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Technical Specifications (In-Cash Procurement)

Technical specifications for the expertise need in the design of Duel Wavelength Imaging Interferometer

This document describes technical needs for expertise in the design of Duel Wavelength Imaging Interferometer, in in support of the ITER Erosion Monitor Diagnostics for ITER. It also describes the proof of principle experiments and R&D to be conducted at the experts site

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1 Purpose

This document describes technical needs for expertise in the design of Duel Wavelength Imaging Interferometer, in in support of the ITER Erosion Monitor Diagnostics for ITER. It also describes the proof of principle experiments and R&D to be conducted at the experts site

2 Scope

The work described below is related to the expertise in the design of Duel Wavelength Imaging Interferometer in support of the ITER 55.G8: Erosion Monitor [R1-R2]. This diagnostic is being developed by IO-CT. This system has gone through the Conceptual Design Review recently [R3] and is posed for the next stage of design. However, to aid the diagnostic development, inputs from this expertise, backed by past experience in the field of Interferometry in general and Speckle Interferometry in particular, is required, together with a reputation in these fields backed by a team of workers and a functioning laboratory. Work will also involve resolution of issues pointed out by the CDR panel, performance of proof of principle R&D experiments, as well as working alongside the ITER PPDI team in carrying out next stage of design.

3 Definitions

C-R: Contractor Responsible. See Contract specifications for definition of duty.

C-TRO: Contractor Task Responsible Officer. Carrying out the contract tasks. See Contract specifications for definition of duty.

IO-CT: ITER Organization (Central Team)

IO-TRO: ITER Organization Technical Responsible Officer. See Contract specifications for definition of duty.

PPDI: Port Plug and Diagnostics Integration Division

For a complete list of ITER abbreviations see: ITER Abbreviations (ITER_D_2MU6W5).

4 References

[R1] R. Reichle, et al, Journal of Nuclear Materials 463 (2015) 180–184

[R2] E. Gautier, et al, Journal of Nuclear Materials 415 (2011) S1182–S1186

[R3] Conceptual Design Review of 55.G8:Erosion Monitor Diagnostic System

[R4] Panel final report on CDR of 55.G8: Erosion Monitor

5 Estimated Duration

The duration shall be for 12 months from the starting date of the task. The contractor may be asked by the IO-TRO to perform travel missions of a short duration for the purpose of the execution of the contract, they will be defined in the course of the contract.

6 Work Description

Plasma-wall interaction in fusion devices is unavoidable, and leads to material erosion, dust formation, and tritium retention **[R3]**. Owing to long pulse and high power operation of ITER the divertor region is expected to erode 3 mm over its lifetime. Therefore erosion of plasma-facing material and generation of dust inside ITER can significantly affect the operation, and the importance of the plasma-wall interactions in the fusion devices has been emphasized. This is because the total in-vessel dust and tritium inventories during an operational campaign are required to be below a limit of 1000 kg and 1 kg respectively, imposed by safety considerations. To ensure respect of these limits, dust and tritium inventories should be monitored during the operational campaign of ITER. Due to increased needs of investigation and monitoring of plasma-wall interaction, the diagnostics measuring dust, erosion, and tritium retention were included in the list of ITER baseline diagnostic systems in 2008.

Long term beneficial effects were predicted regarding erosion, re-deposition and dust related issues if ITER would change from a divertor configuration with carbon at the strike point and Tungsten elsewhere to a full Tungsten divertor while maintaining a Be first wall. The change to a full metal ITER has implications on the plasma-wall-interaction diagnostics to be implemented, and a workshop was organized at ITER to review the diagnostic strategy and help IO in choosing suitable diagnostics for this topic. In the outcome of that workshop, including recent results on modelling and results from the ITER like wall experiment which confirms the predicted benefits is reported with an emphasis on the rationale of the choice and the way in which the various measurement systems and procedures contribute to the achievement of the overall requirements in the area of interest. The conclusion was to recommend the following diagnostic systems (PBS 55 and PBS 57) for a CDR design:

1. Global first wall monitoring of erosion and deposition by the in vessel viewing system (IVVS) using Laser Radar technique. (PBS 57)
2. One or more endoscopes to inspect the sub-divertor region for dust accumulation. Preferably the system should be equipped with mechanical removal of small quantities of dust particles for post mortem analysis (PBS 55.G9).
3. Removable first wall samples to monitor erosion/deposition in the recessed areas of the ITER first wall Be-panels. (PBS 55.GD).
4. A port plug laser based technique to monitor the Tritium retention and the deposition thickness and composition of deposits on relevant parts of the first wall and divertor region (PBS 55.GC).
5. A laser interferometric system (Speckle or similar) to monitor the erosion/deposition on the vertical parts of the ITER divertor (PBS 55.G8).

This CFE related to the system mentioned in Item #5 above. Owing to the decision to have Tungsten only divertors the present changed measurement requirements for Erosion Monitor are

Parameter	Role	Range/Coverage	Time/Frequency	Spatial Resolution	Accuracy
040d: Fine surface metrology - Divertor	2. Phy	Divertor target DR: 3 mm	< 1 pulse*	1 mm lateral	RH: 10 μm

Abbreviations: 2. Phy (Physics), DR (Depth range), RH (Relevant Height accuracy)

*Not required after every pulse, may be performed during maintenance period or on demand
The Erosion Monitor diagnostic is a distributed system with components throughout the ITER tokamak complex. The 55.G8 Erosion Monitor (EM) diagnostic based on Imaging Interferometry will be located in Lower Port# 8 [Figure 1]. The system will measure the change in the topology of the Inner and Outer vertical targets in the Divertor region. Each target plate will be illuminated by a set of two laser beams generated outside the vessel; the scattered image will be transported back outside. In-coming and out-going beams are then combined with reference beams to create speckle interference patterns which will be recorded for further analysis.

The EM will have (optical) components essentially in 7 different places [Figure 2 and 3]:

1. The reference surface between the two halves of the divertor wall (S04, CSS#22)
2. Under the dome of cassette #22, in a dedicated optical box
3. In the inner rack of LP08
4. At the closure plate (vacuum window)
5. In the interspace support structure
6. In the bioshield
7. In the port cell support structure

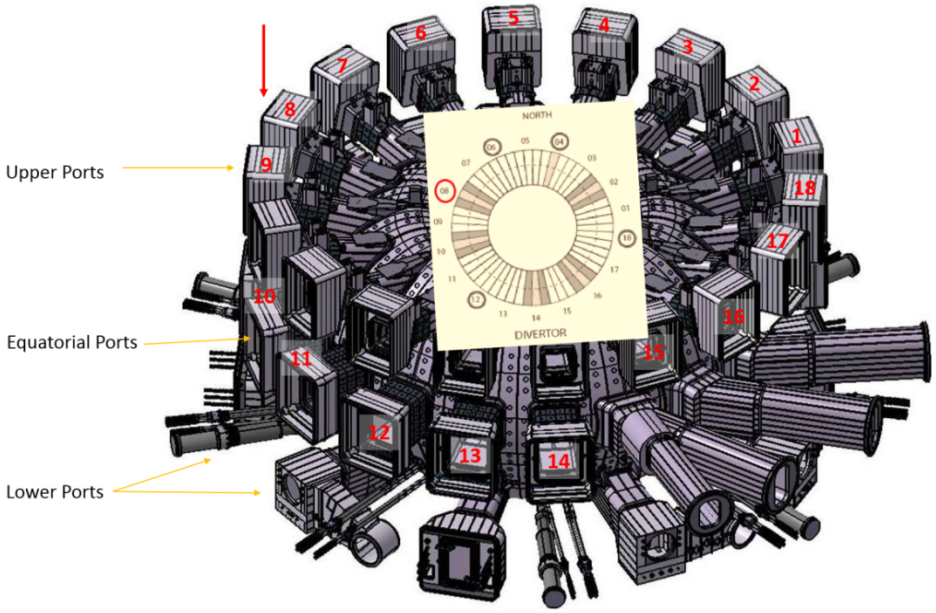

Figure 1: Location of the port for 55.G8: EM

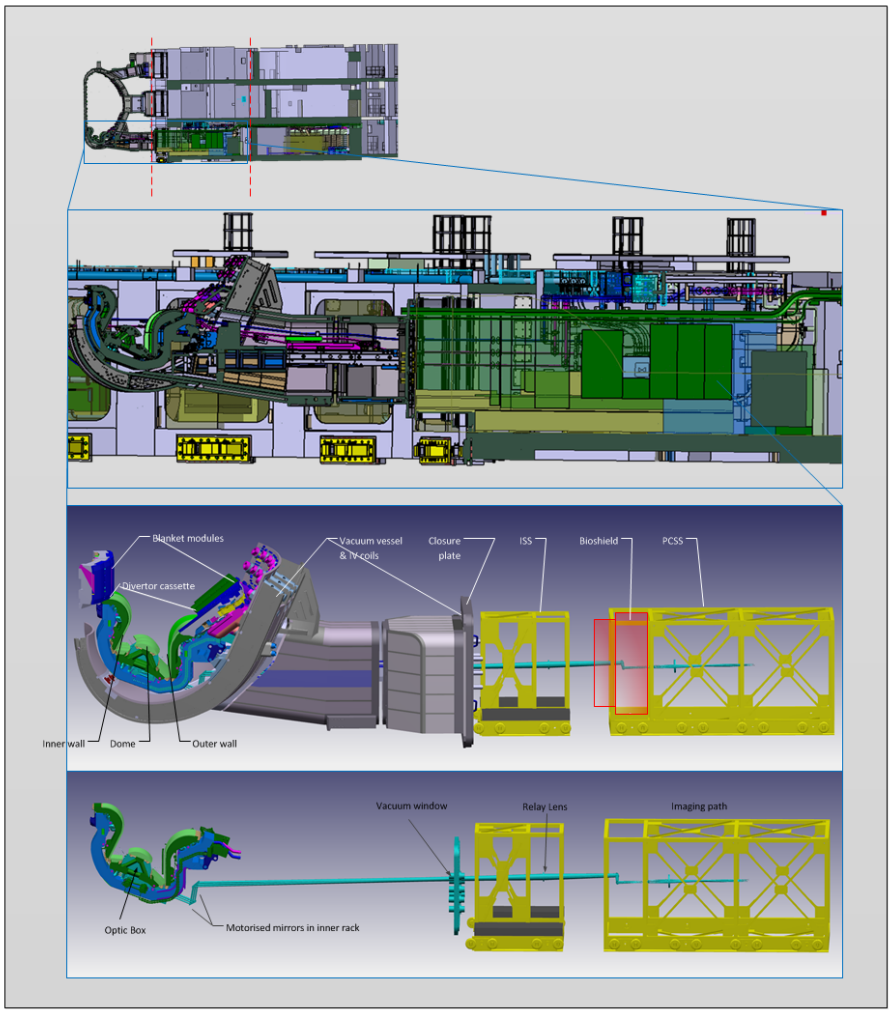

Figure 2: Increasing details of 55.G8: EM in LP#8 area

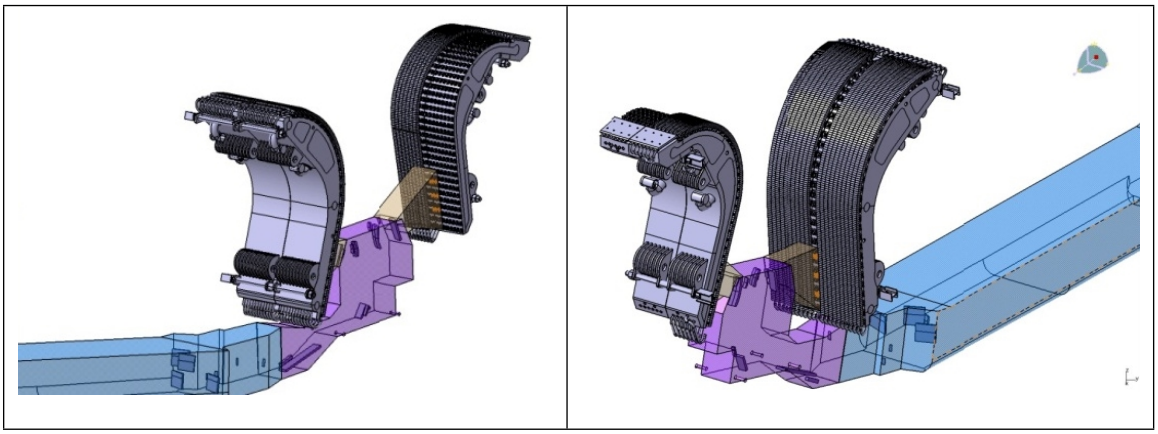

Figure 3: Location of the reference surfaces in the inner and outer divertor plates

The main challenges in designing this are

1. Restricted space in LP#8 for design since this system also shares the port with Divertor Thompson Scattering diagnostic
2. Hostile environment under dome area due to thermal loads, radiation loads, dust and vacuum
3. Long interferometric arms and optical components on different subsystems in the machine making it prone to vibrations during measurements
4. Laser beam and target beam transfer over long distance necessitates restricted choice of lasers and cameras at the back end

55. G8: Erosion monitor system went through the Conceptual Design Review (CDR) where a system based on Duel Wavelength Speckle Interferometry was presented to the panel as a reference design [R4]. Issues that were raised during that review necessitated revisiting the alternate concepts and necessary redesign to certain degree. The main goal of this CFE is to address these issues and recommend changes in the concept if necessary and aid further design.

The work is split into 5 main topics:

1. Five Category 1 Chits were raised related to the measurement requirements, measurement range, contamination of signal with reflection of input laser, wavefront effects due to non-perpendicular measurement targets, and finally the effect of vibrations on the measurements. It is expected that either an improvement of the proposed system or an alternate concept will be proposed by the contractor for the resolution of these chits. The contractor is expected to suggest appropriate conceptual changes to the design to achieve the measurement requirements.
2. During the tenure of the contract the contractor will support the team of engineers in turning these concepts in to workable design
3. In the next part of the contract, the contractor will help IO-CT in generating the list of required R&D tasks and prototyping to verify the proposed concept in two phases. One with a simpler CW laser based system to prove the principle of measurement and then a pulsed laser based system to achieve measurement requirements even in the presence of the expected vibrations. The contractor will also propose the modifications required to take care of the wavefront problem.
4. The contractor will carry out these R&D and prototyping tasks in the contractor's laboratory and reports the results to IO-CT Team.
5. Based on the results of these R&D and Prototyping work the contractor will suggest the modifications necessary in the design of the system.

7 Responsibilities

7.1 Contractor's Responsibilities

In order to successfully perform the tasks in these Technical Specifications, the contractor shall:

- Strictly implement the IO procedures, instructions and use templates;
- Provide experienced and trained resources to perform the tasks;
- Contractor's personnel shall possess the qualifications, professional competence and experience to carry out services in accordance with IO rules and procedures;

- Contractor's personnel shall be bound by the rules and regulations governing the IO ethics, safety and security IO rules.
- Allow IO-TRO or persons nominated by IC-CT to visit contractor's site to witness experimental set up and results of the experiments on mutually accepted terms and conditions between IO-TRO and C- TRO

7.2 IO's Responsibilities

The IO shall:

- Nominate the Responsible Officer to manage the Contract (IO-TRO);
- Organise a monthly meeting(s) on work performed;
- Provide offices at IO premises.
- Grant the access to the IDM as Author to the contractor, in order to upload documentations.
- Review documents in a timely fashion

8 List of Deliverables and due dates

The main deliverables are listed in the table below

D #	Description	Due Dates
D01	Report containing the possible solutions for CDR chits and recommended design changes	T0 + 1 months
D02	Report on the list of R&D and prototyping to be performed before the next design stage	T0 + 2 months
D03	Report of status of CW laser based system design for cheking the concept and set up building at contractors site	T0 + 4 months
D04	Report on measurement, accuracy assessment with CW laser based system	TO + 6 months
D05	Report on development of Pulsed laser based system to take care of the vibrations and wave front effects	T0 + 8 months
D06	Report on measurement and accuracy assessment using pulsed laser system	T0 + 11 months
D07	Final report with recommendations for engineering design	T0 + 12 months

9 Acceptance Criteria

These criteria shall be the basis of acceptance by IO following the successful completion of the services:

- The deliverables will be in the form of reports as indicated in section 8 "List of Deliverables and due dates".
- The deliverables will be posted in the contractor's dedicated folder in IDM.

- The IO-TRO is the Approver of the delivered documents.
- The Approver can name one or more Reviewers(s) in the area of the report's expertise.
- The Reviewer(s) can ask modifications to the report in which case the Contractor must submit a new version.
- The acceptance of the document by the Approver is the acceptance criterion.

10 Specific requirements and conditions

Experience of all skills and techniques in deliverable list – in particular:

- Experience in the field of laser based interferometry in general and speckle interferometry in particular
- Experience with duel wavelength interferometry and or pulsed interferometry will be preferred. Also preference will be given to person with experience in temporal & spatial phase shifting methods and wavefront manipulation. Experience in design and applications of interferometers in high vibration environments will be an added qualification
- Experience in leading and guiding high end interferometric facility will be highly desired
- Experience with creating technical documents and presentations
- Contractor or persons nominated by the contractor may be required to be present onsite from time to time, for interacting with the design team, for discussion of results etc. The duration and time will be mutually agreed by IO-CT and the contractor.

11 Work Monitoring / Meeting Schedule

The work will be managed by means of Progress Meetings and through the formal exchange of documents and transmitted by emails which provide detailed progress.

Progress Meetings will be called by the ITER Organization or the C-TRO. They will be held as needed and at least bi-monthly, either on the IO site or via videoconference. Progress meetings will involve C-TROs and the IO-TRO. External experts will be invited to discuss technical matters. The C-RO will be invited in case of contractual discussions.

For all Progress Meetings, minutes, including action items, shall be written by the C-TRO and be stored in the ITER IDM in order to ensure traceability.

12 Delivery time breakdown

See Section 8 "List of Deliverables and due dates".

13 Quality Assurance (QA) requirements

The organisation conducting these activities should have an ITER approved QA Program or an ISO 9001 accredited quality system.

The general requirements are detailed in ITER Procurement Quality Requirements (ITER_D_22MFG4).

Prior to commencement of the task, a Quality Plan must be submitted for IO approval giving evidence of the above and describing the organisation for this task; the skill of workers involved in the study; any anticipated sub-contractors; and giving details of who will be the independent checker of the activities (see Procurement Requirements for Producing a Quality Plan (ITER_D_22MFMW)).

Documentation developed as the result of this task shall be retained by the performer of the task or the DA organization for a minimum of 5 years and then may be discarded at the

direction of the IO. The use of computer software to perform a safety basis task activity such as analysis and/or modelling, etc. shall be reviewed and approved by the IO prior to its use, in accordance with Quality Assurance for ITER Safety Codes (ITER_D_258LKL).

14 CAD Design Requirements (if applicable)

No CAD design tasks are foreseen for this contract.

15 Safety requirements

ITER is a Nuclear Facility identified in France by the number-INB-174 ("Installation Nucléaire de Base").

For Protection Important Components and in particular Safety Important Class components (SIC), the French Nuclear Regulation must be observed, in application of the Article 14 of the ITER Agreement.

In such case the Suppliers and Subcontractors must be informed that:

- The Order 7th February 2012 applies to all the components important for the protection (PIC) and the activities important for the protection (PIA).
- The compliance with the INB-order must be demonstrated in the chain of external contractors.
- In application of article II.2.5.4 of the Order 7th February 2012, contracted activities for supervision purposes are also subject to a supervision done by the Nuclear Operator.

For the Protection Important Components, structures and systems of the nuclear facility, and Protection Important Activities the contractor shall ensure that a specific management system is implemented for his own activities and for the activities done by any Supplier and Subcontractor following the requirements of the Order 7th February 2012 (PRELIMINARY ANALYSIS OF THE IMPACT OF THE INB ORDER - 7TH FEBRUARY 2012 (AW6JSB v1.0)).