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Report

55.E6 VSRS - Technical Summary for Design Development Service Contract

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Change Log			
55.E6 VSRS - Technical Summary for Design Development Service Contract (VF32E5)			
Version	***Latest Status***	***Issue Date***	***Description of Change***
v1.0	Signed	26 Sep 2017	
v1.1	Approved	06 Oct 2017	Added quality assurance requirements

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1 Purpose

The purpose of this Contract is to provide engineering and design development of the 55.E6 Visible Spectroscopy Reference System (VSRS) diagnostic up to the closure of the Final Design Review. The 55.E6 VSRS diagnostic is an optical diagnostic fully within the scope of IO and is needed (partly) for operation from the First Plasma phase onwards.

2 Background

A key objective of ITER is to demonstrate a power multiplication of Q=10 i.e. to generate 10 times more power from fusion reactions than required to heat the plasma, for extended periods of time ~ 400 s. ITER will be the first magnetic fusion device to be licensed as a nuclear facility (INB-174, see section 10). Diagnostic systems are critical for the successful operation of ITER. They provide the means to observe, control, and sustain the plasma performance over long timescales.

One such diagnostic is the Visible Spectroscopy Reference System (VSRS), which has been allocated the Plant Breakdown Structure (PBS) no. 55.E6. The primary role of this diagnostic is to measure the continuum visible light emitted by the ITER plasma, which provides information on the impurity content of the plasma and the potential 'transparency' for neutral beam heating power (hence providing a warning for potential heating beam shine through that could damage the ITER walls). This measurement of the continuum visible light is a basic control requirement, without which the ITER device is not allowed to operate. As a result the VSRS design shall focus on reliability and robustness.

A second role covers the analysis of impurity line emission also present in the visible part of the emitted spectrum to provide more advanced insight in the plasma properties and behaviour. This implies that, in addition to the robust continuum measurement, dedicated optical analysis instrumentation needs to be foreseen.

A Conceptual Design Review (CDR) for the VSRS diagnostic was held on 20-21 July 2017. Figure 2-1 gives a schematic overview of the VSRS conceptual design. It has front-end optical components in equatorial port 8 (EP8 in the tokamak building B11) and back-end instrumentation in the diagnostic building (room B74-L1-09). The collected light is transported from EP8 to the diagnostic building using an optical fibre bundle. The Design Description Document (DDD) gives a complete overview [1].

After conceptual design, the ITER design process foresees 2 more design development phases (before moving to the manufacturing phase) with a review at the end of each phase to verify the maturity of the design: a preliminary phase and review (PDR) and a final design phase and review (FDR).

The VSRS diagnostic shall be partially operational at ITER 1st plasma operational phase planned to start in 2025 and will be upgraded for the 2nd plasma phase. To be in line with this staged approach 2 PDRs are foreseen: one for components needed for 1st plasma operation and one for components needed for 2nd plasma operation. Because some 1st plasma components – specifically the optical fibre bundles and cables – need to be installed in the building early on, there are three FDRs foreseen: one for optical fibre bundles and cables, a second for the other 1st plasma components and a third for the 2nd plasma components. The timeline for these PDRs and FDRs is indicated in Figure 2-2. This service contract covers the scope up to closure of the last FDR.

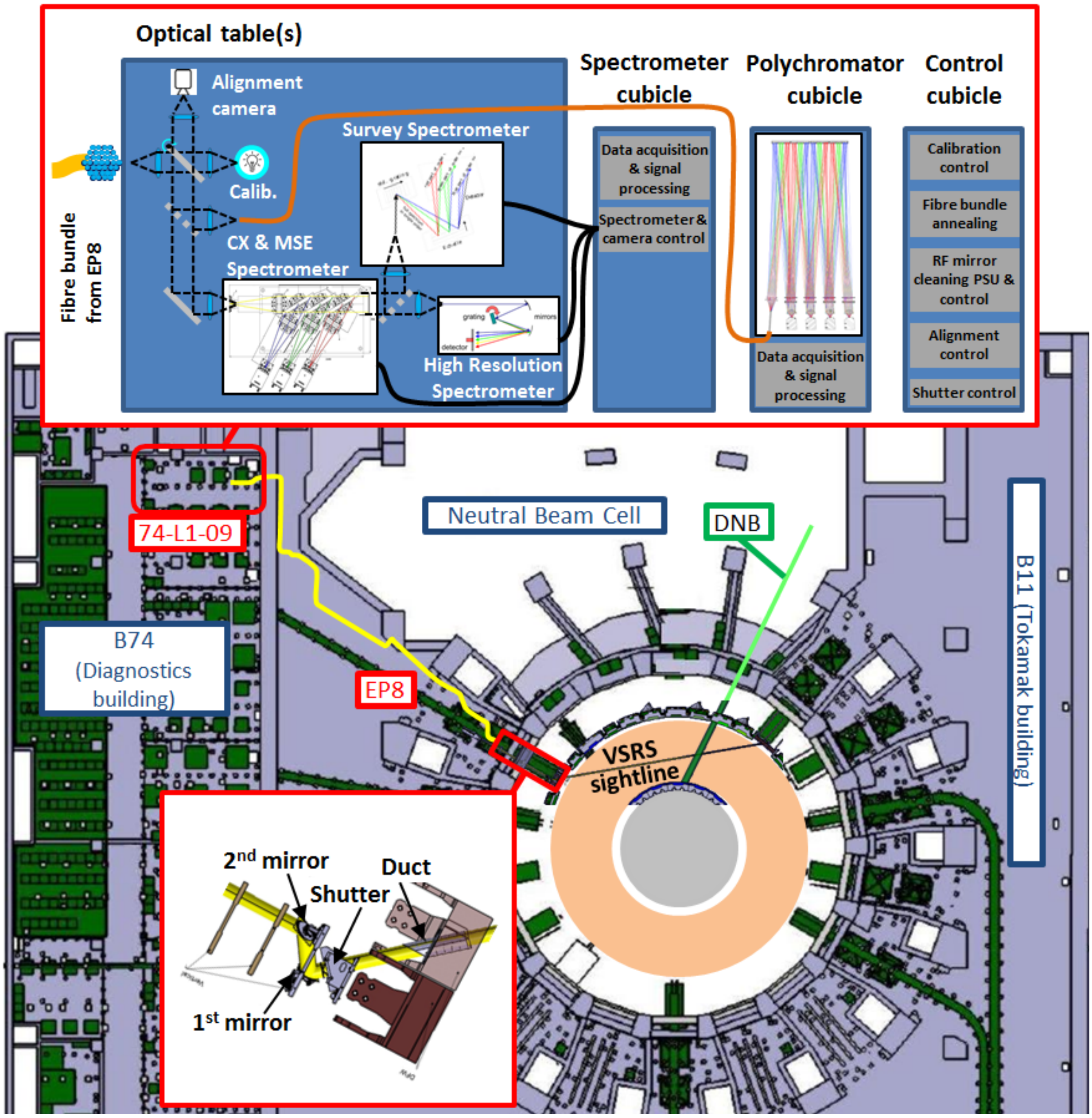

Figure 2-1: Schematic overview of the 55.E6 VSRS conceptual design

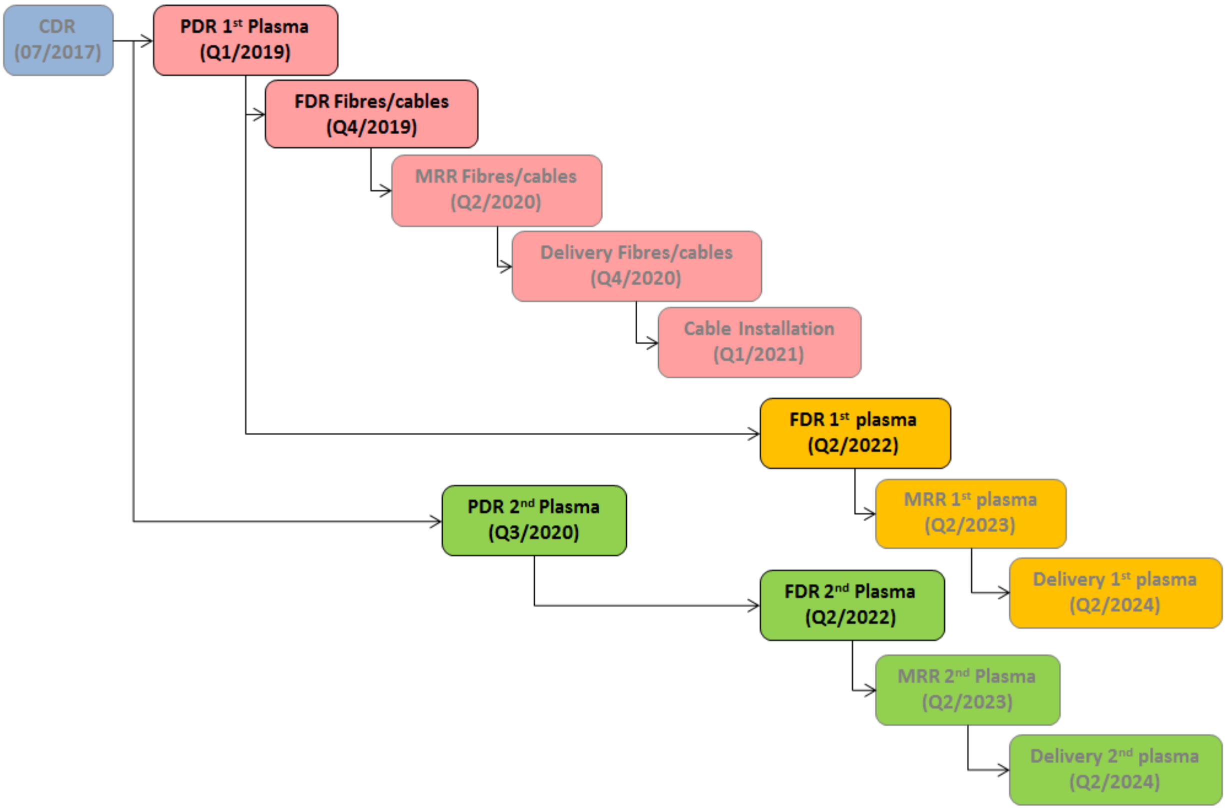

Figure 2-2: Schedule of high level milestones for the 55.E6 VSRS diagnostic. The greyed-out milestones are not in the scope of the service contract discussed.

3 References

[1] System Design Description (DDD) 55.E6 Visible Spectroscopy Reference System (VSRS) (UJ2J2Z v1.0)

[2] Order dated 7 February 2012 relating to the general technical regulations applicable to INB - EN (ITER_D_7M2YKF)

[3] ITER Procurement Quality Requirements (ITER_D_22MFG4).

[4] Procurement Requirements for Producing a Quality Plan (ITER_D_22MFMW)

[5] Quality Assurance for ITER Safety Codes (ITER_D_258LKL)

4 Scope of work

The scope of the development services requires that the Contractor provides specialized engineering design capabilities, in the field of optical design, mechanical design, vacuum compatible design, electrical design (incl. DC up to radio-frequency ~MHz) and – to a limited extend – I&C design. Furthermore the scope of this contract includes (finite element) analyses tasks, optical and measurement performance analyses, prototype manufacturing and testing.

The contract will be set up as a service contract consisting of various needed activities. This is sketched in Figure 4-1. Note that Figure 4-1 is a simplified sketch used for illustration purposes only: it does not show all activities, nor does it represent an accurate timeline. The activities fall in 4 groups:

1. One master activity to coordinate the (system level) design development throughout the full contract.
2. Optical and mechanical design activities as well as analysis, prototyping and testing activities that fall under the scope of this contract.

3. RAMI analysis (Reliability, Availability, Maintainability and Inspectability) and physics modelling and analysis that are optional activities that could be provided within the scope of this contract, but that are not mandatory.
4. R&D activities on mirror cleaning and shutters as well as I&C design activities that are outside the scope of this contract, because they are already covered in existing contracts between IO and third parties. Communication with the partners carrying out these out of scope activities will, however, be required.

The different activities are discussed more detail in the subsections below.

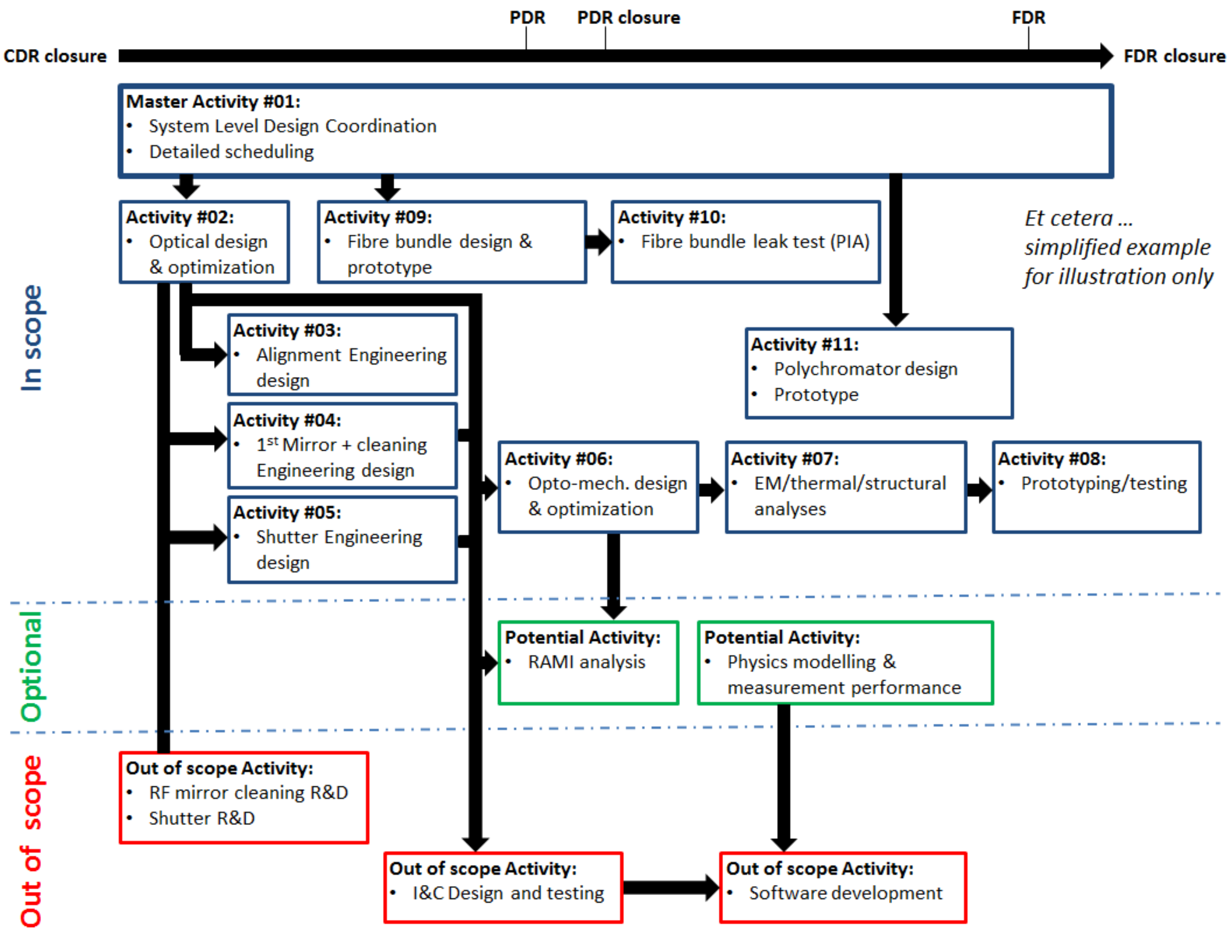

Figure 4-1: Sketch of the structuring of the contract work in multiple activities. For illustration purposes only.

4.1 System Level Design activity

This activity will define the overall design development path, including all aspects: optical, mechanical, electrical, (high-level) I&C, analyses, prototypes and testing.

It also includes support in the definition and freezing of interfaces of the 55.E6 VSRS diagnostic with other plant systems on ITER (e.g. space reservations & floor loads, power/gas/water/compressed air needs, et cetera).

The work within this activity also includes supporting the coordination and follow-up of the activities that are out of the scope of this service contract (I&C development and R&D on mirror cleaning and shutters) but relevant to the VSRS design development.

Given the nature of this activity it would run for the full duration of the service contract.

This work requires on-site presence of the contractor who will work in close collaboration with the IO-TRO.

The main deliverables would be:

- Proposal and subsequent updates of the design development plan, which shall identify and describe in detail the different required activities, their scope, scheduling and outcomes.
- Updates of the top level documentation such as the System Design Description Document (DDD), the Documentation Production Plan (DPP) updates and the Input Packages for the different design reviews.

4.2 Activities as part of the 1st plasma preliminary design

The activities required for the preliminary design of the 1st plasma components are:

Port cell optical design: Allowing imaging either the light coming from the plasma through a vacuum window installed on the vacuum vessel or the light of a calibration light source.

Improvement of the CDR level optical design

Optical tolerance analysis (movement building vs. vacuum vessel)

Opto-mechanical design of (motorized) supports

Alignment system design: Positioning the fibre bundle termination on the image plane of the optical system.

Electro-mechanical design (supports and controlled motion)

In radiation environment

Calibration source design: Calibrated light source (coupled to optical system)

Definition of required specifications (power, wavelengths)

Opto-mechanical & opto-electronical (calibrated detection) design

In radiation environment

Port cell Load Spec. & Analyses: Detailed definition of loads (seismic, thermal, electromagnetic…) on the optical, alignment and calibration systems (all 3 located in the port cell area of EP8).

Thermal, electro-magnetic and structural analysis of the optical, alignment and calibration systems (deformations and failure modes).

To ensure proper functioning during normal operation and after minor incidents (level II or III)

To ensure non-aggression to (nuclear safety) protection important components (PIC) in all accidental (load) conditions.

Optical fibre bundle design: Optical fibre specifications (optical, radiation hardness, diameter …)

Leak tight, protective sleeve/tube (corrugated stainless steel)

Leak tight sealing of terminations

Protection Important Component – PIC (see section 10)

(first part) In radiation environment.

Fibre Load Spec. & testing:	Detailed definition of loads (seismic, thermal, fire, pipe whipping …) on the optical fibre bundle. Prototype manufacturing and leak test (worst case ⇔ fully open at one end) Protection Important Activity – PIA (see section 10).
Optical instruments design:	Optical layout for the optical benches in the diagnostic building. Technical specifications for commercial-off-the-shelf (COTS) optical components (e.g. spectrometers). Design of optical filter based polychromator that can be mounted in a standard 19” rack.
Diagnostic room Load Spec. & Analyses:	Detailed definition of loads (seismic, thermal, …) on the optical benches and cubicles in the diagnostic building (and on the components installed on/in those). Thermal and structural analysis to ensure proper functioning during normal operation and after minor incidents (level II or III) and non-aggression to (nuclear safety) protection important components (PIC) in all accidental conditions.
Cabling design:	Definition of electrical cables installed in the cable trays running from the port cell area of EP8 to the diagnostic building (i.e. cables needed to operate alignment, calibration, shutter, mirror cleaning and – potentially – heating of 1st part of the fibre bundle)
Documentation production:	Preparation of technical documentation related to the 1st plasma components in line with the documentation production plan (DPP)
Closure of PDR chits:	Responding to comments and actions raised at the PDR.

The technical specification that will be provided as part of the call for tender of this contract will provide a detailed description of the requirements for each activity.

4.3 Activities as part of the optical fibre bundle & cables final design

The activities required for the preliminary design of the 1st plasma components are:

Optical fibre bundle design:	Finalizing design of the optical fibre bundle Protection Important Component – PIC (see section 10).
Fibre Load Spec. & testing:	Updated definition of loads (seismic, thermal, fire, pipe whipping …) on the optical fibre bundle (if needed). Leak and performance test of prototype fibre bundle under all defined load conditions Protection Important Activity – PIA (see section 10).
Cabling design:	Finalizing definition of all electrical cables installed in the cable trays running from the port cell area of EP8 to the diagnostic building (i.e. cables needed to operate alignment, calibration, shutter, mirror cleaning and – potentially – heating of 1st part of the fibre bundle)
Documentation production:	Finalization of technical documentation related to cabling and fibre bundle in line with the documentation production plan (DPP).
Closure of FDR chits:	Responding to comments and actions raised at the FDR.

The technical specification that will be provided as part of the call for tender of this contract will provide a detailed description of the requirements for each activity.

4.4 Activities as part of the 2nd plasma preliminary design

The main activities required for the preliminary design of the 2nd plasma components are:

Optical duct design:	Erosion resistant, blackened component located at optical aperture close to plasma, aimed at reducing particle flux to first mirror and stray light. Mechanical design In vacuum, in radiation environment Remote Handling maintenance
Shutter Design:	Aimed at protecting first mirror when the VSRS diagnostic is not in use, by closing off the aperture towards the plasma. Second role for transmission calibration by back-reflection of calibrated light of the back of the closed shutter blades. (Electro-)mechanical design Motion in vacuum, in radiation environment Remote handling maintenance.
First mirror design:	First in-vacuum (flat) mirror, with integrated Radio-Frequency (RF) plasma discharge system for cleaning of deposits on the mirror surface. Opto-mechanical design and RF engineering In vacuum and in radiation environment Remote Handling maintenance
Second mirror design:	Second (flat) mirror Opto-mechanical design In vacuum and in radiation environment Remote Handling maintenance
In-vacuum Load Spec. & Analyses:	Detailed definition of the loads (seismic, thermal, electromagnetic …) on the in-vacuum components (all 3 located inside the port plug of EP8). Thermal and structural analysis of the in-vacuum components (deformations and failure modes). To ensure proper functioning during normal operation and after minor incidents (level II or III) To ensure non-aggression to (nuclear safety) protection important components (PIC) in all accidental conditions.
Front-end optical design: & analyses:	Full optical path from plasma, through in-vacuum optics and port cell optics to coupling into fibre bundle at image plane. Allowing imaging either the light coming from the plasma or the light of a calibration light source. Port cell optical system shall re-use as much as possible the optical design for 1st plasma operation (to increase efficiency and lower cost).

	Optical tolerance analysis with respect to vacuum vessel motion (thermal expansion, vibrations …) and (thermal) deformation of the 1st and 2nd mirrors in vacuum.
	Opto-mechanical design of (motorized) supports
RF mirror cleaning Back-end design:	Design or definition of technical specifications for RF power supply, matching unit(s) and transmission lines
	RF engineering
Documentation production:	Finalization of technical documentation related to 2nd plasma components in line with the documentation production plan (DPP).
Closure of PDR chits:	Responding to comments and actions raised at the PDR.

The technical specification that will be provided as part of the call for tender of this contract will provide a detailed description of the requirements for each activity.

To increase efficiency and reduce cost the ex-vacuum components (with the potential exception of the port cell optical system) used for 1st plasma operation shall be designed such that they can be used for 2nd plasma operation as well.

However, (minor) updates could be necessary, leading to following potential additional activities:

- Update of the alignment system designed for 1st plasma operation.
- Update of the calibration light source designed for 1st plasma operation.
- Update of the (detailed) loads (seismic, thermal, electromagnetic …) on the optical, alignment and calibration systems (all 3 located in the port cell area of EP8).
- Update of the thermal and structural analysis of the optical, alignment and calibration systems.
- Update of the technical documentation related to the 1st plasma components.

4.5 Activities as part of the 1st and 2nd plasma final designs

The activities related to the final design of both 1st and 2nd plasma components consist of a finalization of the activities already defined for the preliminary design phases. This includes further detailing the designs up to a maturity that is ready for manufacturing or (off-the-shelf) procurement, update of loads and load analysis and update of the technical documentation.

Addition activities include the manufacturing and testing of critical prototypes and mock-ups such as:

- The 1st and 2nd mirror for structural (‘shaker table’) testing
- 1st mirror for RF mirror cleaning testing
- Shutter for in-vacuum motion testing
- Alignment system (testing a room temperature and operating (~100C) temperature)
- Calibration system
- Filter-based polychromator

The exact definition of the activities needed (including which prototypes/mock-ups are needed) for the final design phases will be defined at the closure of the PDRs.

4.6 Optional activities

The RAMI analysis is needed as part of the VSRS design development but is currently not foreseen as a required activity in the scope of this service contract. However, if supplier can provide the necessary expertise to perform RAMI analyses, it can be mentioned in the application for information.

Physics modelling, data analysis and measurement performance analysis (up to the physics parameter) is needed as part of the VSRS design development but is currently not foreseen as a required activity in the scope of this service contract. However, if supplier can provide the necessary expertise, it can be mentioned in the application for information.

Pre-qualification will NOT consider the expertise for these optional activities.

5 Experience

Successful implementation of the VSRS diagnostic design development requires a wide range of engineering expertise, a summary of which is given below:

- System level engineering expertise, as well as expertise in (optical) diagnostic development
- Optical engineering expertise for optical design (front-end optics and back-end analysis stations and polychromator)
- Electrical/Electromechanical engineering expertise for the shutter, alignment and calibration designs
- Radio-frequency engineering expertise for the 1st mirror cleaning design
- (Opto.-)Mechanical engineering expertise for the front end (in-vacuum and port interspace) equipment and supports design
- Vacuum equipment engineering experience for in-vacuum components
- Experience with radiation hard design for in-vacuum, port interspace and port cell components
- Experience in Remote Handling (RH) compatible design for the in-vacuum components
- Electro-Magnetic, Thermal and Structural modelling experience for the different required (finite element) analyses
- Optical and measurement performance analyses
- Experience in manufacturing prototypes of opto.- and electro-mechanical components.
- Experience in structural, vacuum and functional testing of opto.- and electro-mechanical prototypes
- Additional expertise that would benefit the execution of the work would be:
- Experience in physics modelling of plasma continuum and line emission
- Experience in RAMI (Reliability, Availability, Manufacturability and Inspectability) modelling

6 Duration of services

As mentioned above the scope of the contract goes up to the closure of the latest final design review.

In the top-level schedule for the VSRS diagnostic development given in Figure 2-2 indicates the latest FDRs in the second quarter of 2022 (closure in 3rd quarter). With the expected start date of this contract in the second/third quarter of 2018 (see section 8) the contract is expected to be carried out over a period of four (4) years.

7 Location of the services

The System Level Design activity requires presence of the contractor on-site for the duration of the contract.

For all other activities off-site engineering expertise is anticipated, supported by on-site engineering when considered necessary given the specific requirements of the activity in question.

8 Timetable

The tentative timetable for the tender phase is as follows:

Description	Date
Call for Nomination	October 2017
Pre-qualification	November 2017
Call for Tender	January 2018
Indicative Award Date	May 2018
Indicative Contract Signature	June 2018
Indicative Contract Start Date	July 2018

9 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 cannot be modified later without the approval of the ITER Organization.

Legal entities belonging to the same legal grouping are allowed to participate separately if they are able to demonstrate independent technical and financial capacities. Bidders' (individual or consortium) must comply with the selection criteria. IO reserves the right to disregard duplicated references and may exclude such legal entities form the tender procedure.

Further information on the ITER Organization procurement can be found at:

http://www.iter.org/org/team/adm/proc/overview

10 Safety requirements

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

For Protection Important Components (PIC) and in particular Safety Important Class components (SIC, a subset of PIC) and for Protection Important Activities (PIA), 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 [2].

11 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) [3].

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) [4]).

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) [5].