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EXPRO STATEMENT OF WORK
ESA EXPRESS PROCUREMENT – EXPRO

DEPLOYABLE TELESCOPE FOR SMALL SATELLITES- EXPRO

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Table of Contents

1. INTRODUCTION

1.1. Scope of the Document

This document describes the activity to be executed and the deliverables required by the European Space Agency in relation to the “Deployable Telescope for Small Satellites”, which serves as a foundational step towards enhancing Earth observation missions with small satellites.

It will be part of the Contract and shall serve as an applicable document throughout the execution of the work.

1.2. Applicable and Reference Documents

ECSS standards are available for downloads at:
https://ecss.nl/standards/ecss-cd-download/

1.2.1. Applicable Documents (ADs)

N/A

1.2.2. Reference Documents (RDs)

The following documents can be consulted by the Contractor as they contain relevant information:

Number	Document
[RD 1]	Technologies for large ultra-stable optical missions: current perspectives and developments at ESA https://doi.org/10.1117/12.2529320
[RD 2]	ECSS-E-HB-11A, Technology Readiness Level (TRL) guidelines
[RD 3]	ECSS-M-ST-10C Rev.1, Project planning and implementation
[RD 4]	ECSS-M-ST-80C, Risk Management
[RD 5]	ECSS-E-ST-10-06C, Technical requirements specification
[RD 6]	ECSS-Q-ST-10C Rev.1, Product Assurance Management
[RD 7]	ECSS-M-ST-60C, Cost and Schedule Management
[RD 8]	ECSS-M-ST-10-01C, Organization and Conduct of Reviews

Number	Document
[RD 9]	ECSS-Q-ST-20C Rev 2, Quality Assurance
[RD 10]	ECSS-Q-ST-60C Rev 3, Electrical, Electronic and Electromechanical (EEE) Components
[RD 11]	ECSS-Q-ST-70C Rev 2, Materials, Mechanical Parts, and Processes
[RD 12]	ARC-STD-8070.1 NASA AMES Technical Standard for Space Flight System Design and Environment Test
[RD 13]	SSMS Vega-C User's Manual Sept. 2020 v4 https://www.arianespace.com/wp-content/uploads/2020/10/SSMS-Vega-C-UsersManual-Issue-1-Rev0-Sept2020.pdf
[RD 14]	ESSB-HB-E-003, ESA Pointing Error Engineering Handbook http://peet.estec.esa.int/files/ESSB-HB-E-003-Issue1(19July2011).pdf

1.3. Acronyms and Abbreviations (alphabetical order)

- AD: Applicable Document
- BB: Breadboard
- BOL: Beginning of Life
- DDR: Detailed Design Review
- DKP: Design Key Point Review
- DT: Deployable Telescope
- EO: Earth Observation
- EOL: End of Life
- FR: Final Review
- FRpt: Final Report
- IR: Infrared
- KOM: Kick-off Meeting
- MAIT: Manufacturing, Assembly, Integration, and Test
- MS: Milestone
- PRn: Progress Review Meetings
- TRB: Test Review Board
- TRL: Technology Readiness Level
- RD: Reference Document
- SoW: Statement of Work
- SS: Sun-Synchronous
- STOP: Structural-Thermal-Optical-Performance
- UV: Ultra-Violet
- v#: Version number
- WFE: Wave Front Error

1.4. Background and Objective(s)

1.4.1. Background

The creation of precision deployable telescopes is a cutting-edge and challenging endeavour anticipated to drive forthcoming space missions. Envisioned for diverse applications across Earth observation (EO) in the infrared (IR), visible, and ultraviolet (UV) spectrums, deployable telescopes necessitate a foundation of highly stable and precise configurations upon deployment.

Deployment optimization stands as a crucial means to economize costs, particularly when deploying telescopes instead of launching them in their final configurations. Unlike large space structures, which are generally volume-constrained during launch, deployable telescopes (DT) exploit the available payload capacity of launch vehicles. Deployable telescopes are limited in use as the deployment process necessitates intricate considerations and systematic trade-offs, particularly in achieving the precise movement of structural parts to tight tolerances after deploying across broad distances.

The innovation of deployable telescopes bears significant potential in enhancing Earth observation capabilities for applications on small satellites, specifically in two areas: high-resolution imaging and LiDAR waveform altimeters for vegetation sampling. High-resolution imaging through deployable optics addresses the critical convergence of spatial and temporal resolution for various Earth observation applications. High resolution imaging finds application across urban climate monitoring, civil security, crisis management, and other Earth observation data-driven services. The inclusion of LiDAR in deployable telescopes presents an opportunity to amplify collecting area and cost efficiency. LiDAR waveform altimeters finds application in surface topography surveying, including tree canopy identification.

A number of configurations have been explored for deployable telescopes for Earth observation applications. These designs can loosely be categorized as either deployable along the optical axis or using segmented apertures. Although both configurations have their advantages and disadvantages, the segmented aperture strategy has seen the most amount of interest in recent years. Deployable telescope designs face challenges associated with temperature gradients typical of EO orbits and the inherent thermomechanical complexities in their design. Maintaining a desirable wavefront error (WFE) while ensuring reliable deployment is a significant challenge. Thus, in addition to optimizing optical design, it is crucial to explore further studies on thermal and mechanical repeatability and stability. These components play a key role in achieving both the required optical performance and deployment reliability.

Deployable telescope technology and their use in both Astronomy and Earth observation is a pivotal subject among ESA R&D developments. Key multi-disciplinary characteristics such as, active optics and high-accuracy pointing have enabled new advancements and trends in the field. Current DT perspectives [RD1] are primarily applied to large mirrors but have notable overlap with DT used on small satellites. This intersection of these domains can be a useful input to future developments.

1.4.2. Objective(s) of the Activity

This study will primarily focus on the comprehensive analysis and refinement of a deployable telescope, addressing critical design requirements and overcoming constraints associated with in-orbit deployable optical systems. It aims to amalgamate lessons learned from current deployable telescope missions and utilize this knowledge to extend the design and functionality to small satellites.

The primary output of the study shall be a candidate deployable telescope design for storage (in a folded state) and use within a 3U-6U satellite. Throughout this study, implementation strategies will be identified and evaluated, facilitating a meticulous trade-off analysis to ascertain an optimal implementation concept. The chosen deployment concept will be refined to enhance its design robustness and shall explore the performance degradation within its operational environment and over the course of its expected lifetime. A comparison to a classical non-deployable telescope shall be made to assess the benefits of the proposed DT concept.

Deployable telescope design for small satellites is the focal point of this study, and the objectives are itemized as follows.

- Objective 1: To define the trade-off and preliminary design of the DT for small satellites focused on EO applications with:
    - Survey the opto-mechanical deployment strategies and trade-offs for possible deployment, stabilization, and active optical control techniques relevant to EO scenario [a] for small satellites (Annex A).
    - Formulate preliminary optical and mechanical design of the DT.

- Objective 2: To define a detailed opto-mechanical design of the DT with:
    - Formulate detailed design of the DT.
    - Perform Structural, Thermal, Optical & Performance Analysis of the DT.

- Objective 3: To conclude findings, extend design and define the inputs needed for future developments with:
    - Conclude study findings, define recommendations for future breadboard (BB) activities, extend DT applicability to EO scenario [b] (see Annex A), and create a technology development roadmap.

2. WORK TO BE PERFORMED

2.1. Work Logic

The work is organised by a set of tasks and are directly correlated to the study objectives.

- Review, survey, trade-off and preliminary design is divided into 2 tasks, and shall achieve the study Objective 1.
- Detailed design & analysis is divided into 2 tasks, and shall achieve the study Objective 2.
- Study conclusions for EO scenarios, future breadboard testing and roadmap definition is defined within 1 task and shall achieve the study Objective 3.

The proposed work logic for workflow is presented in the diagram in Figure 1.

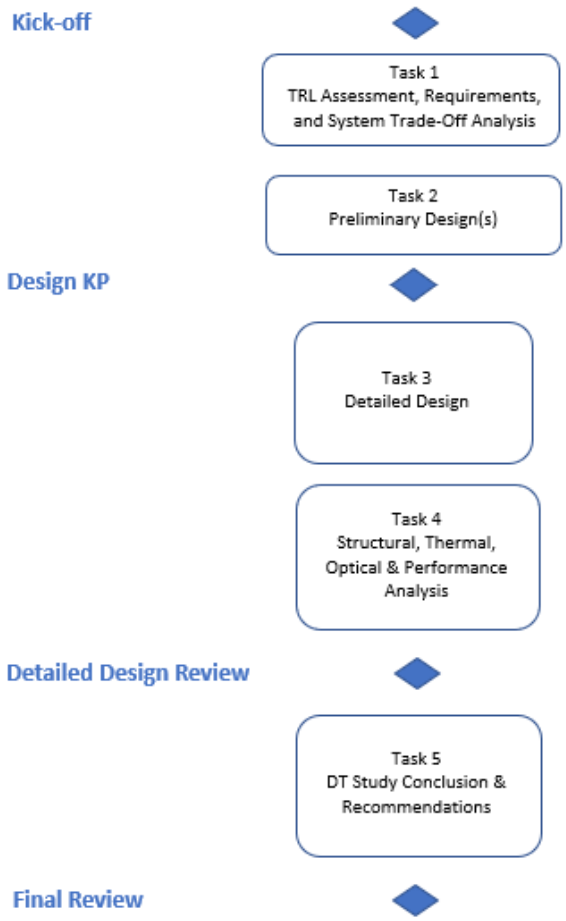

Figure 1: Work logic for Deployable Telescope for Small Satellites Tasks

2.2. Tasks

The work of each of the tasks for the deployable telescope for small satellites design study is described in detail in the following subsections. Given the intended focus on EO applications, the Contractor shall perform the Tasks 1 to Task 4 for the scenario [a] and extend their design to scenario [b] in Task 5, as described below.

2.2.1. Task 1: TRL Assessment, Requirements, and System Trade-Off Analysis

- Input
  - SoW
  - KOM minutes

- Task description

  The Contractor shall begin by examining the applicable EO scenarios defined in Annex A, to ensure a good understanding of the intended EO applications. Next, the Contractor shall focus on [a] EO High Resolution Imaging Scenario (Annex A), and define and justify requirement consolidation, if needed.

  For EO scenario [a], the Contractor shall identify the system drivers and key technical requirements and define a trade-off. Next, a flow down from the proposed EO scenario to the DT requirements shall be defined and captured in D2. Finally, the Contractor shall survey suitable solutions applicable to DT for small satellites and correlate them to the trade-off and requirements determined in the previous step. A TRL assessment and design critical points shall be included in the evaluation.

  Among the general requirements, the Contractor shall give a particular attention to identifying the image quality targeted and the trade-off associated with achieving this target.

- Output / Approval conditions
  - D1: Current State of the Art, TRL Assessment and System Trade-Off Report
  - D2: Deployable Telescope Requirements (v1)

Following the completion of Task 1, results shall be used as inputs to Task 2.

2.2.2. Task 2: Preliminary Design(s)

- Input
  - D1: Current State of the Art, TRL Assessment and System Trade-Off Report
  - D2: Deployable Telescope Requirements (v1)

- Task description

  Following an initial design trade-off, the Contractor shall define a DT Preliminary Design(s). Throughout this task, the preliminary design and objectives shall be prepared by the Contractor and included in D3. A description of the modeling performed shall be detailed in D4. Maintaining a focus on EO scenario [a], the Contractor, shall achieve this by delving into the following.
  - Establish the margin philosophy, specifically with respect to the opto-mechanical performance budgets.
  - Propose different baseline concepts which respond to the specified EO application [a] and match the proposed margin philosophy.
  - Consolidate trade-off analysis and correlate key development areas to the proposed baseline concepts.
  - Select a baseline DT configuration and define preliminary performance and error budgets.
  - Establish high-level operational concept for the selected DT for deploying the mirrors.
  - Formulate a strategy for alignment once the mirrors are deployed (include expected stability, reliability, and failure tolerance).

- Output / Approval conditions
  - D3: Preliminary DT Design Report
  - D4: Analysis Report (v1)
  - MM1: Optical Model (v1)
  - MM2: Performance Model (v1)

Following the completion of Task 2, results shall be presented to the Agency at the Design Key Point (DKP) review, prior to the start of Task 3.

2.2.3. Task 3: Detailed Design

- Input
  - Successful completion of DKP
  - D3: Preliminary DT Design Report

- Task description

  The Contractor shall confirm the baseline design selected for the DT in D5, and shall highlight potential manufacturing strategies in D6. The Contractor, shall complete the intended task by the following.
  - Refine the selected DT baseline design by modeling the optical and mechanical layout and their interfacing.
  - Refine the deployment and alignment strategies for the selected DT baseline.
  - Refine the selected baseline by defining the power and thermal stability concepts during operation.

- Refine optical requirements budget, with a specific emphasis on sensitivities to misalignments and their impact on telescope performance.
- Refine mechanical requirements budget, with a specific emphasis on deployment stability, repeatability and response, and their impact on telescope performance.
- Refine thermal stability requirements budget, with a specific emphasis on telescope positioning accuracies.
- Perform trade-off to achieve an optimal performance balance, including (but not necessarily limited to) the thermal, optical, and mechanical aspects.
- Propose strategies for minimizing straylight.
- Estimate, for the selected baseline, DT survivability to launch loads of Vega-C [RD13].
- Estimate, for the selected baseline, DT survivability to thermal loads.
- Estimate, for the selected baseline, DT operational performance at BOL and EOL.
- Compare the selected baseline DT design to a classical non-deployable telescope.
- Identify manufacturing process and strategies intended for DT development, include an estimated build timeline and key manufacturing considerations (i.e.: tolerances). Preliminary MAIT flow shall be described in D6.

- Output / Approval conditions
  - D5: DT Detailed Design Report
  - D6: Development and Verification Plan for Pre-Developments (v1)

Following the completion of Task 3, conclusions shall be used as inputs to Task 4. Results shall be presented to the Agency at the Detailed Design Review (DDR).

2.2.4. Task 4: Structural, Thermal, Optical, and Performance Analysis

- Input
  - D5: DT Detailed Design Report

- Task description
  The Contractor shall carry out the following analysis on the results derived from the DT detailed design. A description of the modeling performed for the detailed analysis shall be described in D4 (v2).
  - Structural analysis to prove the structural integrity of the system against the mechanical environment during launch (i.e.: non-deployed state).
  - Structural analysis to prove the structural integrity of the system against the thermal environment in the deployed state.
  - Thermal analysis, not limited to, but with an emphasis on in-orbit thermal cycling and temperature gradients.
  - Optical analysis and tolerances, not limited to, but with an emphasis on WFE analysis and image quality, and their correlation to thermal stability and mechanical repeatability.

  - Performance analysis of the proposed deployable telescope.
  - Estimate of straylight

- Output / Approval conditions
  - D4: Analysis Report (v2)
  - MM1: Optical Model (v2)
  - MM2: Performance Model (v2)
  - MM3: Structural Model
  - MM4: Thermal Model

Following the completion of Task4, results shall be presented to the Agency at the Detailed Design Review (DDR).

2.2.5. Task 5: Deployable Telescope Instrument Study Conclusion

- Input
  - Successful completion of DDR
  - All Ds and MoM from the preceding Tasks

- Task description

  The Contractor shall identify critical design points that are suitable for BB testing and provide recommendations for future developments. The recommendations identified for breadboard testing shall have a clear rationale, with the aim to verify critical design points or raise TRL. The Contractor shall submit the BB development recommendation as an update to D6, and shall include the following.
    - Identify critical components/assemblies that need breadboarding.
    - Define BB development strategy, including the intended rationale.
    - Consolidate BB development with corresponding DT TRL assessment.
    - Update key DT manufacturing strategy drafted in Task 3 and correlate to the proposed BB activities.

  Finally, the Contractor shall update DT requirements formulated at the start of the activity (D2) and produce in D7, the conclusions of the activity, including the following.
    - Summarize the findings of the activity.
    - Assess the design requirements targeted for the [a] EO High Resolution Imaging Scenario (see Annex A), and their applicability to future developments.
    - Analyse and propose whether the selected DT design could be retrofitted for use in the [b] EO Lidar Waveform for Vertical Distribution of Vegetation Scenario (see Annex A). Identify future changes needed to DT for use in the LiDAR scenario.
    - A roadmap for the future development of deployable telescopes for small satellites with EO applications.

- Output / Approval conditions
  - D2: Deployable Telescope Requirements (v2)
  - D6: Development and Verification Plan for Pre-Developments (v2)
  - D7: Study Conclusion and Recommendations on Future Development

Following the completion of Task 5, results shall be presented to the Agency shall be presented to the Agency at the Final Review.

3. AGENCY UNDERTAKINGS

N/A

4. REQUIREMENTS FOR MANAGEMENT, REPORTING, MEETINGS AND DELIVERABLES

The following are the requirements for Management, Reporting, Meetings and Deliverables applicable to the present activity.

4.1. Management

4.1.1. General

The Contractor shall implement effective and economical management for the project.

The Contractor's nominated Project Manager shall be responsible for the management, execution of the work to be performed and, in the case of a consortium, for the coordination and control of the consortium's work (including the submission of the deliverables to the Agency).

4.2. Reporting

4.2.1. Minutes of Meeting

The Contractor is responsible for the preparation and distribution of Minutes of Meetings held in connection with the Contract. Electronic versions shall be issued and distributed to all participants, to the Agency's Technical Officer and to the Agency's Contracts Officer not later than five (5) days after the meeting concerned.

The minutes shall clearly identify all agreements made and actions accepted at the meeting.

4.2.2. Bar-chart Schedule

The Contractor shall be responsible for maintaining the bar chart for work carried out under the Contract, as agreed with the Agency.

The Contractor shall present an up-to-date chart for review at all subsequent meetings, indicating the current status of the Contract activity (WP's completed, documents delivered, etc.).

4.2.3. Progress Reports

Every month, the Contractor shall provide a Progress Report in electronic format to the Agency's representatives, covering the activities carried out under the Contract. This report shall refer to the current activities shown on the latest issued bar chart and shall give:

- Action items completed during the reporting period;
- Description of progress: actual vs schedule, milestones and events accomplished;
- Reasons for slippages and/or problem areas, if any, and corrective actions planned and/or taken, with revised completion date per activity;

- Events anticipated during the next reporting period (e.g. milestones reached);
- Milestone payment status.

4.2.4. Problem Notification

The Contractor shall notify the Agency's representatives (Technical Officer and Contracts Officer) of any problem likely to have a major effect on the time schedule of the work or to significantly impact the scope of the work to be performed.

4.2.5. Technical Documentation

As they become available and not later than the dates in the schedule, the Contractor shall submit for the Agency's approval Technical Notes, Task/WP Reports, etc.

Technical documentation to be discussed at a meeting with the Agency shall be submitted electronically two (2) weeks prior to the meeting.

4.3. Meetings

Progress Meetings can take place as appropriate between review meetings.

The final presentation shall take place to a public audience, within twelve (12) months of Contract closure. During the course of the activity the Agency will decide on the format for the final presentation (e.g. dedicated meeting, conference, specific event).

Additional meetings may be requested either by the Agency or the Contractor. With due notice to the Contractor the Agency reserves the right to invite Third Party(ies) to meetings to facilitate information exchange.

For each meeting the Contractor shall propose an agenda in electronic form and shall compile and distribute hand-outs of any presentation given at the meeting. Should the Contractor wish to invite Third Party(ies) to meetings, the prior approval of the Agency shall be sought.

Meeting title	Date	Location
Kick-off Meeting	T0	Telecon
Design Key Point Review	T0+3M	ESTEC
Detailed Design Review	T0+9M	Contractor's premises
Final Presentation/Final Review	T0+11M	ESTEC
Close-out	T0+12M	Telecon/Contractor's premises
Progress meetings	as required	Telecon

4.4. Deliverable Items

In addition to the documents to be delivered according to section 4.2 here above, the following items shall also be delivered.

Delivery requirements for documentation is such that they are electronic searchable, indexed and not encrypted PDF and native (WORD) file to be delivered to the ESA Technical Officer.

The draft version of the documentation shall be sent to the Agency's Technical Officer in electronic format not later than two (2) weeks before the documentation is to be presented.

All documents shall bear the appropriate copyright notice. In all cases, this shall include the title, ESA Contract number, deliverable number, date, status (draft), version and/or revision number. The information shall be repeated consistently in the header or footer of every page.

Documentation

Doc ID	Title	Event	Definition	e-copy to DMS
DMS (Data Management System) address: **tecdms@esa.int**. (or others as applicable for other ESA Directorate) Please note that all finalised (i.e. reviewed and approved by ESA in their final version) documents resulting from a technology Contract shall be electronically sent by the Contractor to D/TEC's Data Management System (DMS) using the e-mail address tecdms@esa.int. This applies not only to the final documentation such as the Final Report or Summary Report but to all approved output documents (TNs, Progress Reports, etc.).				
D1	Current State of the Art, TRL Assessment and System Trade-Off Report	DKP	…….	no
D2	Deployable Telescope Requirements	DKP (v1) FR (v2)	…….	no
D3	Preliminary DT Design Report	DKP		
D4	Analysis Report	DKP (v1) DDR (v2)	…….	no
D5	DT Detailed Design Report	DDR	...	no
D6	Development and Verification Plan for Pre-Developments	DDR (v1) FR (V2)	...	no
D7	Study Conclusion and Recommendations on Future Development	FR		no
TDP	Technical Data Package	Final Review	TDP consists of the final versions of all approved technical documents, delivered during the execution of the activity.	yes
FP	Final Presentation	Final Review		yes
ESR	Executive Summary Report	Final Review	ESR concisely summarises the findings of the Contract. It shall be suitable for non-experts in the field and should also be appropriate for publication. For this reason, it shall not exceed five (5) pages of text and ten (10) pages in total (one thousand five hundred (1500) to three thousand (3000) words).	yes
FRpt	Final Report		The FRpt shall provide a complete description of all the work done during the activity and shall be self-standing, not requiring to be read in conjunction with reports previously issued. It shall cover the whole scope of the activity, i.e. a comprehensive introduction of the context, a description of the programme of work and report on the activities performed and the main results achieved. The FR is a mandatory deliverable, due upon completion of the work performed under the	yes

			Contract. For the avoidance of doubt, "completion of the work performed under the Contract" shall mean the finalisation of a series of tasks as defined in a self-contained Statement of Work.	
CCD	Contract Closure Documentation		The CCD is a deliverable due at the end of the Contract. Work performed under Contract Change Notices adding new tasks with respect to the original Contract shall require separate CCD.	Yes

Other Deliverables (Hardware, Software, Models, Data, Algorithms, etc.)

Item Identifier	Title	Milestone	Quantity to be delivered / Delivery Media	Remarks
M1	Optical Model	DKP (v1) DDR (v2)	…	Format to be agreed with the Agency by KO.
M2	Performance Model	DKP (v1) DDR (v2)	…	Format to be agreed with the Agency by KO.
M3	Structural Model	DDR	…	Format to be agreed with the Agency by KO.
M4	Thermal Model	DDR	…	Format to be agreed with the Agency by KO.

5. SCHEDULE AND MILESTONES

5.1. Duration

The duration of the work for the workflow of the Deployable Telescope for small satellites **shall not exceed [12] months** from kick-off to end of the activity (delivery of the draft Final Report).

5.2. Milestones

The following technical milestones for the workflow shall apply:

- MS1 – DT Design Key Point Review (T0+3 months)
  - Completion of Tasks 1 & 2
- MS2 – DT Detailed Design Review (T0+9 months)
  - Completion of Tasks 3 & 4
- MS3 – DT Final Review (T0+11 months)
  - Completion of Task 5
- MS4 – Contract Close-out (T0+12 months)
  - Completion of Final Report and CCD.

5.3. Reviews

The following reviews shall be held:

- See the task description, study logic and task timeline

ANNEX A. Preliminary Mission Requirements for EO Scenarios

Given that the scope of the study is intended for small satellites, a 3U-6U limit is imposed as a design constraint on the volume of the proposed satellite design. Design solutions for a DT shall consider the [a] EO High Resolution Imaging scenario. An assessment of the DT design selected shall be performed to determine whether the DT can be retrofitted for the [b] EO LiDAR Waveform for Vertical Distribution of Vegetation Scenario.

Table A 1: EO Application Scenarios [a] & [b], relevant to DT for small satellites

[a] EO High Resolution Imaging Scenario				
ID	**Requirement**	**Value**	**Unit**	**Additional Info**
a.01	Orbit Altitude	450	km	
a.02	Orbit Type	Noon-Midnight SS		
a.03	Off-Nadir Pointing	0	deg	
a.04	Non-Operational Temperature Range	-40 to 65	degC	see [RD16]
a.05	Swath	> 1	km	
a.06	Primary Telescope Diameter	≥ 300	mm	
a.07	PAN Band Central Wavelength	580	nm	
a.08	PAN Band Bandwidth	200	nm	
a.09	PAN Band Spatial Resolution on Ground	1.8	m	Native, no post processing
a.10	Detector Selection	Limited to available COTS		
a.11	Un-binned SNR @ Ref Radiance (without TDI)	≥ 100		Ref Radiance = 114 [Wm^2sr-1um-1]
a.12	Optical MTF at Nyquist	> 30	%	Including defocus, aberrations, and manufacturing tolerances.
a.13	System MTF at Nyquist	> 15	%	
a.14	Lifetime of Mission	5	years	
[b] EO Lidar Waveform for Vertical Distribution of Vegetation Scenario				
ID	**Requirement**	**Value**	**Unit**	**Additional Info**
b.01	Orbit Altitude	450	km	
b.02	Orbit Type	Dawn-dusk SS		
b.03	Off-Nadir Pointing	3	deg	
b.04	Non-Operational Temperature Range	-40 to 65	degC	see [RD16]
b.05	Swath	≥ 1.8	km	
b.06	Primary Telescope Diameter	≥ 550	mm	
b.07	Operational Wavelength	850	nm	
b.08	Laser Beam Footprint on Ground	30	m	
b.09	Time Limit for Optical Alignment	< 3	ms	Equivalent to min period between successive measurements. Derived from b.01, b.03.
b.10	Time Window Limit for Optical Stability	≥ 7	ms	Equivalent to max time duration of a coherent measurement. Derived from b.01, b.08, b.14. see [RD18]
b.11	Lifetime of Mission	5	years	
Additional Details are below, for EO Scenario [b], included for informational purposes				
b.12	Laser Power Emitted	10mJ/pulse		
b.13	Laser Pulse Duration	16	ns	FWHM
b.14	Laser Pulse Repetition Rate (PRF)	242	Hz	
b.15	Detector Selection	Si-APD		
b.16	Digitizer Bandwidth	1	GHz	
b.17	Vertical Pulse Averaging	None		
b.18	Cloud Coverage Fraction	0	%	Assume no clouds

Appendix 1 to
ESA RFP/3-18351/23/NL/IB/ab

ANNEX B. LAYOUT FOR CONTRACT CLOSURE DOCUMENTATION
(v2018-10)

Contract Closure Documentation
for
ESA Contract No. 4000XXXXXX/23/NL/IB/ab
Deployable Telescopes for Small Satellites Design Study,
hereinafter referred as the "Contract"

Section 1 – Parties, Contract Duration and Financial Information

Contractor		[CONTRACTOR NAME AND COUNTRY]
Subcontractor(s) *(state if not applicable)*		[NAME AND COUNTRY]
Contract Duration *(insert the dates agreed for kick-off and end of Contract)*		**From**: **To**:
Total Contract Price (*including all CCNs, Work Orders, Call of Orders*) and Total Contract Value *(in case of co-funding; state if not applicable)*		**EUR** EUR
Broken down as follows:	**Original Contract Price** and original Contract Value (*in case of co-funding; state if not applicable*)	**XXX EUR (XXX EUR)** EUR
	CCN x to n **Work Order x to n** **Call-Off Order x to n**	**EUR** in total **EUR** in total **EUR** in total

Section 2 – Recapitulation of Deliverable Items

2.1 Items deliverable under the Contract

If any of the columns do not apply to the item in question, please indicate "n/a".

Table 2.1.1 - Items deliverable according to the Statement of Work and Article 2 of the Contract

Type	Ref. No.	Name / Title	Description	Replacement Value (EUR)/ Other	Location ([1])	Property of	Rights granted / Specific IPR Conditions ([2])
Documentation							
Hardware							
Software			*(Delivery in Object code / Source code?)*				
Other							

Table 2.1.2 – Items deliverable under Article 7 of the Contract (*if applicable*)

The Contractor, after agreement with the Agency with respect to the disposal/transfer of Inventory Items/Fixed Assets under the Contract, shall submit the Inventory/Fixed Asset Record as attachment to the CCD. For each Item/Fixed Asset, the information as requested by Appendix 3 to the Contract shall be provided in the Record.

Table 2.1.3 – Customer Furnished Items and Items made available by the Agency

[1] *In case the item is not delivered to ESA, please indicate the location of the deliverable and the reason for non-delivery (e.g. loan agreement, waiver, future delivery, etc.)*

[2] *e.g. IPR constraints, deliverable containing proprietary background information (see also Table 2.1.3 below)*

[Option 1]
There was no Customer Furnished Items or Items made available by the Agency.

[Option 2]
Any Customer Furnished Items and/or Items made available by the Agency to the Contractor and/or its Subcontractor(s) under the Contract, are listed in the following List of Customer Furnished Items and Items made available by the Agency. The following tables certify which of the Items have been returned to the Agency and which of the Items remain in the custody of the Contractor, and/or a Subcontractor(s) and/or a Third Party(ies) for further ESA work or for other purposes.

Customer Furnished Items

				ESA DECISION		
Item Name	ESA Inventory Number	Location	Insurance Value	Confirmation of Receipt	Deliver to ESA or to another entity	Leave at (Sub-) Contractor's Disposal under a loan agreement

Items made available by the Agency

Item Name	ESA Inventory Number	Location	Replacement Value	Deliver to ESA or to another entity	Leave at (Sub-) Contractor's Disposal under a loan agreement

Table 2.1.4 - Background information used and delivered under the Contract (see Article 6.3 of the Contract)

The following background information has been incorporated in the deliverable(s):

Proprietary Information (*title, description*)	**Owner** (*Contractor / Subcontractor(s)/ Third Party(ies*)	**Affected deliverable** (*which documents, hardware, software, etc.*)	**Description impact on ESA's rights to the deliverable ([3])**	**Other comments**

[3] *if not explicitly stated otherwise, the contractual stipulations shall prevail in case of conflict with the description provided in this table*

Section 3 – Statement on Intellectual Property Rights generated under the Contract

[OPTION 1: NO INVENTION]
In accordance with the provisions of the Contract …… [Contract Number], …… [Company] hereby certifies both on its own behalf and that of its consortium/Subcontractor(s), that no Intellectual Property Right(s) (as defined in the Contract, under the section 'Definitions') has(ve) been generated in the course of or resulting from work undertaken for the purpose of this Contract.**[END OPTION 1]**

[OPTION 2: INVENTION]
In accordance with the provisions of the Contract …… [Contract Number], …… [Company] hereby certifies both on its own behalf and that of its consortium/Subcontractor(s) that the following Intellectual Property Right(s) (as defined in the Contract, under the section 'Definitions') has(ve) been generated in the course of or resulting from work undertaken for the purpose of this Contract:

- Intellectual Property Rights ("IPR") suitable for registration (i.e. "Registered Intellectual Property Rights" as per definition in the Contract) and their current status (Registered – In the process of being registered – Foreseen for registration – Not foreseen for registration)

  ……

  Should any Intellectual Property Rights be indicated as being foreseen for registration or in the process of registration, the Contractor undertakes to notify the Agency's Technical Officer when:
  - registration of any such IPR(s) is rejected
  - registration of any such IPR(s) is obtained (and will provide the registration details)

- Intellectual Property Rights ("IPR") not suitable for registration (i.e. not being "Registered Intellectual Property Rights" as per definition in the Contract)

  ……

The Agency's rights in the Intellectual Property Rights listed above shall be in accordance with the Contract.**[END OPTION 2]**

Section 4 – Output from / Achievements under the Contract

4.1 Technology Readiness Level (TRL)

Indicate the TRL of the technology developed under the Contract using the classification given below (for additional information on definitions, please refer to ECSS-E-AS-11C):

Initial TRL	Planned TRL as activity outcome	Actual TRL at end of activity

1	Basic principles observed and reported
2	Technology concept and/ or application formulated
3	Analytical and experimental critical function and/ or characteristic proof of concept
4	Component and /or breadboard validation in laboratory environment
5	Component and /or breadboard critical function verification in a relevant environment
6	Model demonstrating the critical functions of the element in a relevant environment
7	Model demonstrating the element performance for the operational environment
8	Actual system completed and accepted for flight 'flight qualified'
9	Actual system 'flight proven' through successful mission operations

Note: The TRL shall be assessed by ESA. The Agency's responsible Technical Officer shall verify TRLs 1-4 while TRLs 5-9 shall be assessed through an ESA-internal formal procedure.

4.2 Achievements and Technology Domain

……..
Provide a concise description (max two hundred (200) words) of the achievements of the Contract and its explicit outcome (including main performances achieved): please refer to the final documentation (e.g. Final Report).

Please indicate the Technology Domain (TD 1 to 25) of the development (*please tick off*):

	1	On-Board Data Systems		14	Life & Physical Sciences
	2	Space System Software		15	Mechanisms & Tribology
	3	Spacecraft Electrical Power		16	Optics
	4	Spacecraft Environment & Effects		17	Optoelectronics
	5	Space System Control		18	Aerothermodynamics
	6	RF Payload and Systems		19	Propulsion
	7	Electromagnetic Technologies and Techniques		20	Structures & Pyrotechnics
	8	System Design & Verification		21	Thermal
	9	Mission Operations and Ground Data Systems		22	Environmental Control Life Support
	10	Flight Dynamics and GNSS		23	EEE Components and Quality
	11	Space Debris		24	Materials and Processes
	12	Ground Station System & Networking		25	Quality, Dependability and Safety
	13	Automation, Telepresence & Robotics			

4.3 Application of the Output/Achievements

Please tick off as appropriate:

☐ Possible use in programme:

……..
Please indicate the service domain (see table) relevant to a possible application

	1	Earth Observation
	2	Science
	3	Human Spaceflight and Exploration
	4	Space Transportation
	5	Telecommunications
	6	Navigation
	7	Generic Technologies and Techniques
	8	Security
	9	Robotic Exploration

☐ Actual use in programme:

……..
Please describe the specific programme and application or mission for which the output of this Contract is or will be used.

4.4 Further Steps/Expected Duration

Please tick off as appropriate:

☐ No further development envisaged.

☐ Further development needed:

……
Please describe further development activities needed, if any, to reach TRL 5/6 including an estimate of the expected duration and cost.

4.5 Potential Non-Space Applications

……
Describe any potential non-space applications or products that may benefit from the technology that has been developed. Emphasize potential markets and customers where known.

……..
Describe the principle features of technology that would be required in a technology demonstrator for any identified non-space application. Include an estimate of the resources in time and money that would be required.

<table>
<tr><td colspan="2">The above statements provided in the various sections of this Annex B “Layout for Contract Closure Documentation” for ESA Contract No. 4000xxxxxx/xx/XX/XXX/xxx [insert the corresponding contract number] have been made after due verifications.

The Contractor furthermore certifies that all its obligations with regard to Fixed Assets, if any, have been fulfilled.

If required by ESA, an updated version shall be provided for incorporating amendments requested by ESA.</td></tr>
<tr><td colspan="2">Name of Contractor:
[insert Contractor name]</td></tr>
<tr><td>Authorised signatory:

[insert Authorised signatory full name]</td><td>

[signature of the Authorised signatory]</td></tr>
<tr><td colspan="2">Date:
[insert date]</td></tr>
</table>