ENGINEERING TECHNICAL SUPPORT
FOR THE ITER
TOKAMAK ENGINEERING DEPARTMENT

Call for Nomination (C4N)
Ref. IO/CFN/15/70000217/PMT
Summary of Technical Specifications

1. Purpose

The purpose of this project is to provide engineering, technical and analysis support for the design, procurement, acceptance, installation and commissioning of ITER Tokamak components.

2. Background

ITER (“The way” in Latin) is a next generation fusion tokamak designed “to demonstrate the scientific and technological feasibility of fusion energy for peaceful purposes”. With a long lifespan over than 30 years, it is intended that ITER will be a single step between the current set of fusion experiment and DEMO, a fusion power plant designed to demonstrate safe and reliable, commercial electricity production.

The ITER Organization consists of 7 Parties, acting through the Domestic Agencies (CN, EU, IN, JA, KO, RF, US) each of them will have a role in supplying most of the systems. The ITER Organization has the overall responsibility for the design and operation of the machine.

The Tokamak is the part of the ITER machine closest to the thermonuclear plasma and includes:
- The Toroidal Field Coils
- The Poloidal Field Coils
- The Central Solenoid
- The Correction Coils
- The Feeders
- The Vacuum Vessel and Vacuum Vessel Ports
- The Thermal Shield
- The Cryostat
- The Vacuum Vessel Pressure Suppression System
- The Blanket System
- The Divertor
- The Test Blanket Systems
- The Port Plugs
- The Diagnostics
- The Port Plug Test Facility
- The In-vessel Viewing system
- Ion cyclotron heating
- Electron cyclotron heating
- Heating and diagnostic neutral beams

3. Scope of Work

The engineering services to be provided are grouped in the following Areas of Expertise (AoE), which are going to constitute individual Framework Contracts, Lots 1 to 7. The estimated total value for the project will be about 10 M€.

**Lot 1. Analysis Support** (about 25% of the total workload)

This AoE includes the supporting analysis as required by the design and construction of the tokamak components. It includes the following topics:

- **Electromagnetic analysis**: Off-normal plasma conditions (i.e. plasma disruptions and Vertical Displacement Events) generate eddy and halo currents in the tokamak components, including pipes and pipe bundles. These currents interact with the toroidal and poloidal magnetic field thus generating large electro-magnetic (EM) forces. Eddy and halo currents in the structures shall be calculated on the basis of inputs provided by the DINA code. After that the EM loads shall be evaluated and properly interpolated on very detailed thermo-structural models.
- **Neutronic analysis**: to calculate the neutronic heat deposition, the material activation, the material damage (dpa) and the helium production.
- **Computational fluid dynamic analysis**: to calculate pressure drop, flow rate, heat transfer coefficient, draining and drying, using 1D and 3D CFD codes.
- **Thermal analysis**: both steady state and transient, including surface heat flux and volumetric heat loads, heat transfer by radiation and convection.
- **Mechanical analysis**: both static and dynamic analysis (linear and non-linear), including a variety of loads, typically: pressure, seismic, EM, thermal.
- **Fracture Mechanics**: to justify the tolerance to initial defects of the specific nature of some Tokamak components designs and materials. Classical method defined in structural design criteria such RCC-MR Appendix 16 and additional finite element analysis method for non-conventional structures.
- **French Regulation**: to prepare analysis report to be submitted to the Agreed Notified Body (ANB), as required by ASN (Autorité de Sureté Nucléaire). Familiarity with the “French Decree 99-1046 of 13 December 1999 on Pressure Equipment (ESP - Equipement Sous Pression)” and “French Order 2005 December 12th for nuclear pressurised equipment (ESPN - Equipement Sous Pression Nucléaire)”. 
• **System engineering analysis:** To analyse the propagation of requirements and to perform functional analysis. Global requirements from high level ITER documents like the Project Requirements have to be propagated to all systems and vice versa it has to be analysed whether the propagated requirements fulfil the global ones. Functional Analysis (FA) shall be used to derive the functional specifications for ITER Systems. The FA shall also be used as entry point to risk analysis and RAMI (Reliability, Availability, Maintainability, Inspectability) analysis.

**Lot 2. Manufacture Support** (about 25% of the total workload)

This AoE includes the following topics:

• **Manufacturing feasibility and optimization:** to provide feedback to the design from a manufacturer’s perspective, to identify areas of the design with feasibility issues, to propose improvement of the design with the aim to facilitate the fabrication and reduce the construction cost without impact to performance or quality of the components.

• **Cost studies:** to develop cost assessment of proposed design solutions and in support of Project Change Requests. Cost breakdown should typically include engineering and manufacturing activities, to a level sufficiently detailed to allow identification of cost drivers and including, e.g., the cost for manufacturing drawings, materials, manufacturing jig and fixtures, welding, non-destructive testing, tolerances, test and inspection, QA documentation…

• **Schedule evaluation:** to support the ITER Organization for manufacturing and assembly schedules evaluation to have realistic and reliable schedule based on the experiences from exiting similar projects.

• **Manufacturing inspections:** to provide the ITER Organization on welding experiences of design, materials and process, as well as on non-destructive examination (X-ray, ultrasounds, helium leak test, dimensional tests, pressure tests, etc…). Familiarity with the corresponding EN standards and/or similar code and standard for nuclear facility is advance.

• **Instrumentation & Control:**
  - **Qualification:** to contribute to the follow up of qualifications of instruments.
  - **Procurement:** to assist in the follow up of the procurement of instrumentation with a particular emphasis on signal conditioning and data acquisition. This works includes in particular the development of procedures for factory acceptance and site acceptance with high quality assurance standards.

**Lot 3. Assembly/Installation and Transport** (about 25% of the total workload)

This AoE includes the following topics:

• **Assembly feasibility and optimization:** to identify areas of the design with assembly feasibility issues, to propose improvement of the design with the aim to facilitate the assembly on-site and reduce the construction cost without impact to performance or quality of the components. Assembly feasibility assessment shall include all aspects of assembly including rationalisation of assembly requirements (including testing), lifting, handling and alignment and the corresponding interfaces to the relevant tools,
transport from factory to assembly site, interfaces with other systems and their assembly activities

- **Investigation of the Plug-to-Port high strength fasteners:** to review the current design and address the points of concern (e.g., the thread seizing, a need of locking, etc.), to contribute to the study of the bolt tightening methods, to support the bolt tightness control methods in lieu of the ISI, to assess the analysis methods used by the IO for the bolted joint justification, to review the justification performed by the IO and perform additional assessments/analyses (if needed), to contribute to the procurement studies of the high-strength fasteners and the related PA documentation. The supplier/suppliers should have a sound experience in designing, supply and/or maintenance of the high-strength bolted joint, have an expertise knowledge of the related codes and standards (including the RCC-MR) and experience of work with the regulator organizations (like ASN).

- **Investigation of the Port/Plug sealing systems (both the lip welded seals and the gasket seals – with related fasteners):** to review the current design concepts and address the points of concern, to review the welding/cutting and NDE R&D performed up to now, the structural justification of the lip welded seals (including the structural criteria used) and study the related codes - to develop finally the document on the lip seal application for ITER (in view of submission to ASN in the future), to perform additional assessments/analyses of the lip seals (e.g., based on the fracture mechanics), to assess the analysis methods used by the IO for the gasket seal justification, to review the justification performed by the IO and perform additional assessments/analyses (if needed), to review and contribute to the leak-tightness control methods and studies (including the ISI), to assess the handling/maintenance methods of the sealing components, to contribute to the procurement studies of the Sealing Flange components and the related PA documentation. The supplier should have a sound experience in designing, supply and/or maintenance of the UHV seals, have an expertise knowledge of the related codes and standards (including the RCC-MR) and experience of work with the regulator organizations (like ASN).

**Lot 4. Specialised Analysis for Magnets** (about 5% of the total workload)

- **Customized Cryogenic Thermo-Hydraulic Analysis— (Assessment of Losses in conductors and joints during “advanced” scenario.**

Within Magnet Division special software codes are used to make simulation as part of the conductor design and conductor performance during operation. Some of these codes Thermo-Hydraulic Codes are: Super Magnet, Vincenta and Venecia. Some special Electro-magnetic codes are Cariddi, Traps AV, and MAC.

The requested Expertise is required for Thermo-Hydraulic Simulations.

**Lot 5. Specialised Technology for Magnets** (about 5% of the total workload)

- **Specialised Computational Engineering Support and Expertise:**
  
  For the support of the Magnet Safety Studies, and manufacturing and assembly activities of the Magnet System, consisting of TF, CS, PF, CC, In-vessel Coils and feeders, there are in many cases a need for specialized simulations. These simulations have to be to be carried out by specialists in the software used and who has a good understanding of the engineering
problems. Many simulations require special know-how of the software to solve the unusual problems. The computational models used for these simulations are large and require large run times. The development of automatic procedures is preferable but not always possible. Another important issue is to keep the stability, reliability, and accuracy under of such simulations under control. Software customization, like special user-routines or special ANSYS-APDL macro’s is required in some cases.

Once the simulations are benchmarked and solved the know-how and experience obtained has to be properly documented and transferred to IO. This requires a high level of expertise with the simulation environment; experience is similar situations and familiarity with working according analysis plans. It’s obvious that this needs to be done in close cooperation with IO.

The requested expertise and type of simulations concerned are:

- If necessary access to large computer sources with appropriate software installed.
- Access and capabilities to customize the simulation software.
- Knowledge of and access to structural design codes.

**Lot 6. Composite Expertise** (about 7.5% of the total workload)

- *Composite Expertise:* The ITER magnets use composite materials in a range of locations. The materials are generally based around organic resins, with filler materials consisting (for example) of glass fibre, polyimide, glass particles, metal or ceramic particles, depending on the particular properties required. The requirements are often a complex mixture of manufacturing and assembly needs (workability and handling), and functionality (mechanical and electrical strength, thermal conduction, thermal contraction). The following services would be provided:
  - To provide advice on composite material compositions according to IO requirements
  - To procure small quantities of resins and fillers and deliver to IO or by mutual agreement an IO contractor or DA
  - To simulate manufacturing and assembly operations to establish the suitability of the composition, and the appropriate working and curing procedures
  - To fabricate prototypes of small subcomponents such as insulating breaks
  - To test specific composite material provided by the DAs and their suppliers
    - To provide tests as follows
      - Mechanical strength and moduli at RT, 77K and 4K
      - Viscosity as a function of time at various filling temperatures
      - Thermal conduction (at RT, 77K and 4K)
      - Glassification Temperature
      - Void fraction

The work includes fabrication of suitable test specimens.
Lot 7. Cryogenic Testing and Measurement Expertise (about 7.5% of the total workload)

- Cryogenic Testing and Measurement Expertise:
  The ITER magnets operate at cryogenic (4K) temperatures and accurate prediction of thermal and hydraulic properties (particularly heat transfer, thermal conduction and pressure drop) is essential to ensure the magnets function as expected. To support such predictions, measurements on representative samples under cryogenic conditions are frequently required. The following services would be provided:
  - To provide advice on test configurations to provide accurate measurements of thermal and/or hydraulic properties
  - To maintain in operational conditions a set of suitable cryogenic equipment (included well calibrated and validated instrumentation) for carrying out such measurements. This must include a fully operational cryoplant.
  - To have available an appropriate range of cryogenic instrumentation (particularly thermometers) with in-house knowledge on how to install and operate it to avoid errors, with the supporting electronic systems
  - To design and fabricate (or assist in fabricating if specific manufacturing expertise is required from elsewhere) test specimens (whether fabricated in-house or provided by IO)
  - To evaluate the accuracy of the measurements

4. Experience Requirements

The ITER Organization is looking for Contractors with demonstrated experience in each Area of Expertise for each lot.
In addition, during the tendering process the Supplier will have to provide evidence of:
- QA system: The Tenderer shall have and maintain a valid ISO 9000 certification and shall have the duty to verify and document the equivalent quality level of all its subcontractors and consultants.
- Professional Software: The Tenderer shall provide a list of the professional software available and used, e.g. for structural (static, dynamic, seismic), thermal and thermomechanical analyses, electromagnetic analyses (such as ITER conventional multi-physic analysis software ANSYS), CAD software (such as ITER conventional CAD software CATIA V5 and/or V6, if it is applicable) etc.

5. Award of Framework Contracts

Multiple framework contracts are contemplated, one for each Lot, in order to provide the full range of services required. It is not expected that a single company will have the full capability required for all AoE, and as such, companies are encouraged to tailor their proposed support in areas relating to their specific skills and interests. Suitable teaming arrangements for multiple companies are also encouraged, where appropriate, to enhance the offering of the tenderer.
General information on the scope and design of the ITER machine is described in the [www.iter.org](http://www.iter.org) website.

It is contemplated that the ITER Organization will award framework contracts for an initial period of three years, and may extend contract options for two additional years as required to complete the necessary engineering work.

The framework contract will be implemented by means of Task Orders, intended as a self-standing engineering activity. Each Task Order shall be signed by the Contactor and the ITER Organization.

The language used at ITER is English. A fluent professional level is required (spoken and written English).

6. Candidature – Expression of Interest

Candidature is open to all companies participating either individually or in a grouping (consortium) which is established in an ITER Member State. A consortium may be a permanent, legally-established grouping or a grouping, which has been constituted informally -- but formalized with engagement letters -- 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 consortia shall be presented at the pre-qualification stage, where they will be assessed as a whole. Consortia cannot be modified later without the prior approval of the ITER Organization.

7. Timetable for the Tender Process

The tentative schedule for this tender process is as follows:

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<thead>
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<th>Date</th>
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<td>Call for Nomination (C4N)</td>
<td>December 2015</td>
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<tr>
<td>Pre-qualification of Companies</td>
<td>February-March 2016</td>
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<td>Invitation for Call for Tender</td>
<td>April 2016</td>
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<tr>
<td>Tender Submission</td>
<td>May-June 2016</td>
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<tr>
<td>Contract placement</td>
<td>July-August 2016</td>
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<td>First Task Order signature</td>
<td>September-October 2016</td>
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