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1. Introduction

The Contracting Authority is in the process of building a facility with the objective of using cutting-edge laser technologies for various research projects in the field of laser-matter interaction. Part of the project realization is the purchase of motion system elements for a beam distribution system designed to transport laser L1 to various end stations within experimental hall E1. Precision delay lines will also be incorporated into the beam distribution system for experiments requiring synchronized pulsed beams with a high degree of accuracy at the femtosecond level for fine adjustment of pulse timing and overlap.

1.1. Purpose

This Requirements Specification Document (RSD) lists the technical requirements and constraints on equipment used in the beam distribution system in experimental hall E1. Actuators, linear stages and a rotation stage are necessary for beam steering and switching, directing the output beam of laser L1 to the various end stations within experimental hall E1, while high resolution delay lines are necessary for multi-beam overlap with femtosecond sensitivity.

1.2. Scope

The RSD contains all technical requirements for motion system elements (*PBS code: SE.BDS.BTRS*), including requirements on functionality, performance, operation, design, and delivery, safety, and quality. These motion system elements will be used on the premises of ELI within the beam distribution system for laser L1 and will be used to direct laser power to the various end station in experimental hall E1.

The tender is split into two parts:

- Part I – Delay Lines
- Part II – Motorized Equipment

These elements of the motion system are products belonging to ELI Beamlines category A.

Category A is an Off-the-shelf Product without necessity of modifications and necessity to be subjected to a verification program (review of design, inspection and testing) for ELI applications by the actual project specifications. All verification activities performing by a supplier shall be executed in accordance with the supplier's plan of outgoing inspection and tests. Internal Acceptance Procedure of the product Category A shall be established and applied before the product implementation (operation phase).

1.3. Terms, Definitions and Abbreviations

For the purpose of this document, the following abbreviated terms are applied:

Abbreviation	Meaning
DL	Vacuum compatible delay line
E1	Experimental hall 1
ELI	Extreme Light Infrastructure
L1	Laser output from laser hall 1
MC	Motor controller
MLA	Motorized linear actuator
MLS	Motorized linear stage
MRS	Motorized rotation stage
RSD	Requirements Specification Document

1.4. References to standards

If this document includes references to standards or technical documents the CA allows/permits also another equal solution to be offered. If the Supplier offers another equal solution the CA shall not reject its bid, once the Supplier by appropriate means in the bid proves that the offered supplies, services or works meet in an equivalent manner the requirements including references to standards or technical documents.

2. Functional, Performance and Design requirements

2.1. Part I – Delay Line

2.1.1. General requirements for Delay Line

REQ-019114/A

The Part I – The delivery of the Delay Line shall consist of:

- 1 x DL 500
- 1 x MC for DL

2.1.2. Vacuum Compatible Delay Line (DL) 500

REQ-019115/A

The DL 500 shall be vacuum (10^{-5} mbar) compatible.

NOTE: The vacuum compatibility includes female connector(s) and cable(s) of minimal length 2 m. Part of the delivery shall also include cable(s) with female connector(s) and an overall length of 3 m for operation in standard non-vacuum environments.

REQ-019116/A

The DL 500 shall have integrated limit switches to detect minimum and maximum positions of travel.

REQ-019117/A

The DL 500 stepper motor shall have an integrated encoder to allow for closed loop operation, determining the absolute position of the stage platform with respect to the stage limit switches at any time during operation.

REQ-019118/A

The DL 500 shall have a minimum velocity of 2 mm/s.

REQ-019119/A

The DL 500 shall have minimum load capacity 80 N.

REQ-019120/A

The DL 500 shall have the following properties:

- 0.63 μm on-axis resolution in full step mode
- Flatness better than $\pm 8 \mu\text{m}$
- Pitch better than $\pm 125 \text{ urad}$
- Yaw better than $\pm 60 \text{ urad}$

REQ-019121/A

The DL 500 shall be a stepper motor based linear translation stage.

REQ-019122/A

The DL 500 shall have travel of $505 \pm 5 \text{ mm}$.

REQ-019123/A

The total length, width, and height of the DL500 including the stage, motor, connectors, and mounting adaptor plate (if necessary) shall meet the following criteria:

- Length: less than 1060 mm
- Width: less than 200 mm
- Height: less than 100 mm

REQ-019124/A

The DL 500 shall have a mounting interface furnished with M6 through holes or slots with adequate spacing necessary for mounting the DL500 to a standard metric optical breadboard. The mounting interface shall be flat over the entire length of the DL 500, accounting for any height difference between the fixing interface (bottom surface) of the stage and the stepper motor.

NOTE: The mounting interface specified can be achieved through a mounting adaptor plate or similar device; however, in such instances the fixing interface shall have M4 and/or M6 threaded holes for mounting of the adapter plate.

2.1.3. Motor Controller (MC) for Delay Lines

REQ-019135/A

The MC for DLs shall have integrated stepper motor driver compatible with the stepper motor of the DLs.

REQ-019136/A

The MC shall have 1 channel that is used to control 1 DL.

REQ-020549/A

The MC shall be mountable in a 19" chassis or DIN rail.

REQ-019137/A

The MC shall have an interface for control and communication with a remote host computer. Control of the MC shall be possible through one or more of the following interfaces:

- Ethernet interface with RJ45 plug or SFP cage
- RS232 interface

REQ-020550/A

The MC shall provide one or more protocols for control and communication:

- ASCII based protocol for Ethernet or RS232 interface
- 64bit library for Linux operating system for Ethernet interface

REQ-020551/A

Documentation for ASCII protocol shall be part of delivery, the documentation shall describe the entire set of commands necessary for full operation and parameterization of the MC.

REQ-020552/A

If a Linux library is preferred, this library shall be compatible with C/C++ languages and shall provide necessary header files for C/C++. The header files shall contain all necessary declarations for full operation and parameterization of MC. The library shall be part of delivery.

REQ-019138/A

The MC for DL shall be fully compatible with the DL 500, which includes the capability of detecting limit switch states, rotary encoder position, and the ability to run the DL in a closed loop configuration.

2.2. Part II – Motorized Equipment

2.2.1. General requirements for Motorized Equipment

REQ-019139/A

The Part II – The delivery of the Motorized Equipment shall consist of:

- 30 x MLA
- 6 x MLS 100
- 2 x MLS 150
- 1 x MLS 300
- 1 x MRS
- 11 x MC for MLA, MLS and MRS

2.2.2. Motorized Linear Actuator (MLA)

REQ-019140/A

The MLA shall be vacuum (10^{-5} mbar) compatible.

NOTE: The vacuum compatibility includes female connector(s) and cable(s) of minimal length 2 m. Part of the delivery shall also include cable(s) with female connector(s) and an overall length of 3 m for operation in standard non-vacuum environments.

REQ-019141/A

The MLA shall have integrated limit switches to detect the minimum and maximum positions of travel.

REQ-019142/A

The MLA shall have a minimum velocity of 0.1 mm/s.

REQ-019143/A

The MLA minimum load capacity shall be 30 N.

REQ-019144/A

The MLA shall meet the following requirements:

- 1.2 μ m on-axis resolution in full step mode
- Bi-directional repeatability better than 3 μ m
- Open loop accuracy

REQ-019145/A

The MLA shall be stepper motor based.

REQ-019146/A

The MLA total actuator travel shall be more than 10 mm and less than 15 mm.

REQ-019147/A

The total length of the MLA body shall be 160 mm or less; the MLA body width shall be 27 mm or less and height shall be 21mm or less.

REQ-019148/A

The MLA shall be capable of mechanical mounting to standard optomechanical mirror mounts using 3/8-40 mounting thread with a depth of no less than 3 mm.

2.2.3. Motorized Linear Stage (MLS) 100

REQ-019149/A

The MLS 100 shall be vacuum (10^{-5} mbar) compatible.

NOTE: The vacuum compatibility includes female connector(s) and cable(s) of minimal length 2 m. Part of the delivery shall also include cable(s) with female connector(s) and an overall length of 3 m for operation in standard non-vacuum environments.

REQ-019150/A

The MLS 100 shall have integrated limit switches to detect the minimum and maximum positions of travel.

REQ-019151/A

The minimal velocity of the MLS 100 shall be 1.5 mm/s.

REQ-019152/A

The MLS 100 shall have minimum load capacity 50 N.

REQ-019153/A

The MLS 100 shall have the following properties:

- 10 μ m on-axis resolution in full step mode
- Open loop accuracy
- Flatness better than ± 14 μ m
- Pitch better than ± 150 μ rad
- Yaw better than ± 170 μ rad

REQ-019154/A

The MLS 100 shall be a stepper motor based linear translation stage.

REQ-019155/A

The MLS 100 shall have a minimum of 100 mm of travel.

REQ-019156/A

The total length, width, and height of the MLS 100 including the stage, motor, connectors, and mounting adaptor plate (if necessary) shall meet the following criteria:

- Length: 350mm or less
- Width: 105 mm or less
- Height: 60 mm or less

REQ-019157/A

The MLS 100 shall have a mounting interface furnished with M6 through holes or slots with adequate spacing necessary for mounting the MLS 100 to a standard metric optical breadboard. The mounting interface shall be flat over the entire length of the MLS 100, accounting for any height difference between the fixing interface (bottom surface) of the stage and the stepper motor.

NOTE: The mounting interface specified can be achieved through a mounting adaptor plate or similar device; however, in such instances the fixing interface shall have M4 and/or M6 threaded holes for mounting of the adapter plate.

2.2.4. Motorized Linear Stage (MLS) 150

REQ-019158/A

The MLS 150 shall be vacuum (10^{-5} mbar) compatible.

NOTE: The vacuum compatibility includes female connector(s) and cable(s) of minimal length 2 m. Part of the delivery shall also include cable(s) with female connector(s) and an overall length of 3 m for operation in standard non-vacuum environments.

REQ-019159/A

The MLS 150 shall have integrated limit switches to detect the minimum and maximum positions of travel.

REQ-019160/A

The minimal velocity of the MLS 150 shall be 1.5 mm/s.

REQ-019161/A

The MLS 150 shall have minimum load capacity 50 N.

REQ-019162/A

The MLS 150 shall have the following properties:

- 10 μ m on-axis resolution in full step mode
- Open loop accuracy
- Flatness better than ± 14 μ m
- Pitch better than ± 160 μ rad
- Yaw better than ± 170 μ rad

REQ-019163/A

The MLS 150 shall be stepper motor based.

REQ-019164/A

The MLS 150 shall have a minimum of 150 mm of travel.

REQ-019165/A

The total length, width, and height of the MLS 150 including the stage, motor, connectors, and mounting adaptor plate (if necessary) shall meet the following criteria:

- Length: 550 mm or less
- Width: 120 mm or less
- Height: 80 mm or less

REQ-019166/A

The MLS 150 shall have a mounting interface furnished with M6 through holes or slots with adequate spacing necessary for mounting the MLS 150 to a standard metric optical breadboard. The mounting interface shall be flat over the entire length of the MLS 150, accounting for any height difference between the fixing interface (bottom surface) of the stage and the stepper motor.

NOTE: The mounting interface specified can be achieved through a mounting adaptor plate or similar device; however, in such instances the fixing interface shall have M4 and/or M6 threaded holes for mounting of the adapter plate.

2.2.5. Motorized Linear Stage (MLS) 300

REQ-019167/A

The MLS 300 shall be vacuum (10^{-5} mbar) compatible.

NOTE: The vacuum compatibility includes female connector(s) and cable(s) of minimal length 2 m. Part of the delivery shall also include cable(s) with female connector(s) and an overall length of 3 m for operation in standard non-vacuum environments.

REQ-019168/A

The MLS 300 shall have integrated limit switches to detect the minimum and maximum positions of travel.

REQ-019169/A

The minimal velocity of the MLS 300 shall be 1.5 mm/s.

REQ-019170/A

The MLS 300 shall have minimum load capacity 50 N.

REQ-019171/A

The MLS 300 shall have the following properties:

- 10 μ m on-axis resolution in full step mode
- Open loop accuracy
- Flatness better than ± 35 μ m
- Pitch better than ± 210 μ rad
- Yaw better than ± 170 μ rad

REQ-019172/A

The MLS 300 shall be stepper motor based.

REQ-019173/A

The MLS 300 shall have a minimum of 300 mm of travel.

REQ-019174/A

The total length, width, and height of the MLS 300 including the stage, motor, connectors, and mounting adaptor plate (if necessary) shall meet the following criteria:

- Length: 700 mm or less
- Width: 163 mm or less
- Height: 80 mm or less

REQ-019175/A

The MLS 300 shall have a mounting interface furnished with M6 through holes or slots with adequate spacing necessary for mounting the MLS 300 to a standard metric optical breadboard. The mounting interface shall be flat over the entire length of the MLS 300, accounting for any height difference between the fixing interface (bottom surface) of the stage and the stepper motor.

NOTE: The mounting interface specified can be achieved through a mounting adaptor plate or similar device; however, in such instances the fixing interface shall have M4 and/or M6 threaded holes for mounting of the adapter plate.

2.2.6. Motorized Rotation Stage (MRS)

REQ-019176/A

The MRS shall be vacuum (10^{-5} mbar) compatible.

NOTE: The vacuum compatibility includes female connector(s) and cable(s) of minimal length 2 m. Part of the delivery shall also include cable(s) with female connector(s) and an overall length of 3 m for operation in standard non-vacuum environments.

REQ-019177/A

The MRS shall have integrated reference switches for detection of a minimum of 1 distinct rotational position.

REQ-019178/A

The MRS shall have a minimum rotational velocity of 1.0 deg/s.

REQ-019179/A

The MRS shall have minimum load capacity 20 N.

REQ-019180/A

The MRS shall have the following properties:

- 0.02 degree on-axis resolution in full step mode
- Open loop accuracy
- Bearing flatness better than ± 30 μ m
- Bearing eccentricity better than ± 30 μ m
- Bearing wobble better than ± 100 μ rad

REQ-019181/A

The MRS shall be stepper motor based.

REQ-019182/A

The MRS shall incorporate a mounting platform that is capable of at least 180 degrees of rotation.

REQ-019183/A

The total length, width, and height of the MRS including the stage, motor, connectors, and mounting adaptor plate (if necessary) shall meet the following criteria:

- Length: less than 300 mm
- Width: less than 130 mm
- Height: less than 60 mm

REQ-019184/A

The MRS shall have a mounting interface furnished with M6 through holes or slots with adequate spacing necessary for mounting the MRS to a standard metric optical breadboard. The mounting interface shall be flat over the entire length of the MRS, accounting for any height difference between the fixing interface (bottom surface) of the stage and the stepper motor.

NOTE: The mounting interface specified can be achieved through a mounting adaptor plate or similar device; however, in such instances the fixing interface shall have M4 and/or M6 threaded holes for mounting of the adapter plate.

2.2.7. Motor Controller for MLA, MLS, MRS

REQ-019185/A

The MC shall have RJ45 or RS232 socket that allows communication and control from a remote host computer. This control shall be possible through one of the following protocols:

- ASCII based command protocol (protocol is documented);
- Linux 64bit compatible C++ libraries (libraries are part of the delivery).

REQ-019186/A

The MC for the MLAs, MLSSs, and MRS shall be fully compatible with the MLAs, MLSSs, and MRS, including the capability of detecting limit/reference switch states.

REQ-019187/A

The MC for MLAs, MLSSs, and the MRS shall have integrated stepper motor drivers compatible with the stepper motor of the MLA, MLS, and MRS.

REQ-019188/A

The MC shall have 4 independent channels capable of controlling any combination of MLAs, MLSSs, and MRSs totaling 4 devices.

REQ-019189/A

The MC shall be mountable in a 19" chassis or DIN rail.

REQ-020553/A

The MC shall have an interface for control and communication with a remote host computer. Control of the MC shall be possible through one or more of the following interfaces:

- Ethernet interface with RJ45 plug or SFP cage
- RS232 interface

REQ-020554/A

The MC shall provide one or more protocols for control and communication:

- ASCII based protocol for Ethernet or RS232 interface
- 64bit library for Linux operating system for Ethernet interface

REQ-020555/A

Documentation for ASCII protocol shall be part of delivery, the documentation shall describe the entire set of commands necessary for full operation and parameterization of MC.

REQ-020556/A

If a Linux library is preferred, this library shall be compatible with C/C++ languages and shall provide necessary header files for C/C++. The header files shall contain all necessary declarations for full operation and parameterization of MC. The library shall be part of delivery.

3. Operational Requirements

REQ-019190/A

The Supplier and the Contracting Authority shall agree on the cleaning method to clean devices without decreasing the devices' performance and to avoid contamination when used in a Class 7 clean environment according to ČSN EN ISO 14644 (equivalent to ISO 14644).

4. Building and Environmental conditions

REQ-019191/A

The DL, MLA, MLS and MRS shall fulfil criteria for operation within cleanroom environments up to class 7 as described in the ČSN EN ISO 14644 standard (equivalent to ISO 14644) and maintain all parameters described in the previous section in an environment stabilized to a near-room temperature specified by the supplier within ± 0.5 deg. C.

5. Delivery Requirements

REQ-019192/A

The DL, MLA, MLS and MRS shall be delivered in protective package preventing damage and contamination with a minimum of two plies of separate, clean packaging. The technologies shall be cleaned and packaged to be compatible with cleanroom environments of Class 7 according to ČSN EN ISO 14644 (equivalent to ISO 14644).

6. Safety Requirements

REQ-019193/A

The Supplier shall supply a Declaration of Conformity or any other equivalent document legally recognized and accepted in the Czech Republic for each product type if the appropriate legislation determines the Supplier's obligation to have a Declaration of Conformity (or the equivalent document) for the purposes of a Device sale in the Czech Republic to fulfil the requirements of 2001/95/EC directive or applicable Czech law.

7. Quality Requirements

7.1. General Quality Requirements

REQ-019194/A

The Supplier shall provide the Product User Manual (in electronic form) as part of the delivered Device. The Manual shall include the instructions and descriptions regarding the following procedures:

- transport and handling
- storage and installation
- calibration procedure (if required, see REQ-019196/A)
- safe operation and maintenance procedures
- general use of provided software, SDKs and/or communication protocol documentation where necessary.

REQ-019195/A

The Supplier shall provide information on execution of outgoing check of the Product. At least this information shall comprise declaration about execution of outgoing check and declaration of conformity with technical requirements defined by the product RSD and completeness of the Product.

REQ-019196/A

For the Delay Lines, the Supplier shall supply Calibration Certificate which shall establish:

- the relation between quantity values with measurement uncertainties provided by measurement standards and the corresponding indications with associated measurement uncertainties;
- the relation for obtaining a measurement result from an indication (if required).

NOTE: The calibration interval for the Delay Lines shall be defined by the Supplier.

REQ-019197/A

The Supplier shall establish and maintain a non-conformance control system compatible with ČSN EN ISO 9001 (equivalent to EN ISO 9001).

7.2. Specific Quality requirements

REQ-019198/A

For all motion system elements, the Supplier shall provide the Test report with the results of the outgoing tests (see REQ-019195/A).