

# Statement of Work for Performance Ramping of the L3-HAPLS Laser at ELI-Beamlines

June 2021



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# Statement of Work for Performance Ramping of the L3-HAPLS Laser at ELI-Beamlines

## Preamble

The L3-HAPLS laser is a high repetition-rate, high average-power laser system representing a substantial advancement over the state-of-the-art in Petawatt (PW)-class short pulse laser technology. The L3-HAPLS laser was developed and built by Lawrence Livermore National Laboratory (LLNL) in cooperation with ELI-Beamlines (ELI-BL) from 2013 to 2017 and was integrated into the ELI-Beamlines facility in 2018. Since 2019 the L3-HAPLS laser has been successfully used for experimental research.

The intention of this Strategic Partnership Project (SPP) agreement is to build on the partnership between ELI-Beamlines and LLNL and ramp the performance of the L3-HAPLS laser to its full design specifications. This SPP aims to enable the operation of the L3-HAPLS laser at the PW level with 10Hz repetition rate for experiments, which will place ELI-Beamlines into a unique and leading position amongst laser facilities worldwide.

LLNL is a world leader in the development of high repetition-rate high peak-power laser technology and has developed the laser technology and know-how to team with ELI-BL to achieve the goals of this SPP.

The principal objectives of this SPP between LLNL and ELI-BL are:

- Ramp performance of the L3-HAPLS laser system to PW peak power and to the designed repetition rate.
- Share long-term performance data and operation experience relating to the L3-HAPLS laser system.
- Continue the existing LLNL and ELI-BL partnership in development of next generation high average power ultrafast laser technologies.
- Cooperate in utilization of ELI-BL laser systems for scientific experiments exploiting the unique combination of high peak power and high repetition rate.

## Goals

This SPP is structured into five Goals which simultaneously meet the scientific needs of the operating L3-HAPLS laser in the ELI-BL facility and progressively increases the performance of the system. Each Goal comprises multiple Work Packages anticipated to meet the principal objectives of this SPP. The currently envisioned Goals are as follows:

### Goal 1: Shot-On-Demand PW Operation of L3-HAPLS

The first Goal is to ramp the performance of the L3-HAPLS system to PW peak power in an athermal state by following the lowest-risk approach. Activities anticipated to support this Goal are expected to include:

- [redacted]

Additional scope to improve operational efficiency, and test and qualify components for future average power ramping is also envisioned.

Required Work Packages: WP0 and 1. WP1 is the primary work package for this Goal and requires the successful completion of WP0 as a prerequisite.

### Goal 2: PW Operation of L3-HAPLS at an Intermediate Repetition Rate

The next Goal targets PW peak power at an intermediate repetition rate, where thermal effects are expected to be important. Activities in support of this Goal are expected to include:

- [redacted]

Required Work Packages: WP0 to 2 and WP4, with a strong recommendation for WP3 to minimize risk. WP4 is the primary Work Package for this Goal and requires the successful completion of WP0 to 2 as prerequisites.

### Goal 3: PW Operation of L3-HAPLS at the Full Repetition Rate

The final laser performance Goal is to commission the L3-HAPLS laser system to its full designed performance levels in both peak power and average power. Activities in support of this Goal are expected to include:

- [redacted]

Required Work Packages: WP0 to 6, with strong recommendation for WP8 to minimize risk. WP6 is the primary work package for this Goal and requires the successful completion of WP0 to 5 as prerequisites.

### Goal 4: Support of Performance Ramping and Long-Term Operations of L3-HAPLS

This Goal is to maintain laser system availability for experiments while ramping performance, ensure critical and unique spares are available for long-term operations, and present options for possible future upgrades. Activities in support of this Goal are expected to span the entire duration of this SPP and may include:

- [redacted]

Required Work Packages: WP7 and 8 are the primary Work Packages for this Goal. WP7 requires the successful completion of WP0 to 2 and WP4 as prerequisites.

### Goal 5: Additional Scope

Additional scope that supports the scientific use of the L3-HAPLS system may include:

- The development and execution of scientific experiments that extend the range of supported laser configurations, enable the qualification and commissioning of the L3-HAPLS laser system, or that implement new or unique (e.g. rep-rated) target, diagnostic, or experimental capabilities.

Required Work Packages: WP9 is the primary Work Package for this Goal.

## Roles and Responsibilities

LLNL and ELI-BL are both committed to maintaining and growing the productive collaboration between the two institutions. During the expected several-year duration of this SPP agreement, it is anticipated

that both institutions will need to react to unforeseen changes in funding levels, project priority with respect to other institutional efforts, availability of key personnel, and technical challenges. These changes and challenges may adversely impact the desired pace of execution and schedule goals. However, the Parties are dedicated as follows:

LLNL is dedicated to: executing funded Work Packages on a best effort basis within ELI imposed constraints; providing the specific and unique hardware delineated in the Work Packages required for performance ramping and on-going L3-HAPLS operations activities; participating in co-discussions with critical vendors; and providing detailed recommendations for efficient laser performance ramping based on systems engineering principles and best practices.

ELI-BL is dedicated to: providing fully dedicated availability of trained personnel with experience in operating and maintaining the L3-HAPLS laser hardware; providing dedicated control system specialists with extensive knowledge of the L3-HAPLS control system; ensuring robust communications between LLNL and ELI-BL technical and management teams; effective management of interleaved operations and performance ramping commissioning activities and teams; and access to the L3-HAPLS laser hardware at agreed-upon times for the execution of performance ramping scope (within the bounds of pre-planned user experiments).

Where shipments of physical hardware are required between LLNL and the ELI-Beamlines facility, LLNL will be responsible for formalities and procedures associated with receiving or sending shipments within the USA, and ELI-Beamlines will be responsible for formalities and procedures within the EU. Shipping costs, customs, and import duties will be the responsibility of ELI-Beamlines.

## Work Package Definition and Execution

All activities executed under this SPP will be organized into Work Packages. Each Work Package defines specific objectives in support of one or more of the Primary Goals and organize the anticipated scope into detailed Tasks. Definition of each Task includes: an expected scope description; known or anticipated technical or schedule risks; a cost and schedule estimate; highlights of important resources required or prerequisites to execution of Task scope; and a description of the associated Task documentation and deliverables. Each Work Package includes a summary of the deliverables and the cost. Work Packages will be initiated by mutual agreement of both Parties, through a Technical Query (TQ) memo, and work on the mutually-agreed set of Work Package Tasks may start when funds are in place at LLNL. Appendix A contains a TQ template. Task deliverables comprising an LLNL-authored Technical Report will be submitted via the TQ process to initiate the completed deliverable Report review, and ELI-Beamlines will document completion of the deliverable by issuing an Acceptance Certificate. Likewise, ELI-Beamlines will issue an Acceptance Certificate upon receipt of hardware at the ELI-Beamlines facility, signifying completion of Task deliverables that comprise the production and delivery of physical hardware.

A summary of the Work Packages is presented in the following Table, with full details per above in subsequent sections. It is anticipated that WP0, WP2, and WP3 will be started concurrent with the start of the SPP agreement, allowing for the development of a detailed ramping plan and for production of needed components and spares. This Table also summarizes the estimated cost and LLNL deliverables associated with all Tasks that can be executed in each Work Package.

A tentative schedule is also provided, which will be updated after completion and joint review of the Work Package 0 ramping plan.

*[redacted]*

[redacted]

## Work Package 0: Systems Engineering and L3-HAPLS Laser Ramping Plan

[redacted]



Work Package 1:  
Performance Ramping of the L3-HAPLS Laser to PW  
Shot-On-Demand Operation

[redacted]

## Work Package 2: Production and Testing of a Gas-Cooled Faraday Rotator

[redacted]

Work Package 3:  
Production of Spare Diffraction Gratings and Laser Diode Pulsers  
[redacted]

Work Package 4:  
Performance Ramping of the L3-HAPLS Laser to PW  
Intermediate Average Power Operation

[redacted]

Work Package 5:  
Thermal Management of Compressor Gratings  
for Average Power Operation

[redacted]

Work Package 6:  
Performance Ramping of the L3-HAPLS Laser to PW  
Full Average Power Operation

[redacted]

Work Package 7:  
Enabling Sustained Long-Term and Advanced Operations  
for Optimization of Experiments

[redacted]

Work Package 8:  
Production of Spare L3-HAPLS Pump Laser and  
Short Pulse Laser Amplifier Heads

[redacted]



Work Package 9:  
Support the Scientific Use of L3-HAPLS and the ELI-Beamlines  
Laser and Experimental Facilities

[redacted]

**TECHNICAL QUERY NO.: TQ 2021-001**  
**TITLE: APPENDIX A DRAFT TQ TEMPLATE**

**TC ID / Revision:** 00#####  
**Confidentiality:** Restricted  
**WBS Code:** #.#  
**PBS Code:** ###.L3

<b>Requested By</b>		<b>Date</b>	Month ##, 20##
<b>Addressed To</b>			
<b>System</b>	L3-HAPLS		

<b>Technical Query Description</b>	
<b>Background</b> Background text.	
<b>Description</b> Description text.	
<b>Approval Process</b> Approval process text.	
<b>Requested Actions</b> <ul style="list-style-type: none"><li>- Action Item 1</li><li>- Action Item 2</li></ul>	
<b>Reply Requested By</b>	Month ##, 20##
<b>Attached Documents</b>	None

<b>Technical Query Response</b>			
Technical reply text			
<b>Response By</b>		<b>Response Date</b>	Month ##, 20##
<b>Attached Documents</b>	TQ #####-### Response.pdf		

**TECHNICAL QUERY NO.: TQ 2021-001****TITLE: APPENDIX A DRAFT TQ TEMPLATE**

<b>Final Release By</b>		<b>Date</b>	
<b>Final Release By</b>		<b>Date</b>	
<b>Final Release By</b>		<b>Date</b>	