
TECHNICAL NOTE RELATED TO THE MARKET SURVEY ON THE EC UPPER LAUNCHER PLUG AND EX-VESSEL WAVEGUIDE SYSTEMS

Abstract

The experimental fusion reactor ITER will require 4 Upper Launchers and 1 Equatorial Launcher for the injection of the Electron Cyclotron mm-waves into the plasma for plasma breakdown, heating, current drive and control of instabilities. The system is in a preliminary and final design phase depending on the components. A Call for Tenders for the finalization of the design, manufacture, assembly, test and delivery to ITER of the Upper Launcher plugs and ex-vessel waveguide systems for the Upper and Equatorial plugs will be launched in 2020. The report outlines the scope, design as well as its procurement schedule and strategy.

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1 ACRONYMS

BSM	Blanket Shield Module
BtP	Build to Print
CDR	Conceptual Design Review
CPSP	Closure Plate Sub-Plate
DD	Detail Design
DWU	Diamond Window Unit
EC	Electron Cyclotron
ECH	Electron Cyclotron Heating
EL	Equatorial Launcher
EW	Ex-Vessel
F4E	Fusion For Energy
FAT	Factory Acceptance Tests
FDR	Final Design Review
H&CD	Heating & Current Drive
HIP	Hot Isotactic Pressure
IO	ITER Organization
IV	Intermediate Voltage
M1	Mirror 1
M2	Mirror 2
M3	Mirror 3
M4	Mirror 4
MB	Miter Bends
MBMB	Mono-block Miter Bends
MRR	Manufacturing Readiness Review
N	No
NGT	Narrow Gap TIG
NTMs	Neo-classical tearing mode
ORR	Operation Readiness Review
PDR	Preliminary Design Review
PHTS	Primary Heat Transfer Systems
PIC	Protection Important Component
PP	Port Plug
PPTF	Port Plug Test Facility
QA	Quality Assurance

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QC1	Quality Classification 1
R&D	Research & Development
RCC-MR	Regles de Conception et de Construction des Matériels mécaniques des ilots nucléaires RNR, applicables aux structures a haute température (Design and construction code retained for the Vacuum Vessel)
RF	Radio Frequency
RH	Remote Handling
SC1	Seismic Class 1
SC2	Seismic Class 2
SDC	ITER SDC (Structural Design Criteria/Code)
SF	Structural stability and required functional seismic safety performance
SIC	Safety Important Class
SIC1	Safety Important Class 1
TC1A	Tritium Classification 1A
TLs	Transmission Lines
TRR	Test Readiness Review
UHV	Ultra High Vacuum
UL	Upper Launcher
VQC1A	Vacuum Quality Class 1A
VV	Vacuum Vessel
WBS	Work Breakdown Structure
WG	Wave Guides
Y	Yes

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2 INTRODUCTION TO THE EC AND EC UPPER LAUNCHER SYSTEMS

In application of the ITER agreement, article 14, ITER follows the French Regulation for Nuclear safety. Because of its inventory in nuclear materials, ITER has been classified in France as a nuclear facility "Installation Nucléaire de Base" and in particular numbered as INB no.174 per the French Decree No. 2012-1248 dated 9 November 2012 authorizing IO to create a basic nuclear facility called "ITER". IO, the Nuclear Operator, as well as its external interveners must comply with the French Order of 7th February 2012 establishing the general rules for licensed nuclear installations (INB Order).

2.1 THE EC SYSTEM

The Electron Cyclotron Heating and Current Drive system (EC H&CD, or in short, EC) shall provide microwave heating and current drive to the ITER plasmas. A total of 20 MW of microwaves power at the frequency of 170 GHz in plasma will be initially available from the system.

The EC system is housed in three buildings: the RF (Building 15), the Assembly (Building 13) and the Tokamak (Building 11), see Figure 2.1. The microwave power from the gyrotrons is transmitted to launchers for injection into the Tokamak via 24 TLs.

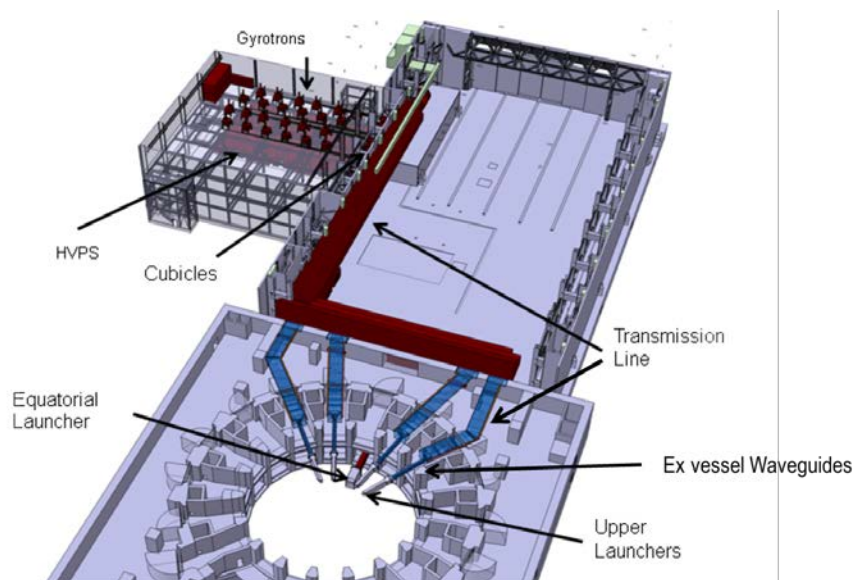


Figure 2.1 EC system layout

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The TLs connect to the ex-vessel waveguides (EW) linked to the launchers, which steer the microwave beams across the plasma cross section. Upper launchers (UL) are located in Ports 12, 13, 15, and 16. The equatorial launcher (EL) is located in Port 14. Power can be delivered from each gyrotron to one of the upper launchers or to the equatorial launcher at any time during the plasma discharge.

The scope of this procurement comprises:

- 4 Upper Launchers
- Ex-vessel waveguides system associated to each of the 4 upper launchers (8 lines each) and 1 equatorial launcher (24 lines)

2.2 THE EC UPPER LAUNCHER SYSTEM

The procurement of four Electron Cyclotron Upper Launchers, to be installed in four upper ports of the ITER vacuum vessel, as well as of the ex-vessel components of the Upper Launchers and Equatorial Launcher is part of the in-kind contribution of Europe to the ITER Project. The Upper Launchers and Equatorial Launcher are shown in Figure 2.2:

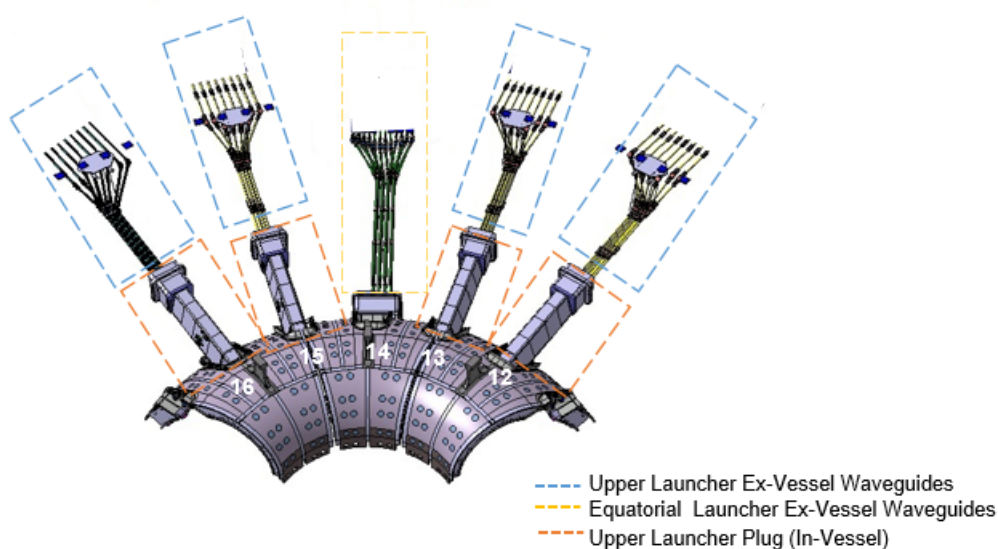


Figure 2.2 The deliverables are the four Upper Launchers and the associated Ex-Vessel waveguides for the Upper and Equatorial Launcher

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The four EC launchers are aimed at providing local current drive to stabilise NTMs and assist in the plasma breakdown and burn though. It also contributes, together with the equatorial launcher, to provide pure heating.

The EC Upper Launcher system is mainly divided into two groups of components:

1. The upper launcher system (UL) includes in-vessel components such as the plug structure, the blanket shield module (BSM) and all internal components: mirrors and steering mechanism, internal waveguides and ancillaries. The in-vessel components are characterised by the fact that it is located in-vessel and therefore does not form part of the first confinement barrier. The primary UL functions are to direct the beams to the appropriate target in the plasma, provide shielding and provide vacuum and nuclear confinement. Note that the back end of the upper launcher plug forms the closure of the vacuum vessel (and therefore part of the first confinement system). The upper launcher system also includes ex-vessel ancillaries such as a pneumatic actuator used for the steering mirrors, cooling pipes, diagnostic feedthrough, etc.

2. The Ex-Vessel waveguides system (EW) is a First Confinement System, located ex-vessel, which starts at the back end structure of the launcher and goes up to the diamond window unit (DWU). The EW is connected to the ITER Vacuum Vessel (VV) and it forms an extension of the torus vacuum and the first confinement barrier. The Ex-Vessel waveguides will connect the transmission lines that comes from the gyrotrons (out of the scope of this contract) to the Upper Port Plug. The waveguides have a circular cross section with the inner surface corrugated and cooled via pipes clamped to the outer surface. The waveguides form a “dog-leg” with the change of direction achieved using Miter Bends mirrors (MB). The diamond windows together with the Isolation Valves form passive and dynamic barriers of the vacuum and tritium confinement barrier between ex-vessel waveguides and the transmission lines.

Both subsystems include ancillaries such as cooling system and instrumentation.

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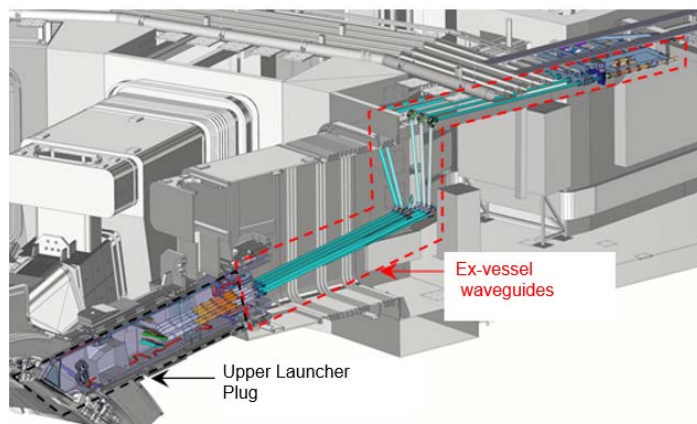


Figure 2.3 Main parts of the EC Upper Launcher system: the Upper Launcher plug and the Ex-Vessel waveguides.

2.3 DESIGN MATURITY OF THE SYSTEM

The design maturity of the system is classified in 3 main levels: Conceptual, Preliminary and Final design. Once the required maturity of each level is achieved, a System Design Review is organized in order to evaluate it (Conceptual Design Review (CDR), a Preliminary design review (PDR) and a Final Design Review (FDR)). Figure 2.4 illustrates the complete cycle of design reviews:

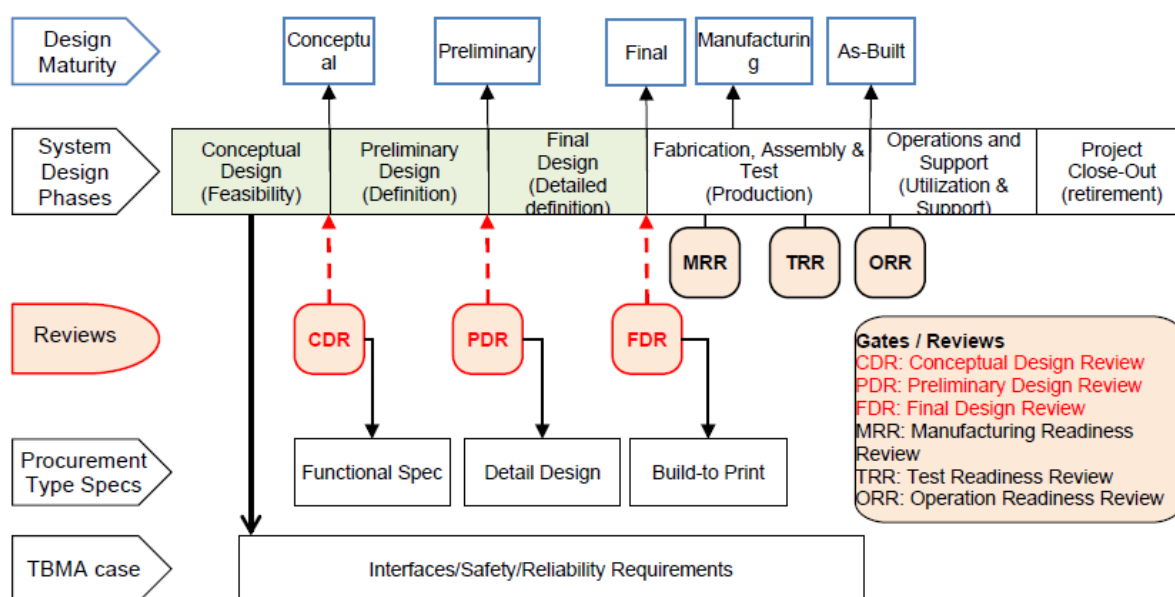


Figure 2.4 Cycle of design reviews

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Some components already have passed a Final Design Review (FDR) and are in preparation of Build-to Print (BtP) specifications, whereas some others are on the Detail Design (DD) phase, with their FDR yet pending. At the Final Design Review, the ITER Organization provides the agreement to the Domestic Agency (F4E in this case) to start the components manufacturing phase, after closure of the components design review process and resolution of any critical issues.

The components that have already passed the FDR and are at the BtP level are:

- Electron Cyclotron Heating (ECH) Upper Launcher port plug including back-end (PIC), which consists on a stainless steel body made of 4 different welded modules. The module 1 (or backend) is equipped with the main flange that provides its fixation to the vacuum vessel providing sealing for the primary vacuum
- Primary Heat Transfer System (PHTS), which is a cooling system limited to the pipes that connect the port plug with the main cooling arrangement, as shown in Figure 2.5. It is used to maintain the optimal temperature of the upper launcher by removing the heat generated during operation due to nuclear heating, stray radiation and photon irradiation. It also allows heating of upper launchers during baking cycles.
- Mirrors 1 & Mirrors 2, which are the first set of mirrors as seen by the microwaves in its exit from the in-vessel waveguides.
- Blanket Shield Module (BSM), which provides the plasma-facing surface, protecting the plug internal components.

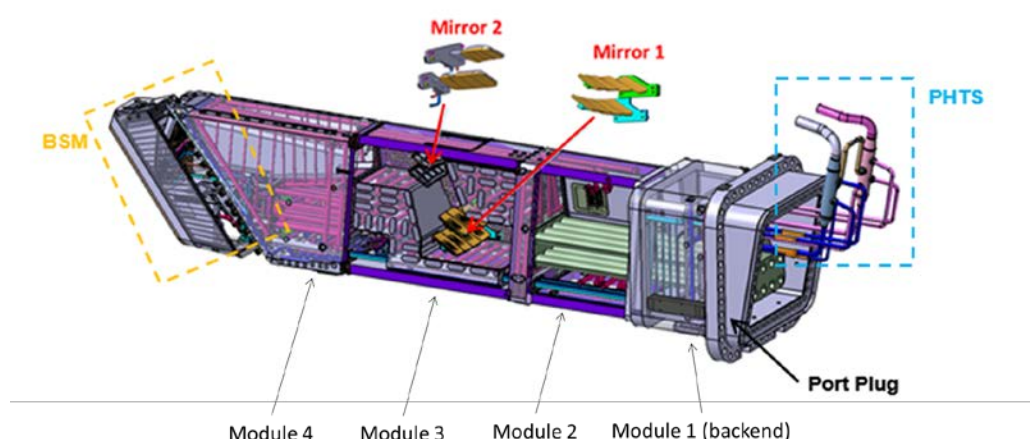


Figure 2.5 Representation of the Upper Launcher plug sub-systems having passed the FDR

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The components that are at the level of Detail Design (DD), with their FDR yet pending, and will need further development (See Figure 2.6), are:

- Ex-vessel waveguides (EW) system, including miter bends, cooling and supports to building.
- In-vessel waveguides system and Closure Plate Sub-Plate (CPSP).
- Mirrors 3 & Mirrors 4
- Upper Launcher diagnostics, cabling and electrical connection
- Electrical Feedthrough
- Diamond Window Unit (DWU)

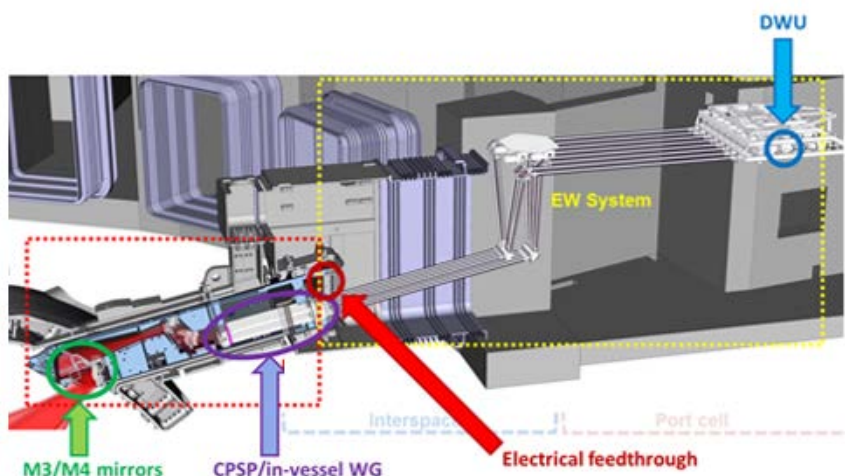


Figure 2.6 Representation of the Upper Launcher plug sub-systems at DD level

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3 SCOPE OF WORK

F4E plans to place a contract with a contractor who will be responsible for the final design, manufacture, assembly, testing and delivery of the EC Upper Launcher Plug and Ex-vessel Waveguide Systems.

Considering different maturity of interfacing systems (see Section 2), the supplier shall act as a technical integrator and manage concurrent manufacture and design of interfacing systems in a coherent manner, ensuring systematic and integrated approach, and overall coordination of the different work packages.

Considering tight schedule for delivery of First Plasma, the supplier is expected to parallelize a substantial amount of both design finalization and manufacture activities, and shall provide the necessary engineering and manufacturing capacity and capabilities to do so.

The activities described below (Contract project management and Quality Assurance according to F4E standards for Quality Class, Safety, Vacuum, Seismic and Pressure classification of defined components, etc.) will be part of the scope of work of the selected supplier.

It is worth to mention that the Isolation Valve is out of the Scope of this contract.

3.1 TENTATIVE WORK BREAKDOWN STRUCTURE

The following list details the activities that must be executed in order to accomplish the project objectives and create the required deliverables:

- Quality and Nuclear Safety management in accordance with contract Management Specification (Annex A to the contract) and nuclear safety regulations applicable to ITER project.
- Finalization of the design and validation (including qualification as appropriate), covering all aspects of product lifecycle, of the EC Upper Launcher and Ex-vessel Waveguides system
- Design and validation (including qualification as appropriate), covering all aspects of product lifecycle, of the Ex-vessel Waveguides system for the Equatorial Launcher
- Environmental and functional qualification activities including testing, analysis and similarity methods
- Preparation of Protection Important Component safety files
- Preparation of documentation for the Final Design Review process according to the F4E procedures
- Preparation of documentation for the Manufacturing Readiness Review process according to the F4E procedures
- Procurement activities for the First Plasma Upper Launcher Plug systems (port #16), which include:
 - Procurement of raw materials and standard components for the First Plasma Upper Launcher

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- Manufacturing and inspection of the Blanket Shield Module, Port Plug and fixed mirrors including auxiliaries
- Manufacturing and inspection of the steering mechanism for the movable mirror including auxiliaries
- Manufacturing and inspection of the in-vessel waveguides (8 lines) including auxiliaries
- Procurement and inspection of the port plug cooling system
- Assembly of the Upper Launcher Plug
- Perform Non-Destructive-Examination
- Procurement, inspection and testing of the cooling system
- Manufacturing and inspection of the Windows including auxiliaries
- Manufacturing and inspection of the ex-vessel waveguides (8 lines) including auxiliaries
- For the procurement of the remaining 3 Plasma Upper Launcher Plug systems (ports #12, #13, #15) with the same scope as for the First Plasma unit (port #16)
- For the procurement of the Ex-Vessel Waveguides for the Equatorial Launcher (24 lines) including auxiliaries (port #14)
- Factory Acceptance testing and related test documentation
- Preparation of a manufacturing dossier including all necessary documentation (welding documentation, material list and certificates, manufacturing and inspection plans, etc.)
- Supply of "as built" 3D model, manufacturing drawings and related QA documentation
- Provide all documentation relating to the components under their supply for compliance with the standard quality requirements including installation, operation and maintenance plans
- Provide the design integration, manufacturing and assembly of all sub-systems and components
- Packing, insurance and transportation to a Test Facility
- Packing, insurance and transportation to ITER in France

3.2 GENERIC DESCRIPTION OF THE HARDWARE

The hardware description will be classified in Upper Launcher and Ex-vessel Waveguides components in the Table 3.1 shown below

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Table 3.1: Hardware Description

UL Sub-System	Nº of units required	Component	Short description
Upper Launcher (Deliver assembled)	4	Port Plug	Support structure of the EC in-vessel system, also provides plasma vacuum confinement
		BSM	Front part of PP which directly faces the plasma
		Electrical Feedthrough	Electrical connections located in the back end of PP to route signals (electrical and optical) from vacuum to air
		Mirrors	M1: fixed, reflects mm-beams from WG to M2 (2 units per plug)
			M2: fixed, reflects mm-beams from M2 to M3 (2 units per plug)
			M3: fixed, reflects and reshapes mm-beams from M3 to M4
			M4: steering mechanism, provides control of the mm-wave injection position into the plasma (2 units per plug)
		Closure Plate Sub-plate	Structure that holds in-vessel WG and provides first confinement
Ex-Vessel waveguides (Assembly excluded)	5	Ancillaries (ex-vessel): Helium System and cooling	Helium actuated system that provides steering of M4 and pipework for cooling the plug (assembly excluded)
		Monitoring Sensors	Various sensors to monitor the EC in-vessel system during ITER plasma operation
		Waveguides sections	Actively cooled and internal corrugated including flanges and connections to cooling and to vacuum monitoring system
		Ceiling Supports	Fixed and sliding
		Cooling Half-Rings	Provides cooling to waveguides flanges area
		Diamond Window Unit	Allows mm-wave propagation while maintaining first confinement barrier
		Miter Bends	Actively cooled waveguides mirrors, redirect the beam inside WG inner space
		Installation frames	Installation and maintenance frames and tooling
		Monitoring systems	Various sensors to monitor the EC ex-vessel system during ITER plasma operation
		Ancillaries (cooling system)	Cooling system to provide active cooling to the different cooled components from the general cooling system. It mainly comprises pipework, valves, manifolds, instrumentation.

The main components mentioned above are shown in Figures 2.5 and 2.6 for better illustration. Furthermore, the number of units to be delivered are four completely assembled Upper Launcher Plugs, as well as five complete packages of ex-vessel waveguides components (not assembled), four for the Upper Launcher Plugs and one for the Equatorial Launcher, as detailed in Figure 2.2.

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3.3 FRAMEWORK CONTRACT IMPLEMENTATION

A possible organization of the work in specific Task Orders within a Framework Contract is as follows:

- TO-1 – Design, MRR, material procurement, manufacturing and assembly of the Upper Launcher Plug Assembly
- TO-2 – Design finalization, qualifications, MRR, material procurement and manufacturing of the Ex-Vessel Waveguides

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4 GENERIC MANUFACTURING AND TECHNICAL REQUIREMENTS FOR THE UPPER LAUNCHER PLUG DESIGN AND MANUFACTURING

4.1 GENERAL REQUIREMENTS

Ex-vessel components			In-Vessel Components		Auxiliaries		
DW Assembly	Miter Bends / Mono-block, Ex-Vessel Waveguides	Ceiling Supports Structure	PP Back-end	PP structure, PP Neutron shields, PP Optical Systems, PP Blanket, Shield Module, In-vessel waveguides	Ex-vessel Cooling circuit (CCWS-1)	In-vessel Cooling circuit (PHTS)	SMA circuit
<ul style="list-style-type: none"> Technical specification * 	<ul style="list-style-type: none"> Applicable requirements from ASME III class 2 NC / RCC-MR 	<ul style="list-style-type: none"> ASME III NF / RCC-MR 	<ul style="list-style-type: none"> RCC-MR 	<p><u>Irradiated Components</u></p> <ul style="list-style-type: none"> ITER SDC-IC EN 13445 and complementary requirements from RCC-MR, according to SDC-IC <p><u>Non-irradiated components</u></p> <ul style="list-style-type: none"> EN 13445 	<ul style="list-style-type: none"> ASME B31.3 ASME B16.5 for flanges ASME B16.34 for valves 	<ul style="list-style-type: none"> ASME B31.3 (Ctg. M1) ASME B16.5 for flanges ASME B16.34 for valves ASME VIII ITER SDC-IC ITER Allowable values and limits in services level C and D 	<ul style="list-style-type: none"> ASME 31.3 ASME B16.5 for flanges ASME B16.34 for valves ASME VIII ITER SDC-IC ITER Allowable values and limits in service level C and D

* According to "Codes and Standard for ITER Mechanical Components"

4.1.1 ITER classification of the EC Upper Launcher Plug and ex-vessel waveguides

The ITER classification of the EC Upper Launcher Plug and ex-vessel waveguides is shown in the following table.

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Table 4.1: ITER classifications of the EC launcher system, note that the highest rating is listed. Some of the individual components may have a lower rating.

Classification	Safety	Quality	Vacuum	Seismic	Tritium	ESP/ ESPN
Upper Launcher Plug (internal components)	Non-SIC	QC1	VQC1A	SC2	TC1A	**
Upper Launcher Plug back end and associated components	PIC-SIC-1	QC1	VQC1A	SC1(SF)	TC1A	**
Ex vessel Waveguides	PIC-SIC-1	QC1	VQC1A	SC1(SF)	TC1A	**

*** See description below*

The definitions of the acronyms shown in the above table are:

- ✓ PIC-SIC-1: Protection Important Components classified as Safety Important Class 1, which are required to bring and maintain ITER in a safe state.
- ✓ Quality Classification, QC1: Items whose failure/malfunction could result in extensive machine downtime.
- ✓ Vacuum Quality Class, VQC1A: Torus primary vacuum components or components that become connected to the torus ultra high vacuum (UVH) through the opening of a valve during normal operations.
- ✓ Seismic Category SC1 (SF): Structural and functional seismic safety performance, this level of requirement guarantees the level of safety as throughout the normal operation of the equipment.
- ✓ Seismic Category, SC2: Non-damage to SC1 equipment; absence of damage to buildings, structures, housing and protecting safety important components, or to buildings that can potentially damage them.
- ✓ Tritium Classification, TC1A: First barrier and associated vacuum jackets and isolation valves (including internal components to a confinement barrier).
- ✓ ESP/ESPN: according to Pressure Equipment Directive (PED 2014/68/EC), Pressure Equipment: French Decree No. 2015/799 dated 1 July 2015 (ITER_D_SK3QKL), Nuclear Pressure Equipment: French order 30th December 2015 (ITER_SMP384) and In service inspection of pressure equipment: Decree n° 2016-1925 of 28 December 2016 (ITER_UD77ER).

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4.2 SPECIFIC REQUIREMENTS

4.2.1 Upper Launcher System

The main assembly of Upper launcher Port Plug System is shown in Figure 4.1:

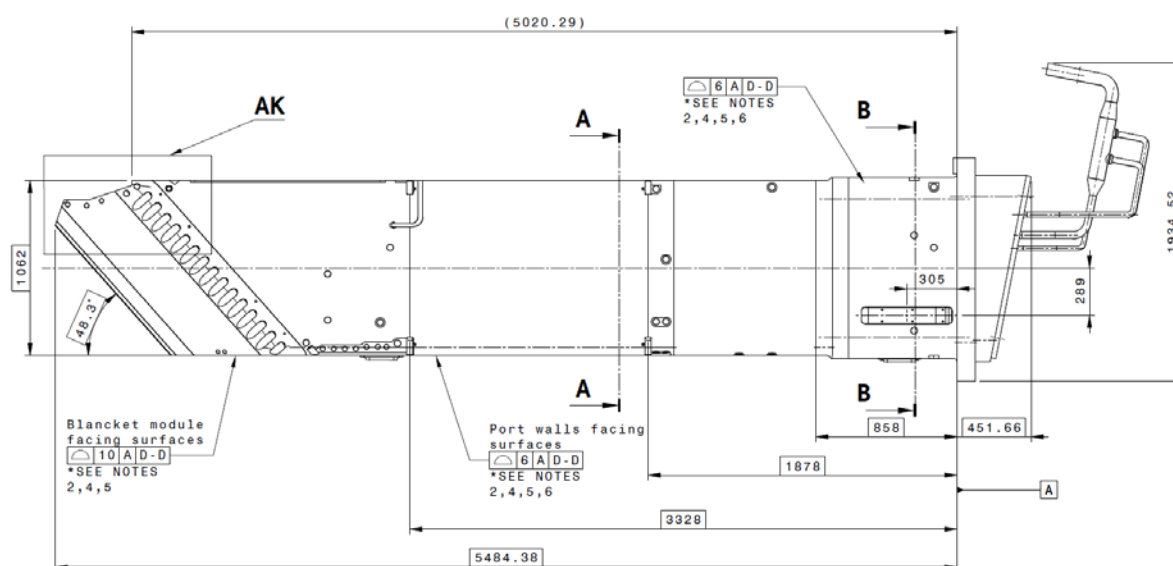


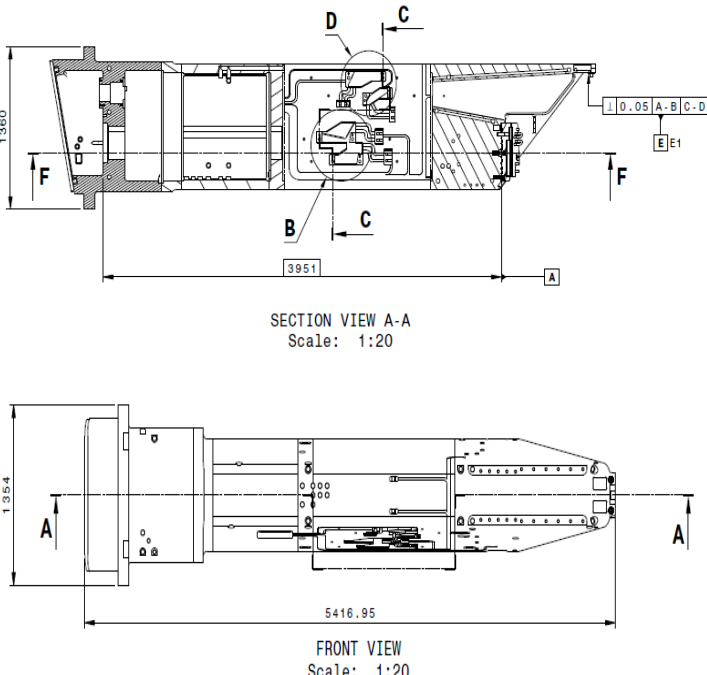
Figure 4.1 Port Plug main assembly drawing

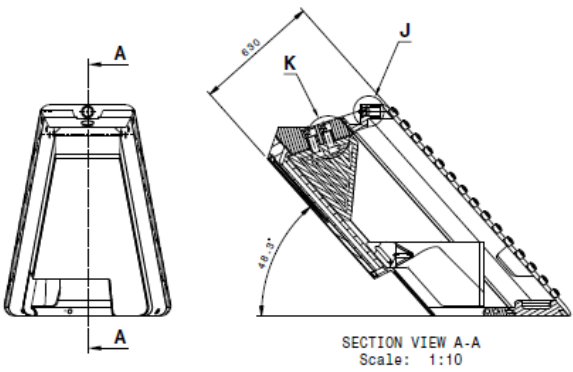
Manufacturing and technical requirements for the BtP components are:

- 316L(N)-ITER grade forgings manufacturing
- Diffusion Bonding of big components (max 1.2 meters)
- Narrow Gap Tig (NGT) welding
- Radiographic and Ultrasonic Testing of welds and forgings
- Machining of big components with fine tolerances
- High precision machining for optical components
- Cleanliness and Ultra High Vacuum (UHV) compatibility for process fluids
- Deep drilling of cooling channels
- Copper Coating, with surface finish of the deposited coating and coating thickness control

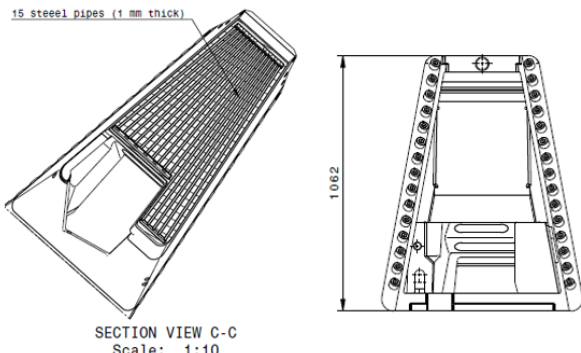
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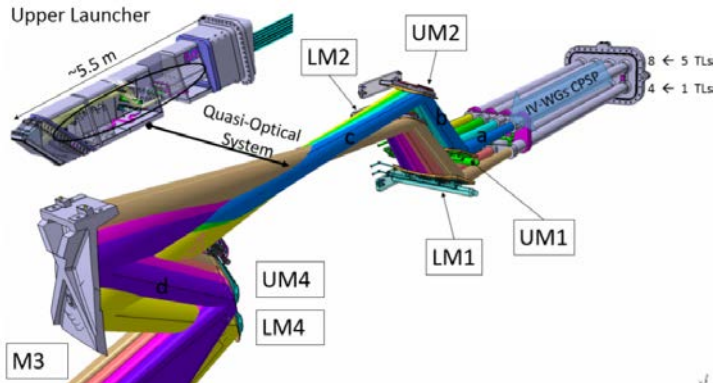
The main components and their most relevant characteristics are explained in the Tables shown below. However, it is important to mention that not all the components are detailed: cooling system, electrical feedthrough, valves, sensors, etc.

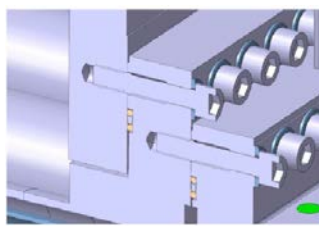
Port Plug		
 <p>SECTION VIEW A-A Scale: 1:20</p> <p>FRONT VIEW Scale: 1:20</p>	Finalization of design (Y/N)	N
	Main materials	316L(N)-ITER grade forgings manufacturing; internal copper coating
	Key technologies	Diffusion Bonding of big components (max 1.2 meters), NGT welding, Radiographic and Ultrasonic Testing of welds and forgings
	Quantity	4
	PIC (Y/N)	Y (PP back-end classified as SIC-1)
	Other relevant aspects	<ul style="list-style-type: none"> Cleanliness and Ultra High Vacuum (UHV) compatibility for process fluids Deep drilling of cooling channels

Blanket Shield Module		
 <p>SECTION VIEW A-A Scale: 1:10</p>	Finalization of design (Y/N)	N
	Main materials	316L(N)-ITER grade and CuCrZr ITER grade forgings manufacturing
	Key technologies	Diffusion Bonding of big components (max 1.2 meters), Radiographic and Ultrasonic Testing of welds and forgings
	Quantity	4
	PIC (Y/N)	N

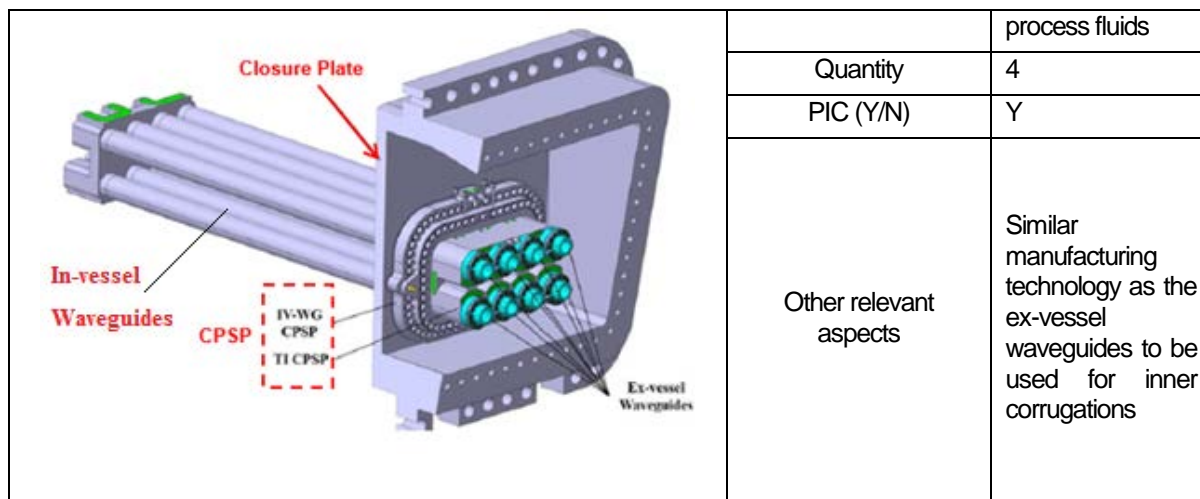
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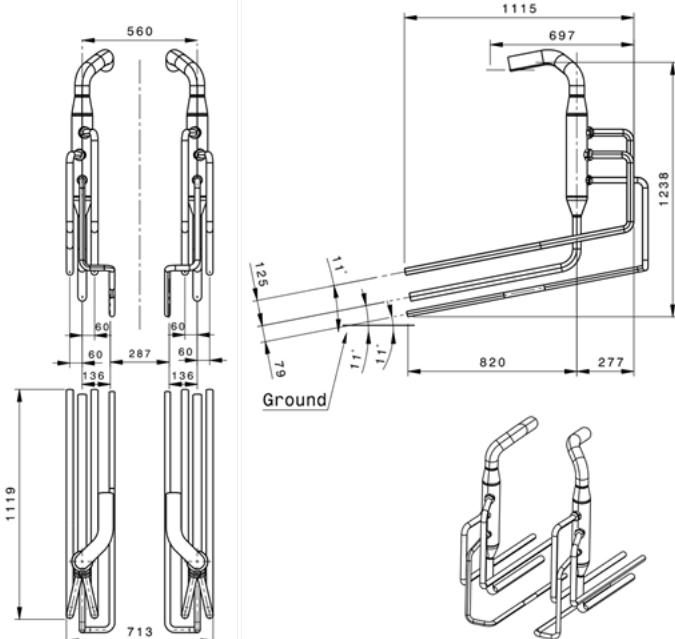
 <p>15 steel pipes (1 mm thick)</p> <p>SECTION VIEW C-C Scale: 1:10</p>	<p>Other relevant aspects</p>	<ul style="list-style-type: none"> Cleanliness and Ultra High Vacuum (UHV) compatibility for process fluids Deep drilling of cooling channels
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Mirrors		
	Finalization of design (Y/N)	Y
	Main materials	316L(N)-ITER grade and CuCrZr ITER grade forgings manufacturing
	Key technologies	Diffusion bonding, optical surfaces precise machining
	Quantity	28
	PIC (Y/N)	N
	Other relevant aspects	<ul style="list-style-type: none"> Copper Coating, with surface finish of the deposited coating and coating thickness control

Closure Plate Sub-Plate and In-vessel waveguides		
	Finalization of design (Y/N)	Y
	Main materials	316L(N)-ITER grade and CuCrZr ITER grade forgings manufacturing
	Key technologies	Deep drilling, corrugation, Cleanliness and Ultra High Vacuum (UHV) compatibility for

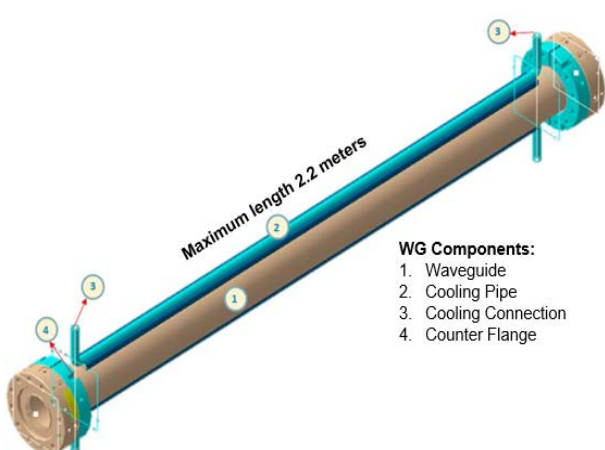
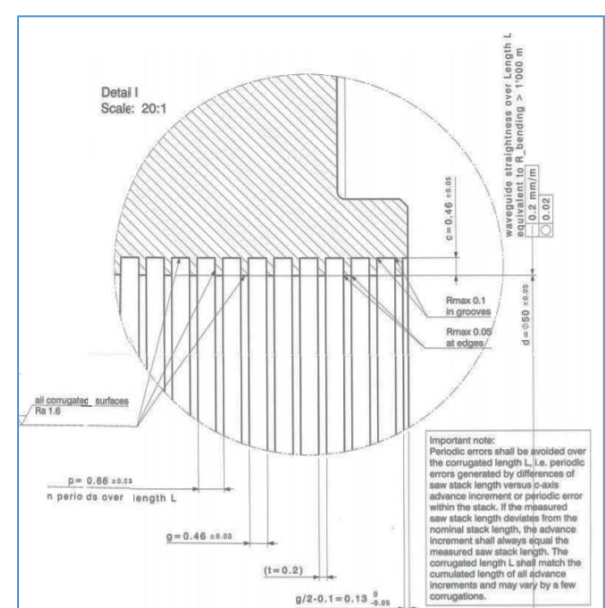
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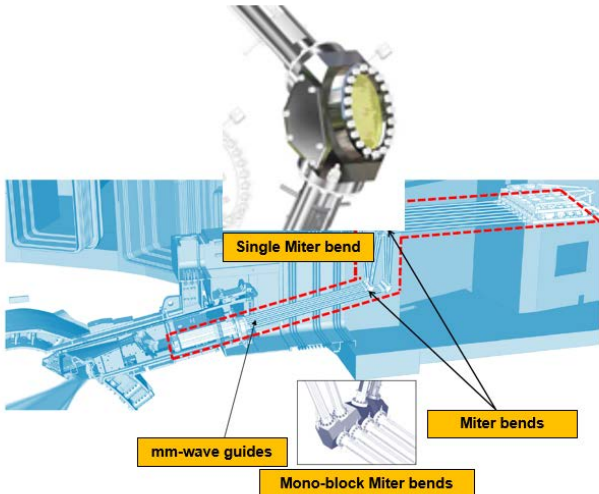
ISC PHTS		
	Finalization of design (Y/N)	Y
	Main materials	316L(N)-ITER grade
	Key technologies	TIG welding, Radiographic and Testing of welds
	Quantity	4
	PIC (Y/N)	Y (classified as SIC-1)
Other relevant aspects	Metrology will need on mm well be placed	

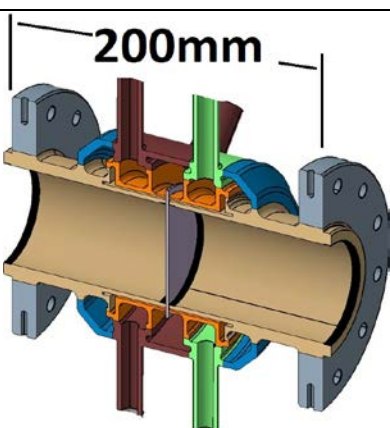
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4.2.2 Ex-VV waveguide system

Waveguides	
 	Finalization of design (Y/N)
	Y
	Main materials
	CuCrZr by forging
	Key technologies
	Deep drilling, internal corrugations (0.46mm grooves in 0.6mm periods), turning and high precision machining, Cleanliness and Ultra High Vacuum (UHV) compatibility
	Some typical tolerances
	+/-0.05mm for corrugations, 0.2mm/m straightness, 0.02mm circularity
	Quantity (m)
	~800 linear meters of 50/66 mm internal/external diameter waveguides
	PIC (Y/N)
	Y
	Other relevant aspects
	<p>All the connections between waveguides are double sealed with monitored interspace. Active water-cooling required for dissipation of internal losses.</p> <p>The ex-vessel waveguide is to be 'aligned' at the torus operating temperature.</p> <p>The waveguide is to be flexible to compensate for tokamak torus displacements of ~50mm in radial and vertical directions.</p>

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Miter Bends		
	Finalization of design (Y/N)	Y
	Main materials	CuCrZr
	Key technologies	High precision machining, corrugation, Cleanliness and Ultra High Vacuum (UHV)
	Quantity of Miter Bend mirrors	112
	PIC (Y/N)	Y
	Other relevant aspects	All the connections between waveguides are double sealed with monitored interspace. Active water-cooling required for dissipation of internal losses.

Window Assemblies		
	Finalization of design (Y/N)	Y
	Main materials	CuCrZr, Cu
	Key technologies	EB welding, NDT of welds, volumetric inspection, leak testing, cleaning
	Typical tolerances	Up to 0.02 mm
	Quantity	60
	PIC (Y/N)	Y
	Other relevant aspects	Diamond disks and its brazing to the Cu Cuffs is provided by F4E

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5 INDICATIVE SCHEDULE

The Figure 5.1 shown below illustrates the tentative time schedule for the Upper Launcher and the Ex-vessel Waveguides for the First Plasma Unit (Port #16).

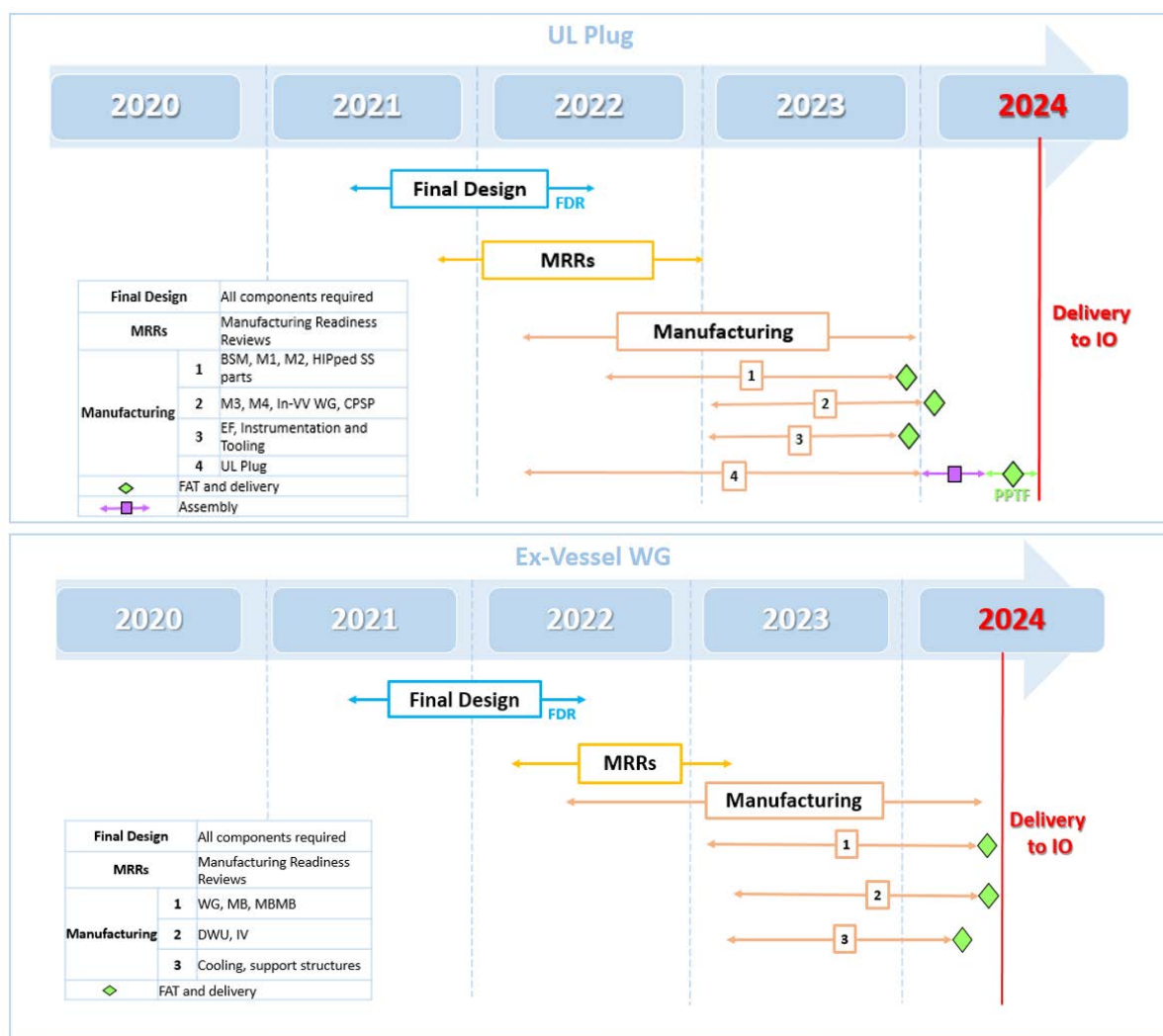


Figure 5.1 Tentative overall time schedule for the Upper Launcher and the Ex-vessel Waveguides for the First Plasma Unit Port #16

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6 SUPPLIER COMPETENCES

The required Supplier competences to perform the activities are illustrated in the following Spider Web figure, and listed below:

- Mechanical Design
- RF/mm-wave physics, design and qualification tests
- Engineering Analysis (Thermal-hydraulics, mechanical, electromagnetic, structural, neutronics)
- Remote handling Analysis
- RAMI analysis
- HIP joining techniques
- Deep machining of WGs and dimensional control (knowledge)
- 3D CAD CATIA/ENOVIA integration
- Built-To-Print & Manufacturing and Inspection Specification
- Systems Engineering
- Managing Sub-contractors
- Quality Assurance
- ITER Environment
- Nuclear Safety
- Design Integration

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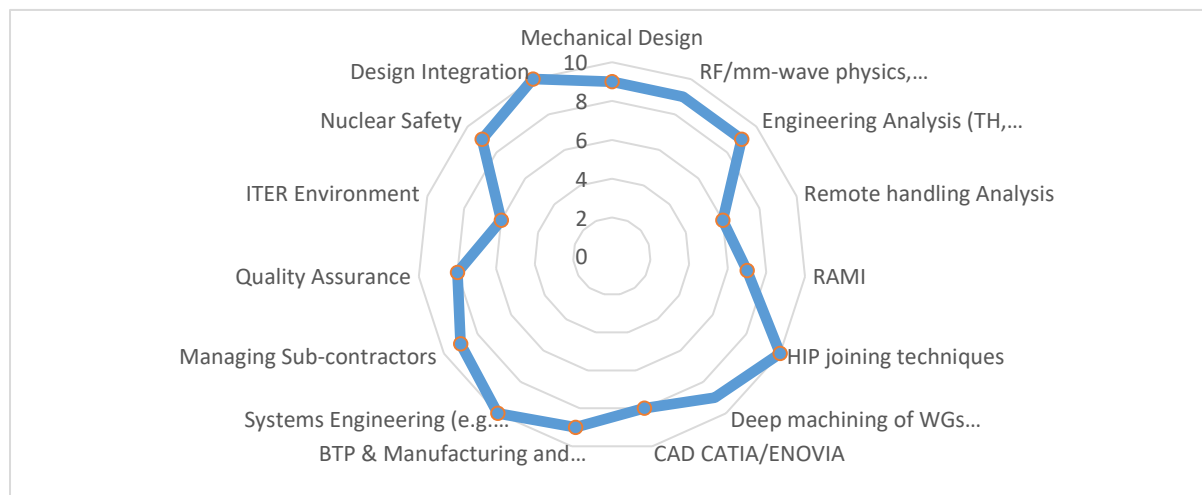


Figure 6.1 Spider web to illustrate the expected required capacities and knowledge required by the Supplier (numbers are qualitative).

Others needed specialized competences are:

- Clean room conditions for compatibility with ITER ultra high vacuum requirements
- Copper coating with controlled layer thickness
- Narrow Gap TIG Welding of austenitic stainless steel

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7 MARKET SURVEY

To establish an optimum contract strategy, F4E needs to develop its understanding of the market with a comprehensive list of possible EU suppliers interested in the Upper Launcher Port Plugs and Ex-vessel Waveguides design and manufacturing.

In the frame of the market survey, interested suppliers are invited to submit information. This information will be visible to F4E and ITER Organization only and will not be communicated to other parties, except if agreed upon by the respondent(s)..

Please answer to the F4E Market Survey. You can access the survey by clicking on this link:

https://es.surveymonkey.com/r/ECUL_EW

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