# Technical Summary

# Framework Contract for the Development of ITER Tokamak Systems Monitoring

## Call for Nomination IO/19/CFT/7-439/LLJ

**Purpose**

ITER is a joint international project aiming to demonstrate the scientific and technological feasibility of fusion power for peaceful purposes. The seven members of the ITER Organization are: The European Union (represented by EURATOM), Japan, the People's Republic of China, India, the Republic of Korea, the Russian Federation and the USA. The ITER Organization is located in Saint Paul lez Durance – France. Further information is available on the ITER website: http://www.iter.org.

The Purpose of this document is to provide a summary description of the technical requirements of the ITER Organization (IO) associated with a future framework contract for the development of ITER Tokamak System Monitoring (TSM) system.

This document shall apply to the Call for Nomination to be issued by the IO to the ITER Domestic Agencies for the development of ITER TSM system. This document is not the final specification for the future framework contract which will contain more details about the specific IO requirements.

**Definitions**

| | |
|---|---|
| IO | The ITER International Organization for Fusion Energy |
| TSM | Tokamak Systems Monitoring |
| Contractor | The supplier of the services to which this Call for Nomination applies |
| ITER Site | Land put at the disposal of the ITER Organization in Cadarache, France |
| CDR | Conceptual Design Review |
| FDR | Final Design Review |

**Background**

The ITER tokamak is a highly complex machine comprising of multiple engineering systems, majorly Magnets, Vacuum Vessel, Thermal Shield, Blanket, Divertor, Cryostat, and a variety of Diagnostics and Plant Engineering systems. Successful operation of ITER hinges on the synergy of these engineering systems. For this reason each of the main ITER engineering system is armed with a collection of discrete operational instrumentation (OI) sensors of

various types to actively monitor the components' state during normal machine operation and off-normal events such as plasma disruptions, vertical displacement events (VDE), and others. Although the OI sensors are deployed as extensively as reasonably possible, they are still not able to spatially survey the entire system with the existing layout. The issue arises when some areas of interest are not sufficiently surveyed. The TSM system is intended to reconstruct information not directly available from sensors and provide a global picture of the ITER machine during operation. To achieve this goal, the TSM system reads the data collected by various OI sensors and then reconstructs, through a set of well-developed dedicated inversion algorithms, the global engineering state of the ITER tokamak. Creation, validation and implementation of the reconstruction algorithms is central in the development of TSM.

The output of the TSM will give the ITER machine operators an integrated view of the machine's conditions and aid the operators in decision making and adjusting the operation plan as necessary. These data are also useful in validating the tokamak engineering models on which the inversion algorithms are built that is significant to the construction of next-generation fusion devices like DEMO. The TSM system has neither safety nor machine protection classifications and it does not have any real-time control actions.

**Scope of work**

The entire work package is executed in five stages as described below.

Stage 1:
The Contractor shall deliver conceptual design of the inversion algorithms to address the following TSM related tasks:

1. To derive the thermo-hydraulic performance of the ITER tokamak engineering systems
2. To derive the thermomechanical behaviour of ITER tokamak engineering systems
3. To derive the electromagnetic response of ITER tokamak engineering systems in transient EM events, including plasma VDE and disruptions and fast discharges of the stored magnetic energy
4. To derive the dynamic response (with inertial load components and possible resonances) of ITER tokamak engineering systems in dynamic events, including fast EM transients and seismic events.
5. To deduce and summarize the interface loads among ITER tokamak engineering systems
6. To detect or deduce accidental electrical contacts between neighbouring engineering systems.
7. To infer the fatigue and structural limit of ITER tokamak engineering systems.

A Conceptual Design Review (CDR) will be held by the end of Stage 1. The Contractor shall provide supports throughout the CDR phase, i.e., from review meeting preparation to the closure of CDR, measured by the resolution of Category 1 and Category 2 chits raised by the review panel.

Stage 2:
Following the approval of the Conceptual Design, the Contractor shall proceed and deliver prototypical algorithms for solving the abovementioned TSM related tasks. The Contractor

shall organize validation test of the developed algorithms on reduced physical models to demonstrate their workability.

A Final Design Review (FDR) will be held by the end of Stage 2. The Contractor shall provide support throughout the FDR phase, i.e., from review meeting preparation to the closure of FDR, measured by the resolution of Category 1 and Category 2 chits raised by the review panel.

Stage 3:
Upon the approval of the Final Design, the Contractor shall convert the design of the prototypical algorithms into a series of technical specifications as input requirements for the coming software coding. The Contractor shall deliver one set of Technical Specifications for each abovementioned (see Stage 1) TSM task.

Stage 4:
The Contactor shall provide support throughout the on-site coding phase of the TSM system. That includes efforts in participating and supervising computer programming, interface development, and integration of the developed software with ITER CODAC and plasma control platform.

Stage 5:
The Contractor shall provide support in the test and commissioning phase of the TSM system on ITER tokamak.

**Timetable**
The tentative timetable is as follows:

| | |
|---|---|
| Pre- Qualification issuance: | Mid of July 2019 |
| Call for Tender issuance: | End of August 2019 |
| Award: | Beginning of 2020 |

**Qualifications and Experience**
The Contractor shall at least meet the following qualifications:

- Proven experience of engineering modelling in solving EM, thermomechanical, structural problems using ANSYS software
- Proven experience of mathematically solving inversion problems
- Proven experience of computer programming using C++ and Matlab
- Proven experience in building control and/or monitoring systems for tokamaks or other fusion devices or similar big-science projects like pulsed magnetic systems, etc.
- Proven technical writing and oral communication in fluent English
- Proven project management and risk mitigation experience

**Candidature**
Participation is open to all legal persons participating either individually or in a grouping (consortium) which is established in an ITER Member State. A legal person cannot participate individually or as a consortium partner in more than one application or tender. A consortium may be a permanent, legally-established grouping or a grouping, which has been constituted

informally for a specific tender procedure. All members of a consortium (i.e. the leader and all other members) are jointly and severally liable to the ITER Organization.

The consortium groupings shall be presented at the pre-qualification stage. The tenderer's composition cannot be modified without the approval of the ITER Organization after the pre-qualification.

Legal entities belonging to the same legal grouping are allowed to participate separately if they are able to demonstrate independent technical and financial capacities. Candidates (individual or consortium) must comply with the selection criteria. The IO reserves the right to disregard duplicated reference projects and may exclude such legal entities from the pre-qualification procedure.