

Technical Specifications (In-Cash Procurement)

**LINAC Ports - Motion system (vehicle) Technical
Summary**

LINAC for Ports - Motion system (vehicle) market survey Technical Summary

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1 Purpose

The goal of this document is to summarize the scope of work of the Contractor - and the interaction between IO and the Contractor - covering design and manufacturing of a Motion system vehicle integrating a linear particle accelerator system (LINAC head) to perform the radiographic examination of welds in the following ports of the tokamak vacuum vessel Upper ports:

- Upper Ports Stub Extension, Upper Ports Extension, Upper Port cryostat flange, Upper Port Cell Bellow, building flange.
- Equatorial ports: Eq. ports and duct bellow, Eq. cryostat flange, Eq. cell bellows, Eq. building flange, NB port stub extension 05, NB port extensions 04/05/06, NB port liners HNB1/ HNB2/ HNB3, NB circular bellows
- Lower Ports : RH port extensions, Cryostat port extensions, Lower RH duct bellows, Lower RH cryostat flanges, Lower RH cell bellows, Lower rectangular bellows, Lower building flanges

This specification summarizes the requirements for the design and supply of Motion system vehicle (namely LINAC Vehicle), this excluding the design and supply of the LINAC Head system.

The ITER Project

The ITER Organization (IO) is a joint international research and development project for which the initial construction activities are underway. The seven members of the IO are: the European Union (represented by Fusion for Energy (F4E)), Japan, the People's Republic of China, India, the Republic of Korea, the Russian Federation and the USA.

The project aims to demonstrate the scientific and technological feasibility of fusion power for peaceful purposes and to gain necessary data for the design, construction and operation of the first electricity-producing fusion plant. It will also test a number of key technologies, including the heating, control, diagnostic and remote maintenance that will be needed for a full-scale fusion power station. The ITER site is in the Bouchés du Rhône department of France. It includes the Headquarters of the IO and a construction worksite. The construction of the facility is on-going. Further information is available on the IO website: <http://www.iter.org>.

2 Definitions

LINAC Head	X-Ray source used for radiographic inspection of welded interfaces. Includes Control command cabinet and power supply units, chiller, cables (with energy supply), that shall be positioned on the Vehicle. The Control command and video unit are positioned far from the Linac X-Ray
VV	Vacuum Vessel. First confinement barrier of nuclear material. The place where fusion reactions will be created
LINAC Motion system	Vehicle that includes all necessary equipment to be used for the displacement and pre-positioning of the LINAC head system in the VV environment, for all ports. It ensures fix and rigid positioning of the LINAC system. All safety measures are secured. All movements are stopped while

performing the X-Ray shots. It is classified under CE Machine Directive and CE Directive CEM.

3 Main applicable Codes and Standards

CE Directive Machine 2006/42/EC
CE EMC Directive 2014/30/UE

4 Scope of work

The LINAC Motion System is a vehicle based platform that integrates all equipment required for the displacement and precise positioning of the LINAC beam head within the vacuum vessel port environment for all ports. The system ensures rigid and stable positioning of the LINAC beam head in all vacuum vessel ports to enable radiographic inspection of welded joints using X ray techniques. The vehicle will be pre positioned in IO buildings B11 galleries and then transported to the port cells. It will reach its final standing position prior to deployment of its arm, which will position the LINAC head according to the required shooting plan inside the port.

The work is divided in 3 different phases and associated gates:

- Preliminary Design of the IO LINAC Motion system - PDR
- Final Design of the IO LINAC Motion system - FDR
- Manufacturing and testing IO LINAC Motion system

The LINAC Head system is excluded from the current Scope of Works. Main interfaces between LINAC Head system and Motion system will be summarized in the Technical Specification.

4.1 Background of Pre Study

The feasibility study of a LINAC mobile unit to inspect VV Ports has been conducted by IO Contractor in Q2 2025.

This pre-study has demonstrated the technical feasibility and potential advantages of deploying a mobile LINAC system for radiographic inspection of the ITER Tokamak port welds.

4.2 Scope limits and main Interfaces with LINAC Head system

Scope limits and interfaces between LINAC head system and Motion system are defined in the schemes below.

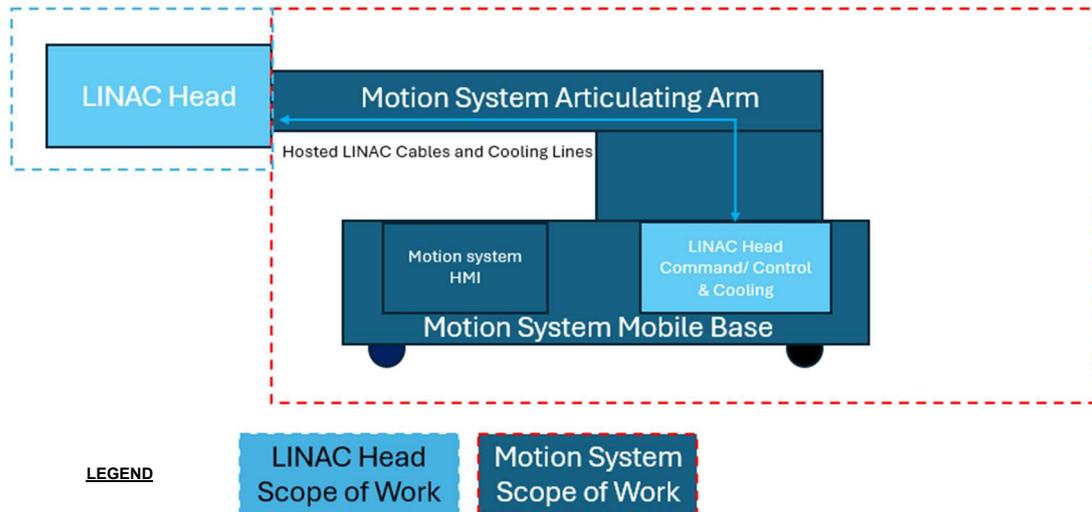


Figure 1 : LINAC general architecture - Interfaces scheme LINAC system

The LINAC system is built around a mobile platform referred to as the Motion System. The Motion System serves as the base unit and integrates the required subsystems for transport, positioning, and stabilization within the port cell environment.

An articulating arm is mounted on the base and is used to position the LINAC Head within each port. The number and configuration of articulating joints and or linear stages required for the arm shall be determined by the Contractor to ensure access to all specified inspection points. The final outcome is enabling precise positioning and angular orientation of the LINAC head relative to the welds and corresponding radiographic film, ensuring optimal alignment for inspection.

The arm of the vehicle will be equipped with:

- Cameras
- High stability system (no drift of articulated joints), to secure LINAC stability during X-Ray exposures (up to 20 min).
- Mechanical interface to mount LINAC Head
- LINAC Cable management system (see examples below)
- Safety measures such as:
 - Vehicle-integrated safety system for preventing vehicle from rolling off concrete platform.
 - Anti-collision systems for the arm
 - Interlocks ensuring no movement during LINAC Head operation
 - Emergency stops (Linac + motion)

The vehicle shall physically accommodate control command units both for LINAC Head system (provided by LINAC Head contractor) and for the Motion system.

Vehicle and Linac System management systems shall communicate (as for safety concerns) but shall not be integrated in a single control command unit. Control/Command, HMI and Safety study will determine the functionalities and physical architecture.

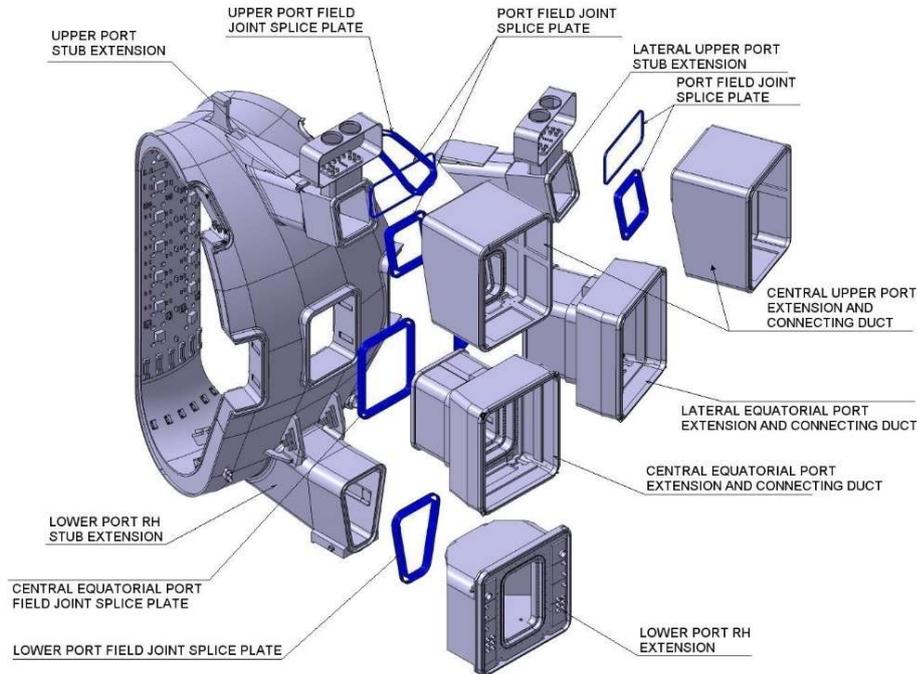


Figure 2 : The port structures of ITER TOKAMAK

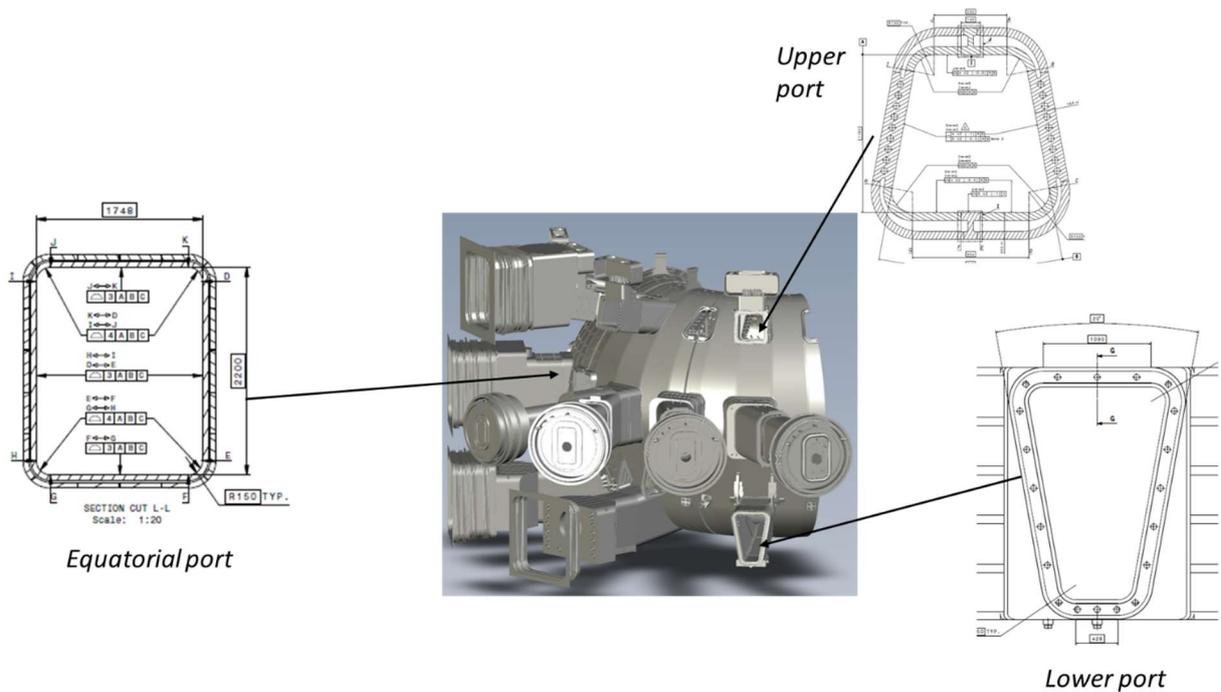


Figure 3: Example of geometries for an equatorial port (regular), a lower port and an upper port

5 System architecture

5.1 LINAC General Architecture

The Vehicle is equipped with telescopic arm. LINAC System is fixed at its extremity. **Figure 1 : LINAC general architecture - Interfaces scheme LINAC system**The chassis of the mobile base houses all embedded control systems, including:

- Mobile base navigation and positioning
- Arm deployment and lift mechanisms

In addition, the chassis integrates critical service systems, such as:

- A cooling system for thermal regulation of the LINAC Head (provided by LINAC Head contractor)
- A dedicated electrical cabinet for the LINAC Head with associated connection board, to supply all necessary energy to the LINAC Head and other actuated systems during inspection operations (provided by LINAC Head contractor)
- An onboard battery system, providing power during transit phases of the Motion system (e.g., from storage to inspection zone)
- A dedicated electrical cabinet for the LINAC Motion system
- LINAC Head cable management system
- A centralized safety management system for the Vehicle and the LINAC Head system

This integrated design ensures mobility, flexibility, within the constrained environment of the Vacuum Vessel, while maintaining high standards of safety and performance for radiographic inspection.

5.2 Additional LINAC positioning system requirements

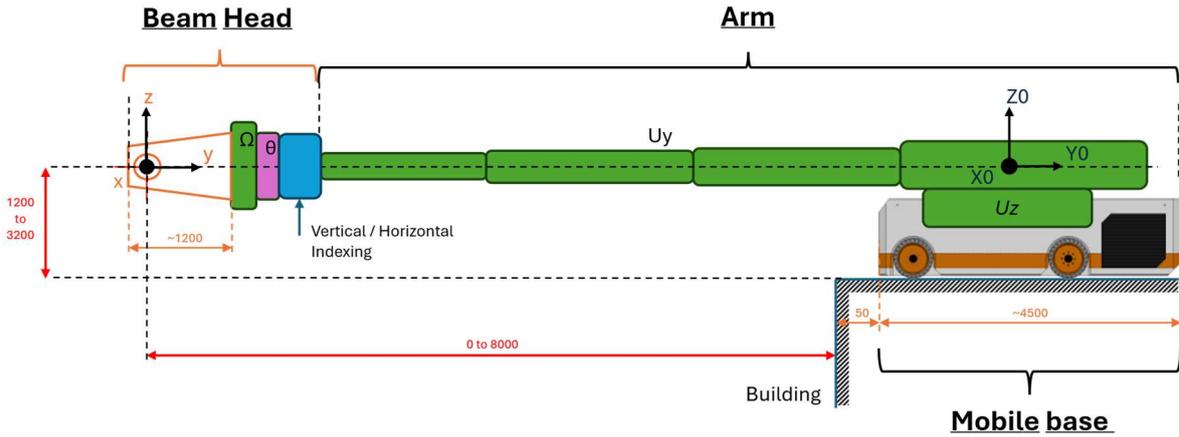


Figure 4 : System axes and movements diagram

Vehicle Sub-systems	Axis	Definition	Preliminary Range (To be verified by vendor during access study)
Arm	Uz	Beam head height	1200 to 3200 mm
	Uy	Beam head distance from the building	0 to 8000 mm
Mobile base	Ux	Lateral movement	-
	Uy	Forward / backward movement	-
	Rz0	Mobile base rotation around Z0	-
	Rz	Mobile base rotation around arm extremity	-

Maximum weight of the Beam Head subassembly: 500 Kg

Maximum weight of the LINAC motion system 6500Kg

The envelope maximum for the Vehicle is:

- 4500mm Length
- 3000mm Width and
- 3200mm in height

Linear Positional Accuracy – The Motion System shall position the LINAC head beam exit window within ± 25 mm in each orthogonal direction of a weld-referenced Cartesian coordinate system, including the direction normal to the welded interface plane and the two in-plane directions. (Value to be confirmed by IO during Preliminary Design phase.)

Angular Accuracy – The Motion System shall orient the LINAC head with an angular accuracy of $\pm 1.5^\circ$ about the two orthogonal rotational axes perpendicular to the emission axis of the LINAC head, referenced to the weld-referenced Cartesian coordinate system. Rotation about the emission axis (roll) is not subject to this accuracy requirement due to the panoramic nature of the source. (Value to be confirmed by IO during Preliminary Design phase.)

Kinematic Control Architecture - The system shall support motion control in a Cartesian coordinate system referenced to the origin of the LINAC head. The operator shall be able to command translational and rotational movements relative to this defined reference frame.

Structural Stiffness and Deflection Compensation- The system design shall include analytical modelling of structural stiffness. Deflection (including arm sag and compliance under load) shall be quantified across the full operating envelope. Compensation strategies shall be implemented to ensure required positioning accuracy at all deployment configurations.

Fail Safe Design- All actuated axes shall default to a mechanically locked condition in the event of power loss. In the event of power loss or system fault, the LINAC head shall remain in a mechanically stable and safe state without unintended motion.

6 Expected contract and main activities duration

The Contractor shall demonstrate proven experience and capability in industrial manufacturing, precision machining, and project and contract management. The Contractor is expected to ensure adherence to schedule, cost, and quality objectives throughout the execution of the contract.

The Contractor shall comply with all technical instructions and contractual requirements during the execution of the work and shall implement a robust quality management system. The targeted duration for the completion of this scope of works is 18 months.

The following milestones are tentatively proposed:

- Preliminary Design Review : Q2 2026
- Final Design Review : Q4 2026
- End of Manufacturing – Delivery : Q4 2027