research entity University of Potsdam (Physical Chemistry, UPPC) is a collaborator for more than a decade investigating the interaction of actinides (lanthanides) with key components of the near as well as the far field of a potential repository for nuclear waste. UPPC has its core competence in the development and application of high-end laser-based spectroscopy in the spectral and time domain. UPPC has (and is currently) been participating in national research projects on radioactive waste storage managed by the PTKA-WTE. Experiments performed at UPPC aim to improve the molecular understanding of organics-radionuclide complexes interplay with calcium-(aluminium)-silicium-hydrate phases (CSH, CASH) in order to strengthen the knowledge on the mobility of radionuclides under hyperalkaline conditions in cementitious environments under consideration of the redox state. The organics may be originating from the degradation of organic additives (cement components) or from polymers of waste components. The redox state +IV, +V as well as +VI will be investigated using novel (to be developed) spectro-electrochemistry techniques for speciation (time-resolved emission as well as absorption techniques). Additionally experiments on the redox state +III are performed as well. The cement phases considered are of CSH and CASH type. Investigations deal with the competition between organic ligands (e.g., ISA, phthalate etc.) in solution and sorption sites on cement phases (CSH, CASH) as well as the possible formation of ternary complexes with organics acting as partners. The influence of elevated calcium or sulphate concentrations (e.g., calcium as intrinsic cation contained in the system may act as a potential partner in the formation of mixed multicores complexes) will also be addressed. Investigation of the competition between organics and cementitious system for radionuclides (in different redox states) as well as the alteration of the cementitious system due to the presence of organics and the subsequent effect on the sorption/release of radionuclides are in the focus of the experiments performed at UPPC. University of Mainz: WP CORI, FUTURE	



The Johannes Gutenberg University Mainz (JGU) is one of the ten largest universities in Germany with about 31,500 students from about 120 nations. Teaching and research activities of JGU's Institute of Nuclear Chemistry (JGU-INC) cover the full range of nuclear chemistry and radiochemistry. In particular, JGU-INC has performed research activities in the field of management and disposal of radioactive waste for more than twenty years and is currently the coordinator of the joint national research project GRaZ (Geochemical retention of radionuclides on cement alteration phases) that has been funded by BMWi and managed by PTKA-WTE since 2015. About 50 bachelor, master, diploma, and graduate students are working in JGU-INC.

JGU-INC has the necessary infrastructure (controlled areas, inert gas glove boxes etc.) to work with all actinides, including Np and Pu. In addition to the standard radioanalytical techniques, the research reactor TRIGA Mainz and sophisticated equipment (XPS, TOF-SIMS, Laser-SNMS, ICP-MS, CE-ICP-MS, and RIMS) are available for investigations. JGU-INC has also vast experience in synchrotron-based X-ray techniques (XANES, EXAFS, μ -XRF, μ -XRD).

The contribution of JGU-INC to CORI aims at extending the knowledge about the effects of organics on the mobility of radionuclides in cement-based systems. In order to obtain a mechanistic understanding of the radionuclide interactions with cementitious phases, batch and diffusion experiments will be combined with speciation studies. The focus of these investigations will be on tri- and tetravalent plutonium (Pu). The cementitious phases will include pure cement preparations (HCP – CEM I) and cement phases (CSH). For investigating possible effects of organics on the Pu mobility, strong complexing organic agents as prioritized in Task 2 of CORI, i.e., isosaccharinic acid, phthalate, EDTA, and short-chained carboxylic acids, will be employed by JGU-INC.

Within FUTURE JGU-INC will address the role of the different mineral constituents of argillaceous rocks (Opalinus Clay) on the mobility of actinides (Np, Pu), which is governed by diffusion and sorption processes. There are open questions on whether redox transformations and sorption of actinides during their diffusion in intact clay rocks are decoupled, subsequent, and spatially separated processes involving several mineral phases or are related mostly to a particular mineral phase.

The combination of speciation calculations (Pourbaix diagrams based on Eh and pH measurements, thermodynamic database) with simultaneous speciation measurements both in solution (CE-ICP-MS) and on the solid surface (XPS, XANES, EXAFS) will provide the basis for developing a unified and complete model of the sorption of Np and Pu on mineral phases considered in FUTURE. Application of techniques with high spatial resolution to heterogeneous natural clay, the identification of most reactive mineral phases responsible for sorption and retardation of Pu and Np, and determination of diffusion parameters from nondestructive measurements are unique and beyond the state-of-the-art.

University of Clausthal: WP UMAN

Clausthal University of Technology – Institute of Disposal Research (TUC-IELF):

The Institute of Disposal Research (IELF) is the only university institute in Germany dealing with radioactive waste disposal in research and education in a comprehensive way.

Interdisciplinary research concerning site characterisation, site investigation, geotechnical barrier systems, and safety cases takes place in the departments of

- Geochemistry-Mineralogy-Salt Deposits,
- Geomechanics (co-opted department),
- Hydrogeology and Hydrogeochemistry,
- Mineral Resources,
- Repository Systems.

The planned research will be carried out by the Department of Repository Systems, which is active in the research areas of Safety Assessment Methodology, probabilistic methods and sensitivity analysis as well as of socio-technical issues related to radioactive waste disposal (co-ordinator of the interdisciplinary ENTRIA project s.o.).

TUC-IELF plans to contribute to the Uncertainty Management multi-Actor Network (UMAN):

- It will become the responsible organisation for Subtask 2.3 – Methodological approaches to uncertainty and sensitivity analysis: TUC-IELF will coordinate the work, organize and participate in technical meetings, share their experience with uncertainty and sensitivity methods and write the deliverable.

Since CEC's PAMINA project, TUC-IELF has taken a leading role in the field of sensitivity analysis (SA) methodology, contributed to deriving a holistic view of SA methods, and developing numerically efficient approaches. It is therefore excellently qualified for the task.

- Subtask 5.1 – Preparation, support and reporting of pluralistic analyses: TUC-IELF will be leader of Topic 1 and coordinate the development of materials to be discussed in seminar 1. TUC-IELF will lead the development of deliverable D5.1. TUC-IELF will also take part to Topic 4, contributing to the development of proposals of methods for a pluralistic assessment of uncertainties.

Due to its co-ordination role in the interdisciplinary research project ENTRIA and its leading role in several OECD/NEA activities at the interface of social, natural and engineering sciences in the area of repository development and safety cases (jointly carried out by the working parties IGSC and FSC), TUC-IELF has excellent prerequisites for carrying out the aforementioned tasks.

Bundesanstalt für Materialforschung und -prüfung (BAM): WP Spent FUEL

The Bundesanstalt für Materialforschung und -prüfung (BAM) is a senior scientific and technical Federal institute with responsibility to the Federal Ministry for Economic Affairs and Energy. It tests, researches and advises to protect people, the environment and material goods. BAM sets and represents high standards for safety in technology and chemistry for Germany and for its global markets, to further develop the successful "Made in Germany" culture of quality. BAM fulfils this role through its dedicated employees.

According to its founding decree, BAM is responsible for the

- further development of safety in technology and chemistry,
- implementation and evaluation of physical and chemical tests of materials and facilities, including the preparation of reference processes and reference materials,
- promotion of knowledge and technology transfer within the BAM's areas of work,
- cooperation in the development of statutory regulations, for example concerning the setting of safety standards and limits,
- advice to the Federal Government, industry, and national and international organisations in the fields of material technology and chemistry.

Five focus areas provide thematic platforms that structure the work. At the same time, they serve to make visible BAM's contribution to politically, socially and scientifically important topics. Within the focus area Energy the Radioactive waste Disposal is one specific area of expertise BAM addresses for several decades. Major topics include safety evaluation and approval of all kinds of containments for transportation and storage of radioactive materials. Materials research and testing, component testing and up to full-scale container drop or fire testing are major competences as well as numerical simulation techniques to evaluate and demonstrate container safety.

The foreseen task BAM will contribute focuses on the integrity of spent nuclear fuel rods affected by thermo-mechanical conditions as well as fuel/cladding chemical interaction. BAM plans the numerical calculation of initiation fracture toughness for Zirlo in the initial elastic region or just shortly after passing this region in the ring compression test (RCT) on the basis of measured load-displacement curves, correlated observed distribution of hydrides, and postulated initial macroscopic cracks. As major outcome a fracture mechanics based failure criterion shall be developed. The gained knowledge base shall provide the basis for an extension to other and also irradiated cladding materials to evaluate fuel cladding integrity under mechanical loads during container operation and also under accidental loads.

Bundesanstalt für Geowissenschaften und Rohstoffe (BGR): WP HITEC, GAS, DONUT

The Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) is the national geoscientific authority providing advice to the German Federal Government in all geo-relevant questions. It is subordinate to the Federal Ministry for Economic Affairs and Energy (BMWi). Since more than 30 years BGR significantly contributes to all geoscientific tasks and undertakings to realize an underground final repository for radioactive waste.

At a constantly high qualitative and quantitative level about 100 BGR experts to perform this research and consultancy tasks. BGR has been advising the national commission on "Storage of High-level Radioactive Waste" since 2014. Due to their comprehensive research activities in the field of radioactive waste disposal, BGR has made numerous expert contributions since the first meeting of the commission, including lectures, data sheets, review articles and data collections. Topics included geoscientific criteria for repository projects in other countries, and easily understandable facts on e.g. claystone research.

BGR is represented in well-established international working groups (OECD/NEA) on potential host rock formations, informally known as the [Salt Club](#), the [Clay Club](#) and the [Crystalline Club](#). The internal structure of the depository research in BGR is optimized for the upcoming tasks related to the Site Selection Act in Germany (StandAG) and comprise of e.g. providing geological maps or catalogues on the distribution of potential host rock formations (salt structures, claystone, crystalline rock formations) in Germany, geological-geotechnical exploration including the development of 3D-geological models, THM-rock and geotechnical barrier material characterization on laboratory and on in-situ scale, long-term safety (scenario development and analysis) and geotechnical safety analyses (THM numerical scenario studies). The types of typical BGR research projects span from i) in-house-initiated, focused projects (e.g. updates/progress and synthesis reports of former studies), ii) initial research projects (methodological developments, feasibility studies, etc.), iii) projects assigned by federal institutions (BfS/BGE) related to explicit existing minesites (Asse II or Gorleben) or repositories (Konrad and Morsleben) in Germany or on international ground (Bure/FR, Aspö/SE, WIPP site/US, Beishan/CN, ect.), iv) mid- and long-term projects with relevant partners on a national level and v) international projects with high visibility (e.g. EU-project coordinator of PEBS (Performance of Engineered Barrier Systems), funding organization of DECOVALEX.org, Mont Terri consortium member since 1996). Stringent project and quality management systems with regular internal and external audits facilitate resource efficiency, strategic disposition and constrain the professional performance.

BGR will contribute to two work packages: a) The impact of elevated temperature ($> 100^{\circ}\text{C}$) on geochemical mineralogical properties of a suite of different bentonites (HITEC) and b) the impact and quantification of advective gas transport on the barrier integrity and barrier performance (GAS). In both these research areas BGR staff have significant share in the international knowledge development in the past decades (LOT, ABM1, ABM2, PEBS, ABM5 and DECOVALEX and Mont Terri Project). In a third work package (DONUT) BGR aims at a guest status. The task focuses on the development and improvement of numerical methods and tools for the numerical modelling of coupled processes. Also here BGR staff has proven significant competence in numerous past and ongoing projects (PEBS, BEACON, DECOVALEX, etc.) and numerous publications.

Amphos 21 Consulting S.L. WP COR1

Amphos 21 (A21) is a private scientific and technical environmental consulting company with offices in Spain, Chile, Peru and France. Main activity fields are offered in the nuclear, mining, water resources and sustainability market sectors. The company was founded in 1994 and the nuclear services account for more than a 60% of the projects developed in Europe. The nuclear department gathers 30 professionals in the fields of chemistry, geochemistry, hydrology and IT development. A21 develop projects for most of the nuclear waste management organisations in Europe, focused on R&D activities in radioactive waste management, from the experimental and modelling studies of the behaviour of spent nuclear fuel and waste forms to the migration of radionuclides in the geosphere and performance assessment of deep and surface facilities for nuclear waste storage and deposition. A21 have worked in projects funded by the European Commission since 1994.

- **Link of the participant to the third party:** In 2018, KIT-INE and A21 signed a “Collaboration agreement on the field of management and disposal of Radioactive Waste”. The relationship between Amphos 21 and KIT-INE started in the 90’s and expands to different type of projects, EC and also private funded developments. The collaboration between KIT-INE and A21 has proven very successful and satisfactory for both parts. Last examples of close collaboration between both parties in EC projects have been CEBAMA, First-Nuclides, CROCK, Recosy and FUNMIG. Other types of collaborations have been through the Taslismán and Actinet instruments. Examples of collaboration not funded by the EC have led to the development of several Ph.D thesis, such as:
 - Tasi, A. (2018) “Solubility, redox and sorption behaviour of plutonium in the presence of α -D-isosaccharinic acid and cement under reducing conditions”. A21 subcontracted KIT-INE for the research project, which was funded by SKB (Sweden)
 - Gonzalez-Siso, M.R. (2018). Determination of key master variables and radionuclide behaviour in the Swedish Final Repository environment

- Fernandes, T. (2017) Geochemical Behaviour of uranium and thorium in the waste of a uranium conversion facility.

Stages of personnel of A21 to KIT-INE and vice versa have been also accomplished through different collaboration and KIT-INE is part of the consortia for the development of the iCP tool and Image project managed by A21 (<https://image-modelling.net/project/view/1/iCP>)

An example of existing current collaboration contracts is the ThermAc3 (2017-2019)

“Thermodynamics and speciation of actinides at elevated temperatures”, extension of the initial contract dated 2015.

- **Tasks to be performed by the third party in WP3 - CORI :**

1. A21 is co-subtask leader in CORI, Subtask 3.
2. Task 3. Interaction of pure cement phases (CASH or CSH) with adipate and phthalate (characteristic of PUR and PVC degradation, resp.) and isosaccharinate (ISA, characteristic of cellulose degradation) in the presence and/or in the absence of Fe. A scientific development is foreseen using pure cement systems (CASH or CSH with variable C/S ratio) The work will follow a bottom-up approach:
 - Uptake of single organic molecules (adipate, phthalate or ISA) with CASH or CSH
 - Uptake of one organic, selected based on previous results, with CASH or CSH in the presence of iron.
3. Task 4. Interaction of Radionuclides (e.g. Ni and/or U) with pure cement phases (CASH or CSH) and organic ligands (adipate, phthalate and isosaccharinate). The bottom-up approach of the study will similar to that detailed in Task 3 and includes:
 - Uptake of selected RN by cementitious phases (CASH or CSH) in the absence of organic ligands (batch experiments with solid samples dispersed in cement synthetic water).
 - Uptake of selected RN by cementitious phases (CASH or CSH) in the presence of organic ligands (batch experiments with solid samples dispersed in cement synthetic water).

PreussenElektra GmbH: WP Spent Fuel

Third Party: PreussenElektra GmbH (PEL)

PreussenElektra is a wholly owned subsidiary of E.ON and has been operating Germany's largest fleet of commercial nuclear power stations. To its portfolio belong six nuclear power stations in the German states of Bavaria, Lower Saxony, and Schleswig-Holstein. Most of these plants were commissioned in the early 1980s. PEL owns minority shares in a further five plants. All of them will have been permanently shut down by 2022 and then await decommissioning. The safe operation of these facilities has been due to the continuous improvement and implementation of high safety standards, an extensive maintenance program and a highly-skilled workforce. One part of PEL's decommissioning activities is the qualification of suitable storage and transport casks for spent nuclear fuel and their subsequent loading and storage. PEL mainly uses the CASMO/SIMULATE toolset for reactor physics and source term calculations.

- ***Link of the participant to the third party:***

PEL and KIT have a long history of research collaboration in the field of nuclear reactor safety and in particular a framework agreement entitled “Agreement for collaboration on the field of management and disposal of radioactive waste” has been put into place since February 2019.

- ***Tasks to be performed by the third party:***

1. PEL contributes its industrial knowledge and experience about source term calculations for spent nuclear fuel and in particular its expertise regarding the requirements and techniques for nuclide vector determination for intermediate storage until final disposal.
2. PEL will be responsible for organizing the activities in subtask 2.4 of the main task “fuel properties characterization and related uncertainty analysis” and will be responsible for delivering the subtask's results. The objective is to standardize the analyses performed by the partners in order to obtain consistent results from a large dataset of samples. This complements the activities of earlier subtasks which focus on developing recommendations for state-of-the-art calculations and are based on a relatively small dataset. In subtask 2.4 calculations with an industry-standard and an improved code will be done, and the statistical significance of the preceding method development

and improvements will be demonstrated. PEL will develop with the partners a set of consistent input and calculation schemas to minimize modelling bias and merge results into a comprehensive report.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

25/ LEI

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

26/ MTA EK

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	<u>N</u>
Does the participant envisage that part of its work is performed by linked third parties	<u>Y</u>
The Linked Third Party, Social Organization for Radioecological Cleanliness (SORC), is a non-governmental organization created in 1993, aims to promote modernization of higher education, enhance the quality and relevance of higher education in the region. According to the aims the SORC would like to give the public the valuable and reliable information about the hazard on the radiations. The most well-known problems of the nuclear accidents (Chernobyl, Fukushima, etc.) but nowadays the NORM materials are in the focus too. Environmental impact and harm resulting from present and past industrial past activities is very complex and diverse according to the type of industry, raw material extraction and exploitation process and waste processing and handling and factors such as site local geology and hydrogeology. Instruments of SORC are primarily capable of measuring environmental samples (laboratory equipment) and Physical process modelling and simulations (GPU-CPU Server). The last 10 years SORC has developed several software, especially an atmospheric modelling software for Hungarian NPP. SORC is in close co-operation with other research groups, therefore it is possible to involve/carry out further numerical simulation. Link of the participant to the third party: MTA EK and SORC have developed the Hungarian National Nuclear Forensics Library. This library (software) dedicated for a comparative assessment of several characteristics with existing information could be used to identify or exclude possible origins of the nuclear materials. In addition, MTA EK and SORC are members of SUSTAINABLE ATOMIC ENERGY TECHNOLOGY PLATFORM (FAETP) in Hungary, it is a nuclear platform for nuclear research where they collaborate on	

the definition and development of research projects on nuclear technologies including aspects of the nuclear waste management. Tasks to be performed by the third party: WP Development and improvement of numerical methods and tools for modelling coupled processes (DONUT) into the Task 2: Numerical methods for high performance computing of coupled processes work will be developed by SORC team. SORC will develop modules with numerical algorithms adapted to the resolution of multiphysic coupled problem on GPU-CPU Server platforms, how is: Models designed to represent the development of discrete gas pathways in clays are likely to be too restricted in application for full scale performance assessment calculations, and the development of continuum models that would satisfy the needs of the latter are considered a priority. A large problem can usually be divided into smaller tasks that operate together in order to create a solution. One possible, effective solution for increasing the computational time can be the parallelization of the source codes. The GPU got a heavy parallel architecture, making the effective for arithmetic operations and calculations. The main plan to compare different programming modules (CUDA, OpenCL, OpenMP, OpenACC) and optimize a module for a cost effective and reliable numerical method. Tibor Kovacs, is responsible for DONUT WP as LTP.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	<u>N</u>
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	<u>N</u>
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	<u>N</u>

27/ NAGRA

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
- EPFL/LMS is a longtime research partner of Nagra in the field of THM coupled processes (laboratory, modelling). Collaboration has started in 2006; a multitude of PhD thesis have been accomplished, focussing on bentonite characterisation, gas transport in sand/bentonite and THM characterisation of indurated clays (Opalinus Clay and other Mesozoic clay formations). New experimental set-ups have been developed to characterise the suction behaviour of clay-rich material. The latest development is an advanced triaxial cell for gas permeability testing with highly accurate control of volumetric strains. The EPFL team has strong modelling capabilities; they have developed an elasto-plastic constitutive framework for modelling gas transport processes in clay-rich media. The modelling framework has been subjected to a comprehensive validation exercise in the context of SKB's EBS-Task Force (Task 7: "gas transport in bentonite"). - CIMNE and Nagra established comprehensive research collaborations 20 years ago. The collaboration started as part of an international project on gas transport in sand/bentonite mixtures at the Grimsel URL. Since then, Nagra has co-funded new experimental set-ups at CIMNE's geotechnical laboratories for investigating gas transport in bentonite and Opalinus Clay. Multiple publications in peer reviewed journals have been completed with emphasis on the deformation behaviour of clay-rich materials in response to gas pressures. On behalf of Nagra, CIMNE is currently performing a comprehensive laboratory programme on gas transport in bentonite in the context of SKB's EBS-Task Force. CIMNE participates in the validation exercise in the context of SKB's EBS-Task Force (Task 7: "gas transport in bentonite") with their own modelling framework.	



- ZHAW/ICP collaborates with Nagra for more than 10 years in the field of microstructural imaging of clay-rich materials. This includes pioneering work on pore connectivity of bentonite and Opalinus Clay (FiB nano-tomography, TEM, BiB, micro-CT) which has been published in peer reviewed journals. The ZHAW team has developed advanced image processing tools for upscaling the microstructural information, aimed at linking the micro-scale to the scale of laboratory testing with core samples. The upscaling techniques have been validated in the context of the EBS-Task Force (Task 7: "gas transport in bentonite").
- INSTITUTE of GEOLOGICAL SCIENCES of the UNIVERSITY of BERNE has been collaborating with Nagra for more than thirty years. The Rock Water Interaction group (RWI) of the institute of Geological Sciences group has acquired expertise not only in the framework of Nagra's projects (e.g. Wellenberg, Projekt Opalinuston, Mont Terri and Grimsel URL's) but also contributed in various ways to international projects (EU-projects and for Nagra's sister organisations). The wide range of expertise by RWI includes but is not limited to: porewater analyses of clayrocks and bentonite materials, transport properties of clay rocks and bentonite materials, mineralogical and petrographical investigations and the evolution of interfaces of engineered and natural barriers. This also includes an in depth understanding of interface processes between steel and bentonite or cement and bentonite under repository conditions.

Involvement of the Nagra LTPs in the EURAD :

- WP GAS: Laboratory experiments in support of Tasks 2.1 and 2.2 (gas-induced damage evolution/self-sealing) and modelling in support of Task 2.3 shall be performed through EPFL and CIMNE.
 - WP GAS: Microstructural analyses of damage evolution and self-sealing processes using advanced 3-D imaging techniques in support of Tasks 2.1 and 2.2 (gas-induced damage evolution/self-sealing) shall be performed through ZHAW. The intended activities include also the processing/upscaling of the microstructural data, which will feed in Task 2.3.
- WP ACED: The University of Berne will contribute to the ACED work package, with an experimental part and a modelling part. The experiment investigates the interaction between a Fe(II) solution and smectite, by using chemical and isotope analysis on the solution and spectroscopic analysis for the solid phases. The modelling part will build on the former experiment and previous experiences. A reactive transport model will be developed to analyse the long-term evolution of Fe-bentonite interaction under repository relevant conditions.

Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

28/ NCSRD

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
The linked third party is DMT GmbH & Co. KG, acronym DMT who is expert in mining, exploitation, radiation protection, waste management. DMT has approx. 700 employees. 65 are working in the field of disposal facilities for radioactive waste. NCSRD is linked to DMT by a MoU for cooperation on a cost-free basis, each party is only responsible for its own costs. The cooperation concerns the future planning of the disposal of the Greek radioactive waste and for planning the decommissioning and dismantling of components and systems of GRR-1 at the	



NCSR D on the one hand and for the planning of disposal options of radioactive waste in countries with small amounts of radioactive waste in general.

Main tasks that will be performed by DMT are within WP9 ROUTES - Task 5 “RWM solutions for small amounts of waste” and Task 6 “Shared solutions in European countries in Waste Management Routes” of EURAD1. DMT (LTP) will take over the management of Task5 and give information about disposal options appropriate for SIMS like the use of old mines, tunnels, bunkers, caverns, deep shafts and boreholes (some 100 m). Expertise in mining as well as treatment and disposal of radioactive waste are only present at DMT. Former investigations for general solutions for countries generating only small amounts of radioactive waste were already performed by DMT in cooperation with NCSR D. Furthermore, DMT will collect the necessary information for the work in Task5 from the other Tasks of the WP. In WP9 Task 6 DMT will contribute by describing examples of sharing facilities in Germany as well as by providing feedback. DMT will share the information from the work in this Task with NCSR D.

Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

29/ NES

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

30/ NJF

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

31/ NRG

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

32/ ONDRAF

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
ULiège The Civil Engineering Department of University of Liège (ULiège) is internationally recognized for its expertise in multi-physical and multi-scale modelling in geomechanics. It has participated to several EC projects in the field of geomechanics applied to the geological disposal of radioactive waste, such as TIMODAZ, FORGE and BEACON. Link to third-party: memorandum of understanding on collaboration and exchange of information on research in geomechanics, including but not limited to research related to the geological disposal of radioactive waste.	



Tasks: ULiège will model gas injections experiments performed on Boom Clay and CO_x in WP6 (GAS), to support the interpretation of these experiments and the identification of key parameters for gas transport in these natural materials. In that context, ULiège will develop innovative tools for multi-scale representation of gas – porous media interactions in clay materials and transport along interfaces. ULiège will also support WP7 (HITEC), participating in benchmark exercises on the modelling of in situ heater experiments in different clay rocks. In that context, the interface element approach developed by ULiège will be upgraded to make it possible to represent time-dependant sealing processes. Improving the understanding of the complex mechanisms involved in gas transport in clays (e.g. such as the development of discrete, unstable pathways controlled by the mechanical behaviour of the porous media) and the thermo-hydro-mechanical couplings, combined with sealing processes, is important to determine how the effects of these complex mechanisms can be bound and, in turn, to justify the use of simpler and robust descriptions for evaluation purposes.

In addition, ULiège will co-organize the joint WP6-WP7 (GAS-HITEC) training activities on multi-physical couplings in geomechanics applied to geological waste disposal.

EURIDICE

Link to third-party: EURIDICE is an Economic Interest Grouping set by ONDRAF/NIRAS and SCK•CEN for the management and operation of The Belgian Underground Research Laboratory HADES. EURIDICE and/or its scientific staff have participated to several EC projects in the field of geomechanics applied to the geological disposal of radioactive waste, such as CLIPEX, SELFRAC (as coordinator), TIMODAZ (as coordinator) and FORGE.

Tasks: As operator of the HADES URL, EURIDICE will provide experimental data to WP7 (HITEC) from the large scale in situ heater test PRACLAY. These experimental data will be used to support the benchmarking exercise. EURIDICE will also support EURAD by providing state-of-the-art knowledge on the geomechanical behaviour of Boom Clay.

Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

33/ POSIVA

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
Envirocase Oy is a R&D consultancy company working with spent fuel disposal and safety case projects internationally. Envirocase do work for UMAN Subtask 3.1 – Types of uncertainties relevant to the safety analysis and the work is related to the safety case and description of knowledge quality assessment methodology. The person doing the work is former Posiva staff member having a good understanding of the safety case related tasks in spent fuel disposal.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

**34/ PSI**

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
EMPA is the Swiss Federal Laboratories for Materials Science and Technology. EMPA and PSI belong are two Swiss biggest research institutes. The Concrete and Construction Chemistry Laboratory focuses on fundamental research, application-oriented research and production development within the field of cementitious materials, with the aim of improving their sustainability. By studying alternative binder systems, concrete of improved durability and high-performance concrete, we aim at reducing the consumption of energy and raw materials and the CO₂-emissions during the life cycle of concrete structures. Laboratory for waste management at PSI and the Concrete and Construction Chemistry Laboratory at EMPA have long standing collaborative research agreement in the area of cement degradation, cement-waste interaction and radionuclides retention by cement minerals. Concrete and Construction Chemistry Laboratory at EMPA is the leading expert in thermodynamic modelling and experimental studies of cement hydration and cement interaction with environment. EMPA participate in WP CORI. Within the Task 3 (Organics-Cement-Interactions) EMPA will investigate the sorption of low molecular weight organics on the main phases present in hydrated cements: C-S-H (high and low Ca/Si C-S-H), AFm-phases and ettringite.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

35/ PURAM

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

36/ RATEN

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N

Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

37/ RWM

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

38/ SCK•CEN

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

39/ SKB

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
Uppsala University, Department of Physics and Astronomy Uppsala University (UU) is a public university founded in 1477. In WP8 for Spent Fuel characterization and evolution until disposal, Uppsala University Department of physics and astronomy, applied nuclear physics, are contributing to three tasks in the work package: 1) In subtask 1.1, UU will perform the scientific and technical coordination of the SFC work package. 2) In subtask 2.2, UU will contribute to the activities by developing improved analysis procedures for calorimetric measurements; analyse the data and describing the results together with detailed fuel histories, which are required for the validation of the theoretical calculations.	

3) In subtask 2.4, The main contribution of UU is to choose regression techniques and perform a multivariate regression analysis between the fuel history parameters and the experimental observables. UU will also assist PEL in establishing well-founded uncertainties for the SNF source-terms. Link to Third Party: Framework agreement and ordering of research tasks on nuclear fuel issues. SKB and Uppsala University have a long research relationship. In this case with the Department of physics and astronomy, applied nuclear physics the research is regarding on nuclear fuel diagnostics. The two latest agreements we have with the Department of physics and astronomy, applied nuclear physics are attached. They are in Swedish, and confidential information is hidden. Please don't hesitate to contact us if you need anything else proving the link between the two organisations.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

40/ SSE "Ecocentre"

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

41/ SSTC NRS

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

42/ STUBA

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N

Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

43/ SÚRAO

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
1. The Institute of Geonics AS CR, v.v.i. (IGN) The Institute of Geonics AS CR, v.v.i. (IGN) which is based in Ostrava, Czech Republic, is one of a number of public research institutions that operate under the umbrella of the Czech Academy of Sciences. The IGN was founded in 1982 with a major focus on engineering applications in the field of geosciences. The research team of the Department of Applied Mathematics and Computer Science has, for many years, been involved in the development and implementation of innovative numerical methods for the simulation of processes occurring within geomaterials and the geological environment. More recently, the Institute has been working intensively on the research of methods for the estimation of uncertainty in modelling. The team is a partner of the National Supercomputing Centre in Ostrava with which it is currently working on a project oriented towards developing high performance, massively parallelisable computing methods. Linked third party (LTP) connection to the beneficiary: Long-term cooperation with SÚRAO, which includes the participation of a team in the international DECOVALEX (Development of Coupled Models and their Validation against Experiments) project since 2008, is supported by a research cooperation agreement (SO2018-095) that was signed in 2018. Tasks to be performed by the LTP: WP DONUT - Development and Improvement of Numerical Methods and Tools for the Modelling of Coupled Processes. The IGN team will contribute to the development of robust and efficient, parallelizable numerical methods for the simulation of hydro-mechanical and thermo-hydro-mechanical (THM) processes in natural and bentonite DGR barriers. The newly-developed methods will be tested on suitable benchmark problems related to the performance-safety analysis of the future Czech DGR. The IGN team will also contribute to the Monte-Carlo methods via a suitable variance reduction technique (Multi-level Monte-Carlo methods for issues concerning poromechanics), a stochastic collocation method and response surface methods. Moreover, IGN research will also focus on sensitivity analysis and inverse identification problems, focusing specifically on the Bayesian inversion technique with the use of surrogate models. The developed uncertainty quantification/reduction methods will be tested on models for the analysis of coupled processes relevant to underground nuclear waste disposal. 2. ÚJV Řež, a.s. The principle mission of ÚJV Řež, a.s. (Nuclear Research Institute, NRI, hereinafter referred to as UJV) is to remain the pre-eminent technical-engineering company in terms of contributing to the development of a long-term sustainable power supply in the Czech Republic and to make up a significant player with respect to European research in the field of nuclear energy. The Waste Disposal Department at UJV focuses primarily on supporting SÚRAO in the development of the long-term deep geological repository R&D programme. Its activities include the conducting of laboratory and field experiments for the quantification of migration and geochemical processes (sorption, diffusion) and laboratory experiments for the quantification of the degradation rates of spent fuel, waste forms and engineered barriers (disposal container materials, backfill and buffer materials). Moreover, the environmental safety performance and risk analysis of geological disposal systems (behaviour, spread of radionuclides and toxic substances in the near- and far-fields of disposal facilities and their environmental impacts) also make up important elements of the research programme of the department. The department is equipped with UV/Vis-spectroscopy, beta and gamma-spectroscopy and AAS etc. equipment and enjoys the support of the UJV's certified central laboratory (ICP-MS, DTA, alpha spectroscopy, DTA, HPLC etc.).	

LTP connection to the beneficiary:

UJV and SÚRAO have enjoyed fruitful cooperation with concern to both national and international projects concerning radioactive waste management and the repository development programme since SÚRAO's establishment by the Atomic Act which was adopted in 1996. In 2017, UJV and SÚRAO signed cooperation agreement No. SO2017-105 focusing on various fields in the area of radioactive waste management and disposal.

Tasks to be performed by the LTP:

WP ACED – the Assessment of the Chemical Evolution of ILW and HLW Disposal Cells. The main contribution involves the combination and detailed evaluation of corrosion experiments under defined system (interface of steel, corrosion products and saturated compacted bentonite) and geochemical modelling of this interface.

WP HITEC – the Influence of Temperature on Clay-based Material Behaviour. The study of changes in the properties of bentonite due to thermal loading (mineralogy with respect to changes of expandable structures of clay minerals, cation exchange capacity, specific surface, re-hydration - retention curves) and the provision of support for the CTU with respect particularly to analytical measurements.

WP GAS – the Mechanistic Understanding of Gas Transport in Clay-based Materials. The performance of laboratory experiments and the study of the migration (advection) of hydrogen through bentonite using experience obtained from previous projects (FORGE, Czech projects); the experiments are based on the detection of the lower pressure limit at which hydrogen breakthrough occurs in bentonite. The experiments will provide support for experiments conducted at the CTU.

WP CORI - Cement-Organics-Radionuclide-Interactions. The study of the degradation of concrete organic additives (superplasticisers) and ion-exchange resins via radiolysis (in an irradiation chamber) and hydrolysis in an alkaline environment and the consequent analytical evaluation of degradation products. Migration studies of the influence of degradation products of organics on cementitious materials – sorption, diffusion, leaching; the verification and description of the fixation of ion exchange resins in cement matrices; changes in the physical and mechanical properties of cement matrices due to the degradation of organics via irradiation and hydrolysis; studies of the migration of organics in cementitious materials influenced by iron corrosion products. The migration of selected tracers and their complexes with concrete additives and the degradation products of organics and the migration of selected tracers fixed on ion-exchange resins and their degradation products (e.g. Ni, U) in CEM I.

WP DONUT - Development/improvement of numerical methods and tools for the modelling of coupled processes. The UJV contributions will focus on the delivery of extensive pre-processed site-characterisation data, including the description and interpretation thereof in close connection with the FUTURE WP. A joint programme has been designed with concern to developments surrounding the mathematical representation of uncertain parameters applied for coupled processes involving cooperation between ÚJV, GRS, JUELICH and HZDR on the conducting of a complex uncertainty treatment and sensitivity analysis based on coordinated data collection, uncertainty quantification and the testing of sensitivity analysis methods applied in geochemical applications.

WP FUTURE - Fundamental Understanding of Radionuclide Mobility. The analysis of the connected pore network and surface topography of fractured crystalline rock samples and mineral infills followed by batch type and flow-through sorption experiments utilising the reference pore water of the specific host rock. UJV will focus on the preparation and characterisation of samples with respect to pore structure, batch sorption experiments (Eu, Ba, Sr, Se, I) and through-diffusion tests (HTO, I, Ba/Eu, U) with crystalline rock samples. The WP envisages extensive cooperation with HZDR and Helsinki university.

3. Technical University of Liberec (TUL)

The Technical University of Liberec (TUL), which was founded in 1953, is a regional public university offering an extensive range of technical and humanities subjects. Two departments are involved in the project: The Centre of Nano-materials, Advanced Technologies and Innovations (established as part of an EU regional operational programme) and the Faculty of Mechatronics and Interdisciplinary Engineering Studies. The specialised fields of the two teams include computer science research and numerical simulation in the field of geosciences. The teams have extensive experience of code comparison and benchmarking related to nuclear waste disposal (coordinated by SÚRAO) and the theory and implementation of numerical methods in the context of national research support programmes. The team also operates the “Charon” cluster of 400 cores in 20 nodes (introduced in 2017) as a part of the Czech MetaCentrum partnership.



LTP connection to the beneficiary:

The link between the participant and the third party is based on joint research work that has been underway via e.g. the DECOVALEX project (on the model development and testing of coupled processes and the processing of data on groundwater flow and the transport of tracers) since 2008 and the GEOSTAB project (on methodologies concerning the stability of underground constructions including SW for compiling 3D records of geological massifs) since 2011. An assessment of past cooperation with a view to subsequent cooperation was incorporated into research cooperation agreement No. SO 2018 – 091 of 9 November 2018.

Tasks to be performed by the LTP:

WP DONUT - Development and Improvement of Numerical Methods and Tools for the Modelling of Coupled Processes. As part of the project the TUL plans to develop and implement numerical approaches related to multi-dimensional domain modelling (fracture-continuum) comprising e.g. processes within intersections, coupling frameworks, the XFEM method and hybrid parallelism. The TUL will apply the multi-dimensional model concept in relation to data from different spatial scales using hydraulic/tracer field data. As part of the uncertainty analysis work, it is planned that the multilevel Monte-Carlo method will be applied to the various model problems, resulting to the effective approximation of generalised moments followed by the approximation of CDF from generalised moments. Finally, the TUL will contribute to benchmarking and the evaluation of the Flow123d simulation code including uncertainty analysis tools.

4. Czech Technical University in Prague (CTU)

The Czech Technical University in Prague (CTU), a public university established in 1707, is one of the largest and oldest technical universities in Europe. The CTU currently has eight faculties (Civil Engineering, Mechanical Engineering, Electrical Engineering, Nuclear Science and Physical Engineering, Architecture, Transportation Sciences, Biomedical Engineering and Information Technology) and a student population of around 18,000. The university offers a wide variety of study programmes and hosts a number of leading research groups. Research groups from the Faculty of Nuclear Sciences and Civil Engineering will participate in the project.

LTP connection to the beneficiary:

The CTU enjoys long-standing cooperation with SÚRAO involving the conducting of a large number of joint research projects (e.g. DOPAS, BEACON, CEBAMA). Indeed, the CTU makes up one of SÚRAO's leading long-term research providers. The CTU and SÚRAO signed the latest framework research cooperation agreement (SO2018-096) on 2 February 2019, which establishes the will of the parties concerned to cooperate in research concerning the future Czech DGR.

Tasks to be performed by the LTP:

WP CORI - Cement-Organics-Radionuclide-Interactions. In close cooperation with UJV Řež, a. s., the CTU will study the degradation of cementitious materials, concrete organic additives and ion-exchange resins with regard to their mutual interaction and transport/retention properties. The research will consist of an analysis of cementitious samples originating from radiolytic degradation and the hydrolysis of the materials, and will include the identification and quantification of organics, organics-cement and organics-iron species and the influence of organics-Fe/organics-cement species on RN transport and cement degradation. Long-term experience of the modelling of geochemistry and diffusion transport in the PHREEQC3 environment will facilitate the subsequent experimental data fitting process.

WP DONUT – the Development/improvement of Numerical Methods and Tools for the Modelling of Coupled Processes. Attention will be devoted to numerical modelling and simulation with concern to thermo-hydro-mechanics and will include modelling issues based on material constitutive laws (CU) as well as HPC issues related to parallelism based on domain decomposition.

WP GAS – the Mechanistic Understanding of Gas Transport in Clay-based materials. The CTU will perform laboratory experiments and study the migration (advection) of gases through bentonite using experience obtained from previous projects (FORGE, CZ projects). A long-term experiment involving slow gas injection and including a series of repeated fracturing (gas breakthrough) tests and the resealing of the bentonite barrier (re-saturation and a permeability check) is planned.

WP HITEC – the Influence of Temperature on Clay-based Material Behaviour. The main objective of the CTU is to characterise and model the thermo-mechanical behaviour of bentonite at temperatures in excess of 100°C. The CTU will perform the analysis of materials exposed to high temperatures, measure the various parameters at high temperatures and perform the laboratory experiments. The laboratory data will

provide input material for the construction of a mathematical model as part of the work package. Along with its various research responsibilities, the CTU will coordinate Task 3 and provide assistance with the preparation of a training workshop.

WP SFC – Spent Fuel Characterisation. The CTU enjoys extensive experience with the determination of the radiation source term during fuel depletion and the consequent decay period. The CTU will study the sensitivity of this source term to realistic levels of impurities in the composition of materials and the importance of structural materials with respect to the overall SNF source term.

WP KM – Training/Mobility. The CTU will assist in the preparation and conducting of training courses. The CTU is able to offer courses involving the research reactor and other laboratories as well as the Josef Underground Laboratory.

5. Charles University (CU)

The Charles University (CU) – is the oldest university in Central Europe. Established in 1348, and with 17 faculties, it is the largest and most respected university in the Czech Republic and also enjoys a high ranking internationally. SÚRAO is involved in the DONUT and HITEC WPs with the CU's College of Natural Sciences (Department of Engineering Geology). The university's main representative in the WPs, Dr. David Mašín, gained his professional experience at a number of leading universities in the field and has based his research at the University of Innsbruck; Imperial College, London; City University, London; Université Joseph Fourier, Grenoble; the University of Dresden; the University of Karlsruhe and the University of New South Wales, Sydney. The subject of the mechanical evolution of bentonite makes up the principal theme of the joint Horizon 2020 project commissioned in 2016 under the acronym BEACON and conducted in cooperation with SÚRAO.

LTP connection to the beneficiary:

Long-term cooperation with SÚRAO, which includes the participation of a team in the international BEACON project (Bentonite mechanical evolution, Horizon 2020, Proposal number: 745942) since 2015, is supported by an agreement on research cooperation signed on 5 April 2018 (SO 2018-094).

Tasks to be performed by the LTP:

WP DONUT, Task 2 – particular attention will be devoted to numerical modelling and simulation with respect to Thermo-Hydro-Mechanics (THM) including modelling issues based on material constitutive laws. The HITEC WP, Task 3 - Subtask 3.1: the CU will focus on the post-mortem analysis of small-scale laboratory experiments performed by the CTU. The CU will investigate swelling under constant load test conditions and conduct oedometric load-unload tests and water retention tests on heat-treated BCV bentonite. Subtask 3.2: the CU will study the BCV material at 100 °C and 150 °C in specialised cells and conduct 2 swelling pressure tests with suction control, 2 swelling under constant load tests with suction control and 1 oedometric load-unload test. Subtask 3.3: the CU will further develop and validate a hypoplastic model for bentonite at high temperature and will conduct simulations of experiments conducted by the CTU.

Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

44/ SURO

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

45/ TNO

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

46/ TS Enercon

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	<u>N</u>
Does the participant envisage that part of its work is performed by linked third parties	<u>N</u>
Does the participant envisage that part of its work is to be performed through financial support to third parties	<u>N</u>
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	<u>N</u>
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	<u>N</u>

47/ TUS

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

48/ UCY



Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

49/ UH

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
JyU (University of Jyväskylä), a linked third party to UH will utilize X-ray techniques to obtain detailed spatial and temporal information on wetting and hydromechanic behaviour of small-scale bentonite samples at elevated temperatures. The experiments will be carried out as a joint effort with GTK. The data obtained will be organized in an open database to support related modelling and model validation carried out in Task 3 (Subtask 3.2). The legal link between UH and JyU is based on Finnish Radiation Safety Research Program and Consortium (Cores). The Finnish Government Resolution on Comprehensive Reform of State Research Institutes and Research Funding took place in September 2013. GTK (Geological Survey of Finland), which is linked 3rd party (legal link) to UH, and GTK will be participating in Task 3, Subtask 3.2. for X-ray tomography. This is to be able to utilise the laboratory capacity and expertise at GTK for the project. The legal link between UH and GTK is based on the Cooperative agreement on shared laboratory facilities (The agreement from signed 2013). TUT (Tampere University of Technology), which is linked 3rd party to UH, will participate in Task 4 (Tools and methods to quantify/derive uncertainties induce by coupled processes) of WP DONUT (Development and Improvement Of NUMerical methods and Tools for modelling coupled processes). The role of TUT will be to develop metamodels for uncertainty quantification related to tools and models developed in DONUT. The legal link between UH and TUT is based on Finnish Radiation Safety Research Program and Consortium (Cores). The Finnish Government Resolution on Comprehensive Reform of State Research Institutes and Research Funding took place in September 2013.' Aalto University, which is linked 3rd party to UH, will participate in Task WP DONUT using the developed THMC coupled Finite Element Code (Abed & Sołowski 2017, 2018). In this project, the Aalto group intends to model the processes related to hydration of bentonite barrier in the nuclear waste storage. In Aalto they will simulate a repository scale problem (i.e. 'generic repository'), as defined early in the subtask by the EURAD participants. The legal link between UH and Aalto is based on Finnish Radiation Safety Research Program and Consortium (Cores). The Finnish Government Resolution on Comprehensive Reform of State Research Institutes and Research Funding took place in September 2013.'	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

50/ UKRI-BGS

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

51/ VTT

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	Y
1. Short description of LTP Galson Sciences Ltd (GSL) is an international environmental safety and radioactive waste research and consultancy company, specialising in radioactive waste management and disposal, nuclear decommissioning and nuclear safety studies, risk and impact assessment, risk management and communication, and geoscience studies. GSL implements national R&D programmes on behalf of the national waste management organisation (WMO) and the waste producers responsible for radioactive waste management. For example, in the UK GSL holds framework contracts to implement national R&D with RWM and LLWR Ltd (waste disposal) and with the NDA for estate-wide R&D (decommissioning and predisposal waste management on behalf of all of the NDA's Site Licence Companies). GSL also implements R&D directly for WMOs in other countries and for international organisations. 2. Description of link between VTT and GSL GSL has built up a close collaboration with VTT Technical Research Centre of Finland (amongst others) over many years via collaborative R&D in all of the above-noted areas, and this collaboration is documented in a series of legally binding Memoranda of Understanding (MoUs) and contracting agreements. The legal agreement under which work in EURAD would be carried out is the attached MoU signed September 2018, which covers the entire radioactive waste management field. VTT and GSL also have a working relation on earlier cooperative EC-funded projects, most recently Euratom projects DOPAS, Modern2020 and THERAMIN. Examples of recent collaboration outside of EURAD that illustrate the scope of recent collaboration include the following: • Project for RWM on durability of concrete containers for radioactive waste. • Project for RWM on radionuclide migration parameter values and laboratory techniques. • Project for RWM on approaches to backfilling, sealing and closure of geological disposal facilities. An example of an existing public contracting arrangement is the consortium led by GSL with VTT participation, to support the UK's Nuclear Decommissioning Authority for "Integrated Waste Management and Site Decommissioning and Remediation." See https://www.gov.uk/government/news/12-million-contracts-support-nuclear-decommissioning-research. 3. Involvement of GSL per Work Package (WP) GSL is involved in ROUTES and UMAN. The work to be done (as per the EURAD proposal) is as follows: ROUTES – WP2 - Contribute to identification and classification of challenging wastes and pre-disposal routes for these wastes; WP4 - (co)Lead development of report on identification of waste acceptance criteria (WAC), and development of WAC where wastes exist, but disposal facilities do not; WP6 –	



contribute to identification of shared predisposal waste management solutions across Europe, including identification of case studies and prospects. UMAN – WP2 - Lead review of general strategies, approaches and tools for managing uncertainties.	
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

52/ VUJE

Does the participant plan to subcontract certain tasks (please note that core tasks of the project should not be sub-contracted)	N
Does the participant envisage that part of its work is performed by linked third parties	N
Does the participant envisage that part of its work is to be performed through financial support to third parties	N
Does the participant envisage the use of contributions in kind provided by third parties (Articles 11 and 12 of the General Model Grant Agreement)	N
Does the participant envisage that part of the work is performed by International Partners (Article 14a of the General Model Grant Agreement)?	N

2.7. Resources to be committed

2.7.1. Summary of staff effort – AWP1

	WP1- PMO	WP2- ACED	WP3- CORI	WP4- DONUT	WP5- FUTuRE	WP6- GAS	WP7- HITEC	WP8- SFC	WP9- ROUTES	WP10- UMAN	WP11- SoK	WP12- Guidance	WP13- Training/ Mobility	Total PM
1/Andra	20	7,1	6	8,5	8,1	2,3	3,2		1,7	2	1,5		1,4	61,8
2/ARAO									0,2					0,2
3/Bel V		1							0,1	2,6				3,7
4/BGE						0,7	3,2			2,2	15			21,1
5/CEA		23	8,9	18,9	5,8	1,4	3,8	10,8	1					73,6
6/CIEMAT		13,8	18,6		13,3	9	17,3	1,6	1,5	1	0,37		2,4	78,87
7/ChRDI							22,9							22,9
8/CNRS	3	10,7	15	41	31	28,2	20,8	38,2		0,8				188,7
9/COVRA		5		2,4		3,2			1	0,3				11,9
10/FTMC			5					19,8	0,7	0,3				25,8
11/CVREZ			3											3
12/Dekom									1					1
13/EEAE									0,8					0,8
14/ENRESA		7		3			0,3	0,1		0,2				10,6
15/FZJ		7,9	6,8	6	19,5	2,4		2	1,5	0,8	16			62,9
16/GRS				1,3	2,6	2,2			0,7	1				7,8
17/IAE									0,5					0,5
18/INCT									1					1
19/IRSN	1,82	12,1		14,6		6,9	0,4	7,5	2,8	4,7				50,82
20/IST-LPSR									0,7					0,7
21/IST-ID									0,8					0,8
22/JSI	0,45	12,2	6,6						1,9	2		2	1,1	26,25
23/JRC	3							9				1,5	1,89	15,39
24/KIT			26,3		18	2,2	2,3	10,8		1,5				61,1
25/LEI		2,1		4,5		0,5	2,5	1,75	0,5	0,8				12,65

	WP1- PMO	WP2- ACED	WP3- CORI	WP4- DONUT	WP5- FUTuRE	WP6- GAS	WP7- HITEC	WP8- SFC	WP9- ROUTES	WP10- UMAN	WP11- SoK	WP12- Guidance	WP13- Training/ Mobility	Total PM
26/MTA EK		3,4		5	5,3			1,8						15,5
27/NAGRA		13,5				17,4	0,6	4,8		0,9				37,2
28/NCSRD									2,7					2,7
29/NES									0,8					0,8
30/NJF									0,5					0,5
31/NRG		3,6		4,9					0,1	0,5				9,1
32/ONDRAF/NIRAS						9,9	11,2		1,5	0,7				23,3
33/POSIVA					20,5		0,4			0,9				21,8
34/PSI		4,4	6	3,1	5,5	4,8		1,2		0,5				25,5
35/PURAM												5,3		5,3
36/RATEN			4,3		8				1,2	2,2				15,7
37/RWM	3					0,7	29,3			0,7				33,7
38/SCK•CEN		6,9	4,6	0	3,1	5,6		6,5	0,2	0,7			6,5	34,1
39/SKB							2,3	3,3	0,5					6,1
40/SSE Ecocentre									14,7					14,7
41/SSTC NRS								10,3	2,5	1,3	13	1,5	1,9	30,5
42/STUBA									0,9	0,2				1,1
43/SURAO		10,9	21,7	0	3,5	10,6	1,5		0,5	1,2		9,5	1,9	61,3
44/SURO									1,4	1,4		1,5	2,3	6,6
45/TNO					4,5									4,5
46/TS-Enercon				4,2					0,1	0,2				4,5
47/TUS				0				1,7	1,1	1,2				4
48/UCY			1						0,3					1,3
49/UHelsinki				6,5	8	0,5	15,5							30,5
50/UKRI-BGS						21,6	21,2							42,8
51/VTT		9					5,4	2,5	1,6	0,5				19
52/VUJE									0,3					0,3
Total	31,27	153,6	133,8	123,9	156,7	130,1	164,1	133,65	49,3	33,3	45,87	21,3	19,39	1196,28

2.7.2. Other major cost items (travel, equipment, infrastructure, goods and services)

1/Andra

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for BGE.

2/ARAO	Cost (€)	Justification
Travel	1 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	1 000	

3/BEL V	Cost (€)	Justification
Travel	6 950	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	14 293	Costs for Other goods and services are planned under the following RD&D WPs: - ACED: 4 250€. Consumables and raw materials for the implementation of the new in-situ experiment NE2-2/1 of Task 2. Costs for Other goods and services are planned under the following Strategic Studies WPs: - UMAN: 10 043€. Organization of seminars and workshops of the WP (budget will be transferred to the organizations hosting these workshops/seminars when identified).
Total	21 243	

4/BGE

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for BGE.

5/CEA	Cost (€)	Justification
Travel	16 300	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	57 705	Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - ACED: 29 000€ : it corresponds to consumables for solution and solid analyses (ICPM-MS analysis ; SEM, TEM, Raman, ToF-SIMS) of the various experiments (glass/steel/clay and glass/steel/cement buffer/clay) - DONUT: 550€ : Consumables for computer - HITEC: 1 474€ : this cost corresponds to consumables for the several mechanical tests performed on clay host rock - FUTuRE: 9 250€ : it corresponds to consumables necessary for the diffusion experiments (for example radioactive and non-radioactive tracers), and for post-mortem analysis of solid samples (m-XAS, m-XRF, m-LIBs) - CORI: 17 431€ : it corresponds to consumables that are necessary for the migration experiments planned with C-14 radiolabeled organics
Total	74 005	

6/CIEMAT

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for CIEMAT.

7/ChRDI	Cost (€)	Justification
Travel	3 750	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	3 750	

8/CNRS	Cost (€)	Justification
Travel	37 775	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	26 481	Equipment costs are planned under the following RD&D WPs: - GAS: 4 000€ - Characterization of the nano-porous structure properties and its effect on H2 sorption, Raman Spectroscopy, X-ray diffraction, QUENS, CT, TEM... - HITEC: 7 500€ - Triaxial cell transparent to X-ray under high Temperature and confining pressure - CORI: 2 500€. - SFC: 12 481€ - Experiment approach for study of degradation process of spent nuclear fuel: Cutting-edge synchrotron methods at the Rossendorf beamline (i.e. high resolution diffraction, x-ray absorption spectroscopy and x-ray emission spectroscopies)
Other goods and services	92 550	Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - ACED: 8 375€ - Consumables and samples for in situ experiment for mineralogical, chemical and transport properties evolution, chemical and mineralogical analyses of solid phases (X-ray tomography, XRD, SEM EDS, Raman spectrometry and TEM) - DONUT: 6 140€. CPU for Diffusion Poisson Coupled Model and new numerical methods. Workshops/meetings. - GAS: 26 540€. Characterization the nano porous structure properties, gas sorption desorption and propagation process in a large range of pressure, Raman Spectroscopy, X-ray diffraction, QUENS, CT, TEM + meetings and workshop organizations - HITEC: 13 638€. Consumables and samples of Boom Clay, Opalinus Clay, Callovo Oxfordian clay for X-ray measurement under high Temperature and confining pressure - FUTuRE: 25 107€. Preparation of clay samples, consumable sorption and redox experiment in a specifically designed chemical reactor - CORI: 12 750€. Consumable and supplies for alpha and gamma radiolytic degradation pf PCE
Total	156 806	

9/COVRA	Cost (€)	Justification
Travel	10 900	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	3 200	Costs for Other goods and services are planned under the following RD&D WPs: - ACED: 3 200€. Certified concrete samples have been exposed to geological representative clay media for several years at start of ACED. To support chemical evolution models, these samples are experimentally investigated by Jülich, ZAG and COVRA. Each organisation performs different chemical analysis to obtain a

		coherent image. COVRA's in-house laboratory equipment will also be used. The costs are for the sample preparation and measurement of chemical elements using ICP.
	-	
Total	14 100	

10/FTMC	Cost (€)	Justification
Travel	5 650	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	2 250	Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - CORI: 2 250€ In Task 2, FTMC will perform hydrolytic degradation of PVC/Cellulose and identification of degradation products. For this task the material (PVC, cellulose) as an object of research, chemicals and goods for hydrolytic degradation are needed. Ion exchange/gas chromatography sorbents, pipette tips, centrifuge tubes, pH electrode will also be needed for detection of degradation products. In Task 4, for study of the competitive effect of Fe(II)/Fe(III) onto radionuclides (Am-243 and Pu-242) sorption in the presence of organics (low molecular weight organic acids / phthalate / adipate) in contact with CEM I/ CEM V cement-based materials (pH 12.5) FTMC must purchase organics and radionuclide solutions (Am-243 and Pu-242). Laboratory glass, goods for filtration (filters) and centrifugation (centrifuge tubes) will be needed. For the examination of chemical and phase composition of the cement the service at X-ray spectroscopy and XRD will be need during experiments.
Total	7 900	

11/CV REZ	Cost (€)	Justification
Travel	2 125	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	5 000	Equipment costs are planned under the following RD&D WPs: - CORI: 5 000€ Task 2 and 3: gamma radiation source Cobalt-60 with the half-life 5 years. Whole CORI contribution will be used for the project issues.
Other goods and services	3 250	Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - CORI: 3 250€

		This money will be used for the material, necessary for irradiation and testing of the superplasticizers (Task 1) and cement samples (task 2), e.g. ducts for gasses, gauges, glass, cables or so on.
Total	10 375	

12/DEKOM	Cost (€)	Justification
Travel	1 700	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	1 700	

13/EEAE	Cost (€)	Justification
Travel	1 600	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	1 600	

14/ENRESA

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for ENRESA.

15/FZJ

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for FZJ.

16/GRS

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for GRS.

17/IAE	Cost (€)	Justification
Travel	1 100	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-

Total	1 100	

18/INCT	Cost (€)	Justification
Travel	1 400	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	1000	Costs for <i>Other goods and services</i> are planned under the following Strategic Studies WPs: - ROUTES: 1000€. Cost of organization of internal meetings, small consumables, dissemination of information between Polish stakeholders (webpage, posters, leaflet).
Total	2 400	

19/IRSN	Cost (€)	Justification
Travel	31 300	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	2 000	Equipment costs are planned under the following RD&D WPs: - GAS: 2 000€. Development of a special set-up consisting on a transparent PMMA (Polymethyl methacrylate) cell will be used to perform a microstructural analysis of the mixture at initial state and during gas /water injections by X-ray micro-tomography and laboratory consumables for the mock-up test of gas injection into highly heterogeneous bentonite pellet-powder sample.
Other goods and services	36 500	Costs for <i>Other goods and services</i> are planned under the following WP: - PMO: 16 000€. Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - ACED: 16 125€. Laboratories materials and consumables. - DONUT: 375€. Laboratories materials and consumables. - HITEC: 1 000€. Costs for <i>Other goods and services</i> are planned under the following Strategic Studies WPs: - ROUTES: 3 000€. Organisation of workshops and meetings.
Total	69 800	

20/IST-LPSR	Cost (€)	Justification
Travel	1 400	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	1 400	

21/IST-ID	Cost (€)	Justification
Travel	1 400	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	800	Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - ROUTES: 800€. Organisation of meetings.
Total	2 200	

22/JSI	Cost (€)	Justification
Travel	17 250	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	24 180	Costs for <i>Other goods and services</i> are planned under the following WP: - PMO: 5 680€. Organisation of meetings. Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - ACED: 2 000€. Chemicals, gases for instruments, standards, laboratory consumables. - CORI: 15 500€. Chemicals, gases for instruments, standards, laboratory consumables. - SFC: 1 000€. Chemicals, gases for instruments, standards, laboratory consumables.
Total	41 430	

23/JRC	Cost (€)	Justification
Travel	16 150	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	51 658	Costs for Other goods and services are planned under the following RD&D WPs: - SFC: 51 658€. Waste and consumables for implementation in SFC WP
Total	67 808	

24/KIT

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for KIT.

25/LEI	Cost (€)	Justification
Travel	8 850	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	500	Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - DONUT: 500€. Consumables and supplies, dissemination and conference fee, open acces publication fee
Total	9 350	

26/MTA EK	Cost (€)	Justification
Travel	6 225	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	4 625	Equipment costs are planned under the following RD&D WPs: - ACED: 1 625€. Encapsulation machine, boxes for the in-situ experiments (with temperature, humidity pH control), access to study the surface of the containers (exp. wet catalytic oxidation, corrosion and other redox processes on steel container surfaces). - DONUT: 2 000€. Rental of CPU run-time for numerical simulations; (exp. GPU-CPU 1U Server with 2 × Tesla C2050 + 2x Intel Xeon X5550, 96 GB RAM). - SFC: 1 000€. Rental of Ar, N2, H2 gas cylinders, in-situ cells, for irradiation test, special capsules.

Other goods and services	6 650	Costs for Other goods and services are planned under the following RD&D WPs: - ACED: 1 000€. Consumables: radioisotopes, chemicals, laboratory material for supporting experimental work, steel containers for several experiments. Dissemination cost (workshops, meetings); to present the results. - DONUT: 1 500€. Dissemination cost (workshops, meetings, publications); to present the results of the comparison for different programming modules (CUDA, OpenCL, OpenMP, OpenACC) and optimize a module for a cost effective and reliable numerical method. - SFC: 2 250 EUR. Consumables like: thermocouples, sealing rings etc... - FUTuRE: 1 900€. Consumables: radioisotopes in solution form, chemicals, laboratory material for supporting experimental work
Total	17 500	

27/NAGRA

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for NAGRA.

28/NCSR	Cost (€)	Justification
Travel	3 800	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	
Total	3 800	

29/NES	Cost (€)	Justification
Travel	1 400	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services		-
Total	1 400	

30/NJF	Cost (€)	Justification
Travel	1 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	1 000	

31/NRG

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for NRG.

32/ONDRAF/NIRAS

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for ONDRAF/NIRAS.

33/Posiva	Cost (€)	Justification
Travel	3 500	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	3 500	

34/PSI

The sum of the costs for 'travel', 'equipment', and 'goods and services' does not exceed 15% of the personnel costs for PSI.

35/PURAM	Cost (€)	Justification
Travel	2 400	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	2 400	

36/RATEN	Cost (€)	Justification
Travel	6 700	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	8 125	Costs for Other goods and services are planned under the following RD&D WPs: - FUTURE: 3 475€ - purchasing 99Tc standard solution, pure clay minerals, and other lab ware. - CORI: 3 650€ - purchasing 59Ni and organic 14C radioactive solutions, and other lab ware Costs for Other goods and services are planned under the following Strategic Studies WPs: - ROUTES: 1000€ (cost for hosting one meeting)
Total	14 825	

37/RWM	Cost (€)	Justification
Travel	9 750	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	9 750	

38/SCK•CEN	Cost (€)	Justification
Travel	19 725	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	1 600	Equipment costs are planned under the following RD&D WPs: - GAS: 1 600€. Equipment costs: pressure sensors, diffusion cells, Swagelok material, magnetic coupled gear pumps, pump heads
Other goods and services	48 536	Costs for Other goods and services are planned under the following RD&D WPs: - ACED: 7 500€ - o Organisation of ACED WP meetings - o Computer and software licences, open access publications - DONUT: 861€

		- o Computer and software licences, open access publications - FUTuRE: 4 250€ - o Lab consumables, analysis costs, radioactive spike solutions, diffusion cells - CORI: 35 925€ - o ISA and carbohydrate measurements - o 24 stainless steel irradiation containers with Swagelok material - o 24 teflon containers (2L) for chemical degradation studies - o Purchase of pure alpha and beta ISA
Total	69 861	

39/SKB	Cost (€)	Justification
Travel	8 725	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	5 000	Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - SFC: 5 000€. Costs for other goods and services are needed to arrange workshops and meetings planned for in the SFC work package
Total	13 725	

40/SSE Ecocentre	Cost (€)	Justification
Travel	1 100	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	1 100	

41/SSTC NRS	Cost (€)	Justification
Travel	10 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-

Total	10 000

42/STUBA	Cost (€)	Justification
Travel	1 375	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	1 375	

43/SURAO	Cost (€)	Justification
Travel	44 325	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	14 075	Equipment costs are planned under the following RD&D WPs: - ACED: 2 000€ (UJV). Modification of existing experimental apparatus for evaluation of specific issues, computing technology - GAS: 1 700€ (UJV). Migration cells, GDS pumps, possible modification of existing experimental apparatus. - HITEC: 4 125€ (CU, UJV). Modification of existing experimental apparatus, sensors (5000€ for UJV) - FUTuRE: 3 750€ (UJV). Migration cells; GDS Pumps; Shielding; equipment for tracer tests - CORI: 2 500€ (UJV). Experimental apparatus and cells, pressure pumps, depreciation costs of analytical device
Other goods and services	37 264	Costs for Other goods and services are planned under the following RD&D WPs: - ACED: 2 500€. (UJV). External analyses, software licences, publication costs - DONUT: 3 195€ (SURAO, CTU, CU, TUL, UJV). Translation costs, software licences (?) - GAS: 5 500€ (CTU, UJV). Laboratory materials and consumables, maintenance of migration apparatus. - HITEC: 9 719€ (CTU, CU, UJV). Laboratory chemicals and consumables, external analyses (8500€ for UJV) - FUTuRE: 3 775€ (UJV). Radionuclide source purchase; Laboratory chemicals; Maintenance of migration apparatus; External analyses (XRD) - CORI: 12 575€ (CTU, UJV). Radiochemicals, external analyses, laboratory tools and consumables
Total	95 664	

44/SURO	Cost (€)	Justification

Travel	6 250	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	6 250	

45/TNO	Cost (€)	Justification
Travel	1 250	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	1 250	Equipment costs are planned under the following RD&D WPs: - FUTuRE: 1250€. TNO shares its geochemical lab with Utrecht University and Deltares. We need to rent equipment from UU for the experiments foreseen. This will be arranged under the partnership agreement that exists among these three organisations. Additionally, depreciations costs for expensive apparatus and analyses must be booked.
Other goods and services	3 200	Costs for Other goods and services are planned under the following RD&D WPs: - FUTuRE: 3200€. Chemicals as well as commercially available minerals must be bought for the experimental activities. Besides, small laboratory equipment may be bought.
Total	5 700	

46/TS ENERCON	Cost (€)	Justification
Travel	2 825	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	188	Costs for Other goods and services are planned under the following RD&D WPs: - DONUT: 188 €. Cost for organisation of a meeting
Total	3 013	

47/TUS	Cost (€)	Justification

Travel	7 150	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	2 121	Costs for Other goods and services are planned under the following RD&D WPs: - SFC: 171€ - Consumables, supplies, post costs, communication costs, organisation of meetings with experts from other Bulgarian organisations. - DONUT: 1950€ - Consumables, supplies, organisation of annual workshops and periodical meetings with experts, post and communication costs.
Total	9 271	

48/UCY	Cost (€)	Justification
Travel	2 350	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	2 350	

49/UHelsinki	Cost (€)	Justification
Travel	7 250	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	16 150	Costs for <i>Other goods and services</i> are planned under the following RD&D WPs: - DONUT: 750€. Supplies / Computational services - HITEC: 14 400€. (JYFL) Temperature and water flow controlling units. Sample holders and instrumentation for X-ray tomographic experiments / Laboratory instruments and supplies for X-ray tomographic experiments / (GTK) XCT using time (UHelsinki) Laboratory supplies - FUTURE: 1 000€. Laboratory supplies and irradiation services
Total	23 400	

50/UKRI-BGS	Cost (€)	Justification

Travel	4 825	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	54 600	Costs for Other goods and services are planned under the following RD&D WPs: - GAS: 20 486€ - HITEC: 34 114€ This budget covers: ▪ Dedicated cells (isostatic, triaxial, uniaxial) ▪ Flow meters ▪ Consumables for gas injection ▪ Tubing and pressure fittings ▪ Displacement and pressure transducers ▪ Data acquisition ▪ Construction and comissioning of apparatus, ▪ Numerical modelling ▪ Regular lab analyses ▪ Imaging and data processing ▪ Sample Preparation ▪ Petrophysical characterisation
Total	59 425	

51/VTT	Cost (€)	Justification
Travel	12 700	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	4 250	Costs for Other goods and services are planned under the following RD&D WPs: - ACED: 2 000€. Consumables, publications - HITEC: 2 250€. Costs for publication, for meeting organisation costs and for material & consumables
Total	16 950	

52/VUJE	Cost (€)	Justification
Travel	1 000	Travel costs are needed to properly implement the actions that are planned in each relevant WP (WPs annual meetings/Tasks meetings, workshops, seminars) ; to participate in EURAD General Assemblies and EURAD Annual Meetings , WP workshops; and to participate in scientific conferences/workshops to present EURAD/WPs results and outcomes.
Equipment	-	-
Other goods and services	-	-
Total	1 000	

51/VTT	Cost (€)	Justification
Large research infrastructure	30 486	- SFC: 1 975€ - ACED: 13 865€ - HITEC: 14 646€ LRI cost of VTT Research Facility. The LRI costs are calculated based on working hours of the project and according to VTT's ex-ante assessment of the methodology on Direct Costing for Large Research Infrastructures (LRI), approved by the Commission on 24th February 2015. The Materials, Production & Performance Research Facilities covers wide variety of material R&D laboratories in VTT locations. The laboratories are divided in to subgroups; autoclaves simulating process facilities, electron microscopy laboratory e.g. with high resolution requirement, trailer laboratory for dangerous liquid environments, tribology laboratory including the nanoindentation device, accredited non-destructive testing (NDT) laboratory, hotlab for elevated temperatures, creep laboratory for long-term loading, metallographic laboratory, destructive materials testing laboratory, fatigue laboratory and additive manufacturing laboratory with 3D printing devices for metallic materials. The laboratories concentrating on powder technologies and are divided in to two groups; powder manufacturing laboratory and consolidation laboratory e.g. hot isostatic pressing (HIP). The Research Facility provides also equipment for testing and experimental research in the area of vibration and durability in the area of Robotics multi-technology research, development and testing facilities. Centre for Nuclear Safety (CNS) will include class A, B and C facilities for experimental research and handling of radioactive materials. Research facility consists of hot cells and equipment used in CNS. Hot cells that protect employees from radiation are situated in class A laboratory in two separate floors. Equipment that are used to examine the properties of radioactive material samples are located inside the hot cells. Samples are handled behind lead glass utilizing manipulators and cameras. Opening of transport capsules of radioactive materials, storing of radioactive samples and specimens as well as handling of radioactive waste will also occur in class A laboratory. A Comprehensive set of microscopes will be linked to the class A laboratory. VTT's methodology on LRI complies with the clauses of the H2020 Grant Agreement (Capitalised and operating costs of large research infrastructure Article 6.2.D.4, the extent verified during the audit) and therefore, the LRI costs should be considered as direct costs of the project.
Total	30 486	

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ANNEX 8

MODEL FOR THE STATEMENT ON THE USE OF THE PREVIOUS PRE-FINANCING PAYMENT

➤ For fields in [grey in square brackets]: enter the appropriate data

STATEMENT ON THE USE OF THE FIRST PRE-FINANCING PAYMENT

(To be filled out by the coordinator)

The undersigned:

- declares that [...] % of the first pre-financing payment of EUR [insert amount] paid for Grant Agreement [insert grant agreement reference: number, title of the action and acronym] have been used,
- declares that this is based on substantiated data (bank slip/treasury account) provided by each beneficiary,
- requests a second pre-financing payment of EUR [insert amount] for [insert grant agreement reference: number, title of the action and acronym].

SIGNATURE

For the coordinator:

[electronic signature]

Done on [electronic time stamp]



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