FUSION FOR ENERGY

The European Joint Undertaking for ITER and the Development of Fusion Energy

THE GOVERNING BOARD

DECISION OF THE GOVERNING BOARD ADOPTING THE PROJECT PLAN (EDITION 2009) OF THE EUROPEAN JOINT UNDERTAKING FOR ITER AND THE DEVELOPMENT OF FUSION ENERGY

THE GOVERNING BOARD:

HAVING REGARD to the Statutes annexed to the Council Decision (Euratom) No 198/2007 of 27 March 2007 establishing the European Joint Undertaking for ITER and the Development of Fusion Energy (hereinafter "Fusion for Energy") and conferring advantages upon it[1] (hereinafter "the Statutes") and in particular Article 6(3)(d) and Article 11 thereof,

HAVING REGARD to the Financial Regulation of Fusion for Energy[2] adopted by the Governing Board on 22nd October 2007, last amended on 18th December 2007[3] (hereinafter "the Financial Regulation"), and in particular Article 30 thereof;

HAVING REGARD to the Resource Estimates Plan adopted by the Governing Board at its meeting of 26th November 2009;

HAVING REGARD to the comments and recommendations of the Executive Committee on the proposal for the Project Plan at its meeting of 4-5th November 2009[4];

HAVING REGARD to the comments and recommendations of the Technical Advisory Panel on the proposal for the Project Plan provided during its meeting of 4th November 2009,

Whereas:

(1) The Director should, in accordance with Article 8(4)(c) of the Statutes, draw up the project plan for a period of five years;

(2) The project plan should include (a) a statement on the aims and activities of the Joint Undertaking for the following five years and (b) a description of the status of the activities and projects of Fusion for Energy containing the necessary information on changes occurred since the previous version;

(3) The Executive Committee should in accordance with Article 7(3)(b) of the Statutes comment on and make recommendations to the Governing Board on the proposal for the Project Plan;

(4) The Governing Board should adopt the project plan.

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1 O.J. L 90, 30.03.2007, p. 58.

2 F4E(07)-GB03-11 Adopted 22/10/2007

3 F4E(07)-GB04-06 Adopted 18/12/2007

4 F4E(09)-EC17-Summary Adopted 05/11/2009

HAS ADOPTED THIS DECISION:

Article 1

The Project Plan (Edition 2009) of Fusion for Energy annexed to this Decision is hereby adopted.

Article 2

This Decision shall have immediate effect.

Done at Barcelona, 27th November 2009

For the Governing Board

Cca FVarandas

Carlos Varandas

Chair of the Governing Board

ANNEX

FUSION FOR ENERGY PROJECT PLAN
(EDITION 2009)

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INTRODUCTION

The European Joint Undertaking for ITER and the Development of Fusion Energy or 'Fusion for Energy' (F4E) was created under the Euratom Treaty by a decision of the Council of the European Union.

F4E was established for a period of 35 years from 19th April 2007 and its offices are situated in Barcelona, Spain. The objectives of F4E are three fold:

- Providing Europe's contribution to the ITER International Fusion Energy Organisation (IO) as the designated EU Domestic Agency for (DA) Euratom;

- Implementing the Broader Approach Agreement between Euratom and Japan as the designated Implementing Agency for Euratom;

- Preparing in the longer term for the construction of demonstration fusion reactors (DEMO).

In accordance with the Financial Regulation of F4E and its Implementing Rules, this Project Plan lays down an indicative programme of activities that are foreseen to be implemented in the following five year period 2009-2018. This information is complemented by the Resource Estimates Plan.

The legal basis and organization of Broader Approach Agreement and the role of F4E in its implementation differ from ITER case. As a consequence the part of F4E for the Broader Approach Agreement activities is presented in a separate section with a format appropriate to the nature of the activities.

All F4E activities presently planned for DEMO are covered under the Broader Approach Agreement and presented in the BA section of the Project Plan.

The detailed planning of F4E activities related to ITER should be considered to be preliminary pending formal agreement on the baseline at ITER Council level.

ITER

OVERALL SCENARIO

At the 4th ITER Council in June 2009, the ITER Organisation and the Domestic Agencies (DAs) including Fusion for Energy (F4E) were asked to study the possibility of implementing a phased scenario for ITER construction, with a first plasma in December 2018 (Scenario-1). It was also agreed that Scenario 1 be used by the DAs as a working basis for the further development of the ITER project baseline.

At its 11th meeting the F4E Governing Board concluded that "the initial timetable set by Scenario-1 as presented is unacceptable for the EU with regard to the timely fabrication of components" on the critical path, namely the Buildings, the Vacuum Vessel (VV) and the Toroidal Field (TF) coils and therefore that adopting "Scenario 1 as presented risks compromising F4E's ability to discharge Euratom's obligations to ITER."

In order to mitigate the costs and risks of Scenario-1 for EU components on the critical path F4E will implement alternative fabrication routes (presented here as Modified Scenario 1[5]). Fig. 1 shows a summary of the EU Procurement Schedule according to Modified Scenario 1.

Modified Scenario 1 is characterized by the following main dates:

Tokamak Building Ready for Equipment (RFE)	June 2015
Delivery Date for first couple of EU TF Coils	April 2015
Delivery Date for first EU Vacuum Vessel Sector	February 2015
Delivery Date for last EU TF Coil	February 2017
Delivery Date for last EU Vacuum Vessel Sector	September 2017

The optimum fabrication routes for the TF coils and VV sectors will be established on the basis of negotiations with the potential industrial contractors and as a result it may be possible to bring forward some of the above-mentioned dates.

The Project Plan has been drawn up according to Modified Scenario-1 with the assumption that the associated Procurement Arrangements (PAs) between F4E and the ITER International Organisation (IO) are concluded on time and according to the agreed level of design.

ITER Credit

Based upon the timetable laid down by Scenario-1, the estimated amount of ITER credit that is foreseen to be awarded to the EU through the signature of PAs between F4E and IO is shown in Fig. 2. Note that this does not include the amount of ITER credit that will be allocated to EU/F4E for Additional Direct Investments (which are to be decided by the ITER Council) as well as ITER Task Agreements (ITAs) and Seconded EU Staff.

In Fig. 3 the indicative credit that is expected to be awarded by IO to F4E according the milestones and deliverables laid down in the PAs is provided. Up to present, no ITER credit has been awarded to F4E pursuant to PAs. However, 8.834 kIUA was awarded by the IO to the EU/F4E during 2008 for staff secondments and ITAs. Note that the information in Figs. 2 and 3 should be updated in the future according to Modified Scenario-1.

Main Milestones

The short- and long-term main milestones that arise from the Modified Scenario-1 are presented in tables 1 and 2 and explained further in the individual detailed descriptions of each Work Breakdown Structure (WBS). A “traffic light” indication of the status of each milestone is provided noting of course that this is a newly established schedule and can only provide a meaningful measure of implementation in the coming year.

[5] Noting that this cannot be considered as a complete scenario for the ITER construction as the implications on the machine assembly and operational schedule have not yet been taken into account.

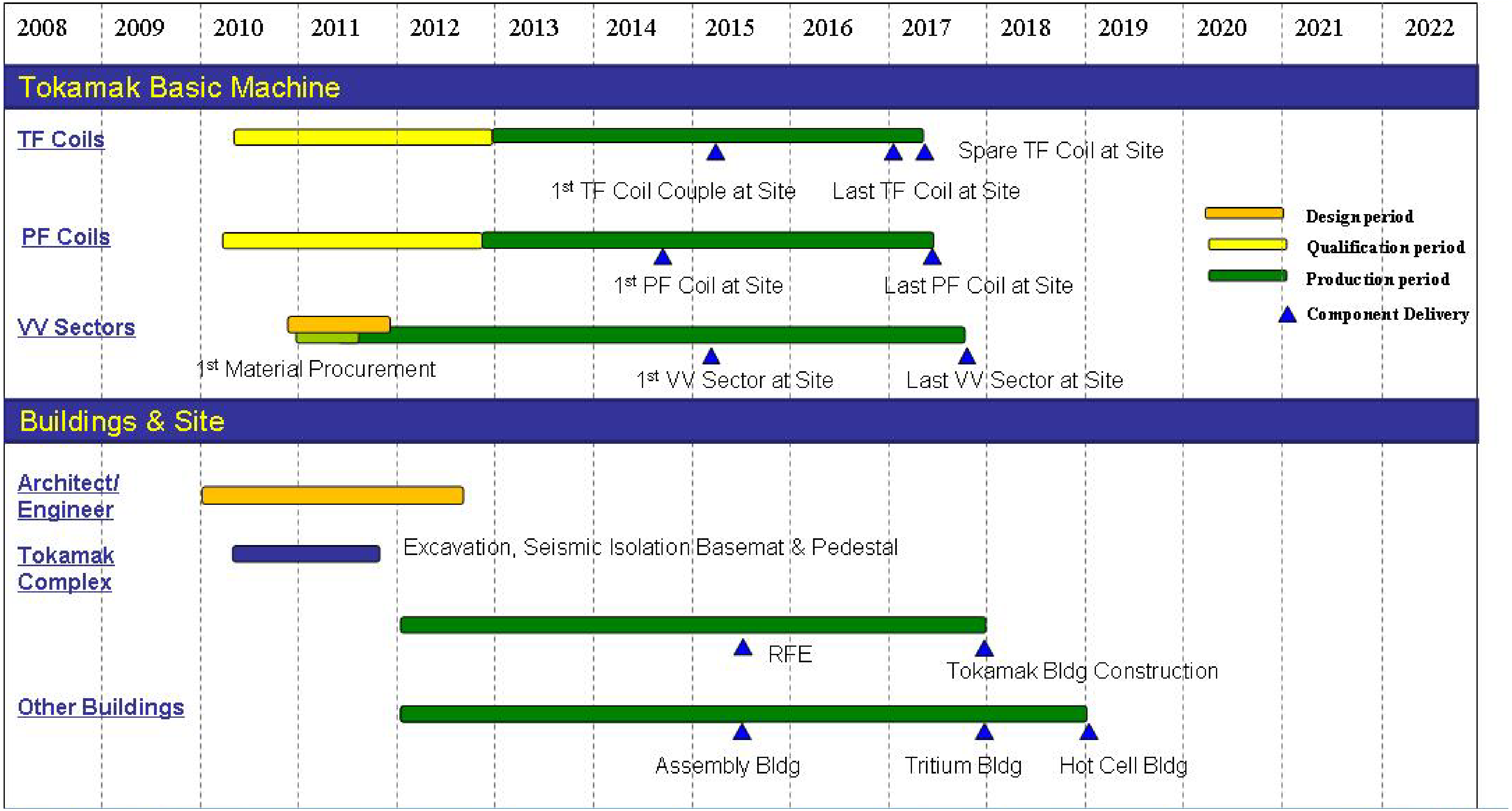


Fig. 1 EU Procurement Schedule Summary (Modified Scenario 1)

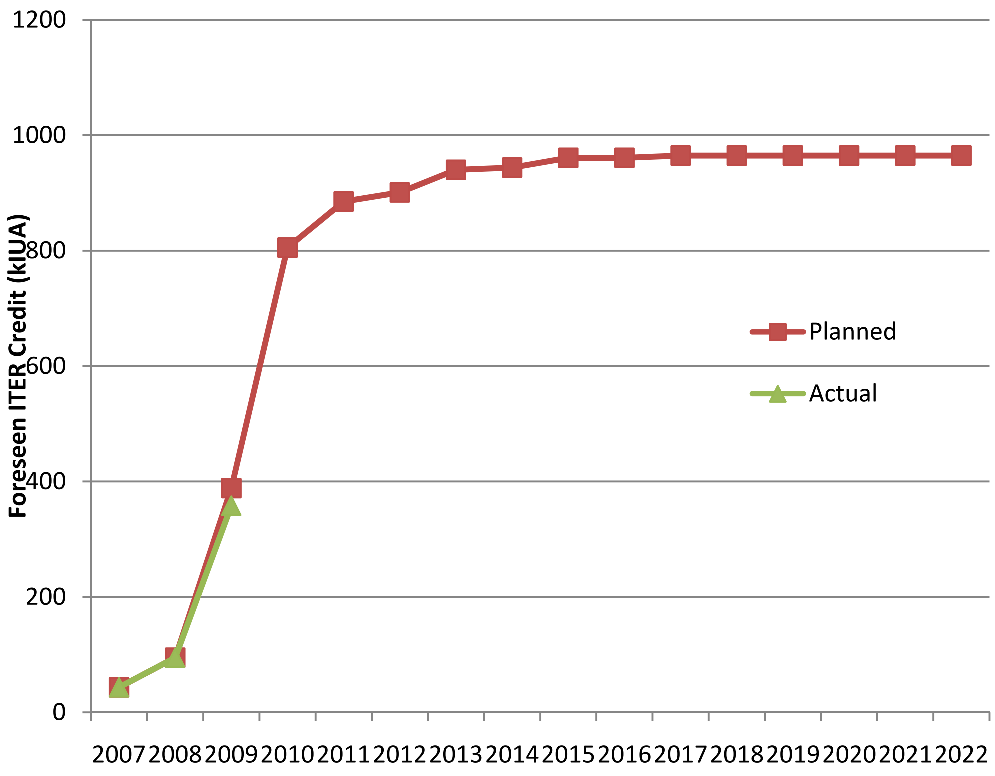


Fig. 2 Planned (red) and actual (green) ITER credit foreseen through PAs for Scenario-1[6]

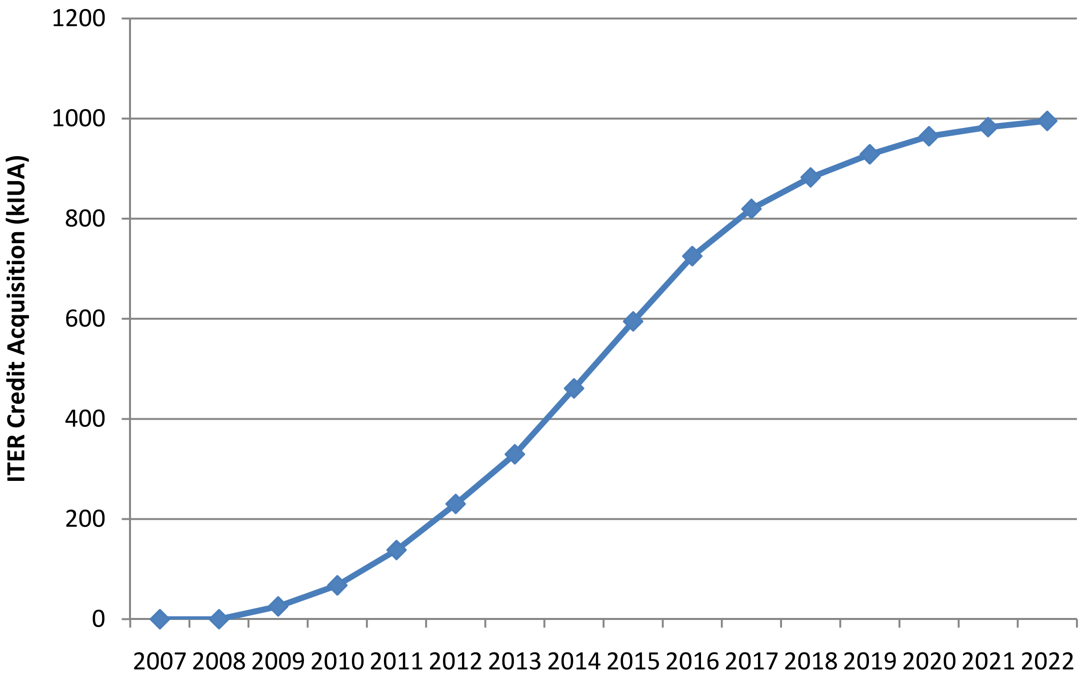


Fig. 3 Acquisition of credit by the EU through PAs for Scenario-1

[6] The difference between the integral value of figs. 2 and 3 is due to the fact that the date of some PAs has not been defined.

TABLE 1 - SHORT TERM MILESTONES

WBS	System	Milestone	DA	Expected Date	Status
1.1A	Magnets – TF Coils	Contract Signature for Prototype Radial Plate (Lot 1)	EU	September 2009	
1.1A	Magnets – TF Coils	Contract Signature for Prototype Radial Plate (Lot 3)	EU	December 2009	
1.1.6A	Magnets – TF Conductor	Contract signed for Cu Strand Production	EU	April 2009	
1.1.6A	Magnets – TF Conductor	Contract signed (supplier A) for SC Strand Production	EU	August 2009	
1.1.6A	Magnets – TF Conductor	Contract signed (supplier B) for SC Strand Production	EU	November 2009	
1.1A	Magnets – TF Coils	Contract Signature TF Coils Winding Pack	EU	March 2010	
1.1.6A	Magnets – TF Conductor	End of Cu strand production	EU	April 2011	
1.1A	Magnets – TF Coils	Radial plate prototypes completed	EU	May 2011	
1.1A	Magnets – TF Coils	Contract signature for Radial Plate procurement	EU	November 2011	
1.1A	Magnets – TF Coils	Dummy double pancake completed	EU	January 2013	
1.1.3	Magnets – PF Coils	Contract signature for PF coils	EU	April 2010	
1.1.3	Magnets – PF Coils	Dummy Double Pancake for PF6	EU	December 2012	
1.1.3	Magnets – PF Coils	Delivery of PF5 and PF6 to IO	EU	September 2014	
1.1 2A	Magnets – Pre Compression Rings	Manufacture and testing of full-scale prototype	EU	February 2012	
1.1 2A	Magnets – Pre Compression Rings	Delivery of lower 6 pre-compression rings to IO (3 + 3 spares)	EU	October 2013	
1.1.6A	Magnets – TF Conductor	Delivery of conductors from EU	EU	December 2013	
1.1.6C	Magnets – PF Conductor	Delivery of conductors for PF6 coils	EU	December 2012	
1.5 1A	Vacuum Vessel	Contract Signature for Main VV Sectors	EU	September 2010	
1.5 1A	Vacuum Vessel	In-Wall Shielding delivery (for Sector 5)	IN	Oct-Nov 2012	
1.5 1A	Vacuum Vessel	Start of Sector 5 Assembly	EU	April 2013	
1.5 1A	Vacuum Vessel	Start of Sector 3 fabrication	EU	June 2013	

1.6.1 A	Blanket First Wall	FW prototype Completion	EU	July 2012	
1.7	Divertor Cassette	Manufacturing of Cassette Prototype	EU	Jan 2012 – Sep 2013	
1.7	Divertor Inner Vertical Target (IVT)	Manufacturing and Testing of IVT Prototype	EU	Mar 2011 – Dec 2012	
2.34	Remote Handling – In-Vessel Viewing System (IVVS)	IVVS-GDC plugs (with provisional IVVS) for ITER: manufacturing design completed and approved	EU[7]	December 2014	
3.1.1	Vacuum Pumping	Torus Cryopumps and related equipment: testing of PPC completed	EU	October 2012	
3.1.1	Vacuum Pumping	NB pumping system: procurement of MITICA cryopump completed.	IO/EU	Sept-2014 (tentative)	
3.1.3	Vacuum Pumping	Start contract for manufacturing LD system	EU	August 2013	
3.2.5	Tritium Plant	Design Review of Final Design of WDS water holding tanks (both emergency and storage tanks)	EU	July 2011	
3.4.1	Cryoplant	LN_2 plant detail design approved by IO	EU	March 2013	
3.4.1	Cryoplant	80K loop detail design approved by IO	EU	March 2013	
4.1,4.3	Power Supplies	All design completed	EU	July 2012	
5.1	Ion Cyclotron H&CD Antenna	Final Design completed	EU/IO	June 2013	
5.2	Electron Cyclotron Upper Launcher	Final Design Review T-barrier	EU/IO	January 2012	
5.2	Electron Cyclotron Upper Launcher	Final Design Review Launcher Assembly	EU/IO	February 2013	
5.2P3	Electron Cyclotron Power Sources	Decision to Continue on the Coaxial Cavity Gyrotron Progr	EU	January 2011	
5.2P4	Electron Cyclotron Power Supplies	Main Contract for Main and Body Power Supplies Signed	EU	November 2012	
53.6 NBPS	Neutral Beam System – Power Supplies	Start of procurement for HNB1	EU	October 2014	
53.x	Neutral Beam System - NBTF	Start of SPIDER operation	EU	January 2013	
5.5A.01-A06	Diagnostics	On-vessel magnetics diagnostics sensors/platforms and external Rogowski coil design complete	EU	May 2012	

[7] interface with CN DA for GDC

5.5A.01-A06	Diagnostics	On-vessel magnetics diagnostic sensors/platforms delivered	EU	July 2013	
5.5D.01	Diagnostics	Blanket bolometer diagnostic platform design complete	EU	December 2012	
5.5D.01	Diagnostics	Blanket bolometer diagnostic platforms delivered	EU	February 2014	
5.5E.01	Diagnostics	Core-plasma charge exchange recombination spectroscopy port plug component design complete	EU	November 2014	
5.5F.03	Diagnostics	Plasma Position Reflectometer in-vessel mm-wave component design complete	EU	November 2011	
5.5F.03	Diagnostics	Plasma position reflectometer in-vessel mm-wave components delivered	EU	February 2014	
5.5G.01	Diagnostics	Mid-plane visible/IR wide angle viewing system port plug component design complete	EU	December 2014	
5.5N.01	Diagnostics	In-Vessel Services on-vessel cables design complete	EU	February 2012	
5.5N.01	Diagnostics	In-vessel services on-vessel conduits delivered	EU	May 2014	
5.5N.03-N.06	Diagnostics	Upper Port Plug #01 design integration complete	EU	December 2013	
6.3	Site & Buildings	End of PF Coils Building Assistance Contract	EU	December 2009	
6.2	Site & Buildings	Start of Architect Engineer Contract	EU	January 2010	
6.2	Site & Buildings	End of Value Engineering Contract	EU	February 2010	
6.3	Site & Buildings	PF Coil Building - Construction design complete	EU	July 2010	
6.3	Site & Buildings	Ready for Equipment of PF Coils fabrication building	EU	July 2011	
6.2	Site & Buildings	Excavations & Support Structures - Final acceptance of the works	EU	September 2011	
6.1,6.2,6.3,6.5	Site & Buildings	AE Services - Tender design complete	EU	July 2011	
6.2	Site & Buildings	Start of Tokamak Building Construction	EU	January 2012	
6.2	Site & Buildings	Anti-Seismic Bearings - Final acceptance	EU	June 2012	

6.2	Site & Buildings	Start of Hot Cell Building Construction	EU	June 2014	
5.6	Test Blanket Modules (TBM)	TBM prototypical mock-ups (PMU) conceptual design achieved	EU	December 2012	
5.6	Test Blanket Modules (TBM)	TBM fabrication technologies: Preliminary welding procedure specifications (pWPS) ready	EU	December 2011	

TABLE 2 - LONG TERM MILESTONES

WBS	System	Milestone	DA	Expected Date	Status
1.1A	Magnets – TF Coils	Delivery of TF10/TF11 to IO	EU	April 2015	
1.1A	Magnets – TF Coils	Last Radial Plate delivery	EU	October 2015	
1.1.3	Magnets – PF Coils	Delivery of PF3 to IO	EU	June 2017	
1.5 1A	Vacuum Vessel	Sector 5 Fabrication, Ass'y, Testing & Delivery	EU	February 2015	
1.5 1A	Vacuum Vessel	Sector 4 Fabrication, Ass'y, Testing & Delivery	EU	June 2016	
1.5 1A	Vacuum Vessel	Sector 7 Fabrication, Ass'y, Testing & Delivery	EU	September 2017	
1.6.1 A	Blanket First Wall	First Wall : 1st series delivered	EU	October 2015	
1.6.1 A	Blanket First Wall	First Wall: Series delivered	EU	End 2019	
1.7	Divertor Cassette	Batch 1 – Manufacturing of 6 Cassette Bodies	EU	May 2014 – Apr 2015	
1.7	Divertor Cassette	Last Integration of Divertor Cassette	EU	August 2020	
1.7	Divertor Inner Vertical Target (IVT)	Stage 1 – Manufacturing of 6 IVTs	EU	May 2013 – Apr 2015	
1.7	Divertor Inner Vertical Target (IVT)	Stage 3 – Manufacturing of 36 IVTs	EU	May 2016 – Oct 2019	
2.32	Divertor Remote Handling	DIV RH manufacturing design completed and approved	EU	September 2015	
2.32	Divertor Remote Handling	DIV RH delivered to ITER site, installed, accepted and handed-over to IO	EU	August 2017	
2.33	Remote Handling – Transfer Cask System	Final TCS 1st batch casks for ITER manufacturing design completed and approved	EU	April 2016	
2.33	Remote Handling – Transfer Cask System (TCS)	TCS batch 1 delivered to ITER site, installed, accepted and handed-over to IO: (batch 2 could follow 2 years later, TBC)	EU	October 2017	
2.34	Remote Handling – In-Vessel Viewing System (IVVS)	IVVS-GDC plugs (with provisional IVVS) delivered to ITER site, installed, accepted and handed-over to IO (final IVVS should follow ~2.5 years later, TBC)	EU	March 2017	
2.35	Neutral Beam Remote Handling	NB RH 1st priority items (monorail crane and others TBD) manufacturing design completed and approved	EU	July 2015	

2.35	Neutral Beam Remote Handling	NB RH 1st priority items (monorail crane and others TBD) delivered to ITER site, installed, accepted and handed-over to IO (2nd priority items should follow ~1 year later, TBC)	EU	April 2017	
3.1.1	Vacuum Pumping	Torus Cryopumps and related equipment: End of delivery	EU	July 2016	
3.1.1	Vacuum Pumping	CVBs: end of delivery	EU	July 2015	
3.1.1	Vacuum Pumping	HNB & DNB pumping system: end of delivery	EU	April 2020	
3.1.3	Vacuum Pumping	Delivery of LD system to ITER site	EU	October 2015	
3.2.3	Tritium Plant	Design review of Final Design of ISS.	EU/IO	August 2016	
3.2.3	Tritium Plant	ISS delivered to ITER site	EU	November 2021	
3.2.5	Tritium Plant	Manufacturing of residual WDS and delivery to ITER site	EU	End 2022	
3.4.1	Cryoplant	All systems handed over to IO	EU	February 2018	
3.4.1	Cryoplant	2nd LN2 plant commissioned	EU	December 2017	
3.4.1	Cryoplant	2nd 80K loop commissioned	EU	April 2017	
4.3	Power Supplies	All procurements completed	EU	May 2016	
5.1	Ion Cyclotron H&CD Antenna	Antenna delivered to ITER site	EU	January 2019	
5.2	Electron Cyclotron Upper Launcher	First launcher delivered to ITER site	EU	September 2017	
5.2	Electron Cyclotron Upper Launcher	Forth launcher delivered to ITER site	EU	December 2018	
5.2P3	Electron Cyclotron Power Sources	1st Set (2MW) of Gyrotrons (Tube and SCM) Delivered to ITER	EU	August 2018	
5.2P3	Electron Cyclotron Power Sources	4th Set (2MW) of Gyrotrons (Tube and SCM) Delivered to ITER	EU	August 2019	
5.2P4	Electron Cyclotron Power Supplies	Last Set of EC HVPS Delivered to ITER	EU	December 2018	
53.6 NBPS	Neutral Beam System – Power Supplies	EU Supply for IHNB1 accepted, ready for integration.	EU	January 2018 (PS only) April 2018 (incl. NBPS and NB Control)	
53.6 NBPS	Neutral Beam System – Power Supplies	EU Supply accepted for IHNB2, ready for integration.	EU	July 2018 or October 2018 (incl. NBPS and	

				NB Control)	
53.x	Neutral Beam System - NBTF	Start of MITICA operation	EU	August 2015	
53.x	Neutral Beam System - NBTF	Results of the MITICA experiments in H2	EU	June 2018	
53.x	Neutral Beam System - NBTF	Results of the MITICA experiments in D2	EU	May 2020	
5.5A.01-A06	Diagnostics	Divertor magnetics sensors delivered	EU	May 2020	
5.5B.01	Diagnostics	Radial Neutron Camera port plug component design complete	EU	November 2015	
5.5B.01	Diagnostics	Radial neutron camera port plug components delivered	EU	November 2017	
5.5C.01	Diagnostics	LIDAR core-plasma Thomson scattering port plug component design complete	EU	August 2015	
5.5C.01	Diagnostics	LIDAR core-plasma Thomson scattering port plug components delivered	EU	August 2018	
5.5C.07	Diagnostics	LFS collective Thomson scattering port plug component design complete	EU	August 2015	
5.5C.07	Diagnostics	LFS collective Thomson scattering port plug components delivered	EU	August 2018	
5.5E.01	Diagnostics	Core-plasma charge exchange recombination spectroscopy port plug components delivered	EU	March 2018	
5.5G.01	Diagnostics	Mid-plane visible/IR wide-angle viewing system equatorial port plug #03 components delivered	EU	November 2017	
5.5G.03	Diagnostics	Pressure gauge/platform design complete	EU	January 2015	
5.5G.03	Diagnostics	Pressure gauges/platforms delivered	EU	November 2017	
5.5N.03-N.06	Diagnostics	JA-DA Divertor Impurity Monitor upper port plug #01 components delivered from IO	IO (JA)	March 2017	
61,62,63,65	Site & Buildings	Construction - Tokamak RFE	EU	July 2015	
61,62,63,65	Site & Buildings	Completion of Tokamak Building Construction	EU	December 2017	
61,62,63,65	Site & Buildings	Completion of Hot Cell Building Construction	EU	December 2018	
6.3.A1	Radwaste Type A and Conventional Waste	Design review of solid and liquid radwaste system and components	F4E	November 2017	

5.6	Test Blanket Module (TBM)	Final engineering design review achieved	EU	December 2016	
5.6	Test Blanket Module (TBM)	Ancillary systems and support equipment delivered to ITER site for assembly	EU	June 2019	
5.6	Test Blanket Module (TBM)	TBMs (EM-TBMs) + Port Plug Frame assembly tested	IO	March 2020	

	On time
	To be closely monitored
	Delay expected

Risk Management

A preliminary analysis has been carried out with IO to identify what the DAs consider to be the top risks of the project from a technical point of view selected from a standard list that included 64 risks. For F4E the greatest risk events are:

- The lack of Project Interface definitions which may lead to inter project links being missed;
- The lack of capable and experienced resources in the marketplace (skilled resource shortages);
- That R&D requirements still evolving (delay in manufacturing).

Some risk mitigation actions were identified:

- Allocation of adequate resources for interface control, design maturity and follow-up;
- Improvement of integration between the organisation levels of IO and DAs;
- Development of a procurement strategy that optimises the splitting into smaller scope contracts, still keeping the risk of interface control under a reasonable limit.

In addition, mitigation activities are categorised into:

- Improved configuration management planning;
- Simplification and optimization of in kind procurements;
- Use, when possible, well understood manufacturing and processing techniques;
- Increasing collaboration with industry and research institutions to further develop courses and qualifications, and to attract resources of the appropriate calibre;
- Deploy Key Performance Indicators (KPI) to track progress and allow proactive management and re-prioritisation of resources.

As far as the EU procurements are concerned, table 3 presents a list of the top risks and the corresponding mitigation actions as they have been identified up to now. More detailed information and a broader analysis of the risks for the most critical EU procurements packages are presented in Annex II.

TABLE 3 - SUMMARY OF TOP RISKS

Components	Type	Description	Mitigation
TF and PF Conductor			
	Interfaces	Cable production coming from many other DAs. In particular some strand/cable are coming from RF. Components (cables and final conductors) have to cross EU-RF border. Risk: custom/formality problems.	Careful follow up on production and transportation.
	Technological	Jacketing, compaction: Insertion of long length cable. Compaction by rollers or dies. Risk: Damage of the cable during the insertion	Intense monitoring during qualification phase
Toroidal Field Coils			
	Commercial/ procurement	Only one consortium in Europe is capable to carry out the whole procurement (radial plates, winding packs, coil insertion and cold tests). Risk of monopoly situation and of a cost increase.	Split procurement in smaller technologically-homegenous work packages accessible to more competitors with specific competences: Radial Plates, Winding Packs and Coil Case Insertion.
	Technological	Risk associated with the fabrication of the radial plates is the combination of large dimensions (up to 12m) and tight tolerances (tenths of mm).	Manufacture two prototypes: one side and one regular, using different manufacturing routes in order to explore different fabrication technologies to find the best value-for-money
	Technological	No previous experience of the production of coils of this size with wind, react and transfer technology. Different behaviour of conductors during heat treatment. Risk of delay due to development and learning curve.	i) Manufacture one double pancake prototype (already in PA) before starting production. ii) Carry out an intense R&D program before starting series production. iii) Utilize experience gained with the TF Model Coil iv) Synergy with Japanese DA.
	Technological	Risk coil insertion: Welding of the coil case is very complex due to the variable thickness (from 30 to 120 mm) and because there is a risk to damage the winding pack during the operation. Non Destructive Testing (NDT) is also critical due to geometrical constraints.	i) Pre-qualify critical processes (weld and NDT) well in advance. ii) Launch investigation of technologies to protect winding during welding. iii)Work in close contact with JA DA to benefit from synergy

Poloidal Field Coils			
	Commercial/ procurement	This supply will be carried out in parallel with the three major supply contracts for the TF coils (radial plates, TF winding and insertion), which will already utilise the production capacities of the few potential European suppliers. Risk of cost increase due to the lack of competition or delays.	Maintain interest for all potential suppliers.
	Technological	The required production rate is very high: two production lines in parallel are needed for pairs of PF coils starting from PF6/PF5. In addition, considering the size of the industries with expertise in magnets , this could require additional recruitment and training of new staff with high risk of human errors. Risk of failure during pre-industrialization and production.	i) Utilize multiple resources on-site. ii) Close support and monitoring of the supplier production status.
Precompression Rings			
	Technological	Pre-compression ring assembly. Risk of damage to the brittle pre-compression ring during assembly would reduce the lifetime; the extent of the reduction would depend on the position and severity of the damage.	Manufacturing a spare set of top pre-compression rings (the bottom pre-compression rings already have a spare set).
Vacuum Vessel			
	Commercial/ procurement	The start of the construction activities prior to the finalization of design interfaces could lead to change notices to the Supplier resulting in scrap and other changes to be paid by F4E.	Refuse ITER Requests for Changes. No construction activity starts before the finalization of the design for the interface components
	Technological	Due to lack of a full-size sector prototype and if the prescribed tight tolerances are not achieved, one might have to reject the first-of-a-kind sector.	Extensive mock ups and distortion modelling to be completed before embarking on the critical stages of first sector construction.
	Interfaces	Due to the lack of control over the supply of the Inner-Wall-Shielding (IWS) plates, that is under the responsibility of the IN-DA, the IWS blocks could arrive with low quality dimensional and cleanliness specifications. In this case correction works are required by the VV Supplier under F4E's responsibility.	Improve interface with IO and IN DA in order to anticipate better the characteristics of the IWS blocks.
	Commercial/ procurement	Due to the market situation and perceived difficulty of material production and full order books of material suppliers, difficulties in material supply could arise.	Increase budget (liquidated damages) for the procurement of the material in order to provide an incentive the VV Supplier to give priority to the order

	Commercial/ procurement	Due to stringent and late input of requirements from the Agreed Notified Body (ANB) additional quality requirements could be imposed on the supplier, possibly resulting in production difficulties	Improve communication with ANB
Blanket / First-Wall	A risk assessment is premature at this stage because the design has not reached a sufficient maturity to allow an appraisal of the risks and the procurement sharing is still under discussion.		
Divertor - Inner target	F4E does not identify any very high risks		
	Commercial	Risk of having only one supplier for the procurement of the Carbon Fibre Composite (CFC) material, with possible high costs.	R&D launched to qualify on time a second material supplier.
	Schedule	Risk of higher rejection rate due to non conformance of CFC material supply	Material procured from two qualified suppliers
	Schedule	Acceptance tests during series production originally planned to be performed in the RF. This increases the risk of delay due to complex custom procedures.	Performance of acceptance tests in Europe at a test facility shared with the First Wall (FW) procurement.
Divertor – Cassette			
	Schedule	Tight tolerances for the assembly of the Inner Vertical Target onto the cassette body to be performed by the EU DA. Risk of delay due to components out of tolerances.	R&D to qualify the assembly procedure and possibly relax the fabrication tolerances.
	Schedule	Risk of delay due to rejection of components supplied by other DAs not satisfying the requirements of tight tolerances.	Close follow-up with the IO of the components supplied by the other DAs and diagnostics.
Remote Handling (RH)			
	Technological	Risk common to all the RH packages (less relevant for NB RH due to the lower (10^2-10^3 less) gamma radiation field: no availability of radiation (rad) hard motors/sensors/electronics.	R&D programme to qualify rad hard components
	Technological	IVVS (resident in VV - vacuum- temperature - magnetic field): no availability of magnetic-field-vacuum-baking compatible rad-hard components (including neutron fluence ~10^{15} n/m^2 tbc).	R&D programme and/or remove actuation system as much as possible from the inside of the plug (engineering assessment to be done).
	Technological	Risk of non-performing RH system because of poor definition of interfaces with the components to-be-handled and non-obvious bugs in the hardware/software.	Prototyping and testing prior to release of final production

	Management	Managerial risk related to safety nuclear authority (in particular for the transfer casks moving contaminated radioactive components in tokamak and HC building) not "licensing" the RH for nuclear phase.	Demonstrate suitability, reliability and fail safeness with a prototyping and testing phase.
Vacuum pumping and fuelling			
	Technological	Risk of Tritium Permeation to Cryogens.	Resolve Tritium permeation issue in the cold valve boxes/cryojumpers and adjust the design accordingly.
	Technological	Risk of inadequate valve performance.	Employ specialist valve manufacturers in the early stages of design.
	Technological	Risk of poor pump performance due to excessive drop in the cryopanels	Quantify experimentally pressure drop characteristics of cryopanels
	Technological	Risk of T-compatibility as presence of magnetic fields and radiation environment and high detection sensitivity are critical issues for leak detection, leak localization equipment.	Addressing the issue from the beginning in the design and manufacturing contracts of the components subject to leaks and, if necessary, carry out some R&D to develop dedicated/suitable mass spectrometry leak detection devices. R&D to develop leak localization systems.
Tritium Plant			
	Schedule	Risk of delays on delivering of the tanks with respect to the scheduled closure of the B2 level of the Tritium Building	Include in the design activity the option of installing the tanks in pieces to be then assembled in situ.
NBI			
	Management	NBTF Complicated organisational aspects, with involvement of IO, F4E, other DAs and NBTF Host may result in the progress of activities being affected by ill defined responsibilities and lack of clearly identified technical leadership which may cause difficulties and delays.	1) Early involvement of legal/administrative services to define the necessary agreements and their content. 2) Clear definition and simplification of workflow and responsibilities; clear identification of the responsible Parties for the technical deliverables aiming at minimising interfaces internal to Europe. 3) Decisional process and authorities streamlined and agreed amongst Parties beforehand.
	Technological	Delays in the operation of NBTF-MITICA or in the achievement of the expected results may lead to the situation that not all the key components could have been tested and the relevant risk could not have been completely mitigated.	1) Delay as much as possible the launch of the affected procurement contracts 2) Draw up procurement contracts will as much flexibility as possible to allow changes 3) Accept a delay in the start of HNBs

			operation
	Technological	Large extrapolation of performance from previous negative ion based neutral injector systems may mean that the full ITER HNB performances are not reached resulting in a reduction of the heating power for the first ITER injectors.	1) Substantial development programme at the NB Test facility as main mitigating action 2) earlier experiments on ion source (e.g. ELISE) and investigation on HV issues.
	Technological	The unavailability on the market of the Absolute Valve may cause that a Supplier may not be found and/or the procurement of the Absolute Valve with a metallic seal of 1.6 meters may cause serious difficulties.	A specific R&D program has been launched directly by IO for the manufacture and the test of a size 1 metallic seal & seat.
	Technological	The European 1MV DC bushing connecting to HVD1 is non standard and the integration technically challenging which means that there is no guaranteed industrial interest to deliver at reasonable cost.	1) Consultation with external expert, 2) Procurement strategy (competitive dialog), 3) Bushing prototype as part of procurement as main mitigating action
Diagnostics			
	Technological	Diagnostic components viewing the plasma are exposed to a combination of erosion by energetic neutrals and deposition of migrated carbon/beryllium eroded at the divertor and first-wall. This results in very demanding specifications for 'first mirrors' in diagnostic optical systems (LIDAR, CXRS and WAVS) for which no design solutions exist and could mean that first mirror lifetime is not consistent with RAMI requirements for diagnostic systems.	1) Transfer to IO liabilities for design underperformance against RAMI requirements for systems including first mirrors; and 2) Agree with IO a set of minimum mitigation measures to be incorporated in the design (likely to include mechanical shutters and calibration systems).
	Management	ITER procedures envisage conduct of design reviews for whole diagnostic systems but sub-systems of individual diagnostics have a wide range of delivery dates in the IPS from 2013 to 2021. R&D and design efforts could therefore be conducted (in support of the design reviews) well before they are required for manufacture of the sub-system, which may result in a commitment profile inconsistent with the budget.	Organise the PA along the lines of 'separable sub-systems', with limited and easily defined interfaces, to allow phasing of design and supply meeting DA resource-levelling requirements

	Schedule	Slow contractual procedures, e.g. due to the insufficiency of F4E technical personnel; a very small supplier base (single bidders); inadequate contract tender responses; or protracted contract negotiations could lead to an inability to place timely contracts or complete R&D/Design on time. As a result the PA schedule might not be met and liabilities could be incurred in connection with delays in cross-party interfaces.	1) Minimize the number of R&D/design contracts by structuring system development as one large, initial contract (for suppliers to prove their ability to deliver complete, technically competent work to schedule) and a longer-term framework contract to complete the design (i.e. ensuring a very close collaboration between F4E and suppliers, making it possible to manage the development with a limited number of F4E personnel); and 2) Carry out time-critical tasks using contracts with full supplier liability rather than on a 'best-efforts' basis
	Technological	The high radiation environment experienced by in-vessel diagnostic components leads to very demanding specifications for in-vessel electrical joints, for which no qualified design solutions exist. Development of currently envisaged electrical joining concepts for in-vessel diagnostics may not be capable of meeting RAMI requirements for this environment.	1) Conduct of urgent R&D as far as possible before PA signature - Urgent R&D for all diagnostic systems included in 2009 and 2010 Workprogrammes; and 2) Follow several, parallel R&D paths.
	Schedule	Hardware needed for R&D and design activities undertaken in one contract may have to be procured in a second, independent contract and which could be inconsistent with the first contract's schedule. This could result in delays to the R&D and design schedule and/or incomplete R&D with a consequence that the PA schedule might not be met.	1) Implement framework contracts in a number or areas for the supply and support of R&D/design activities. Pre-selected suppliers should be able to respond quickly to the procurement needs arising from R&D/design contracts; and 2) Use contracts allowing both R&D/design and procurement activities.
	Commercial	The diagnostic system-level design could fail to meet the ITER requirements as defined in the PR. If the PR requirement is required by the PA, this would result in a non-conformity and resultant cost increases, if ITER IO insist that requirements must be met.	1) At the PA negotiations, agree reduced requirements for system that are more likely to be achievable; 2) Agree higher target requirements to be achieved by the design, on a best effort basis only; and 3) Design system to be upgradable to higher performance later during the ITER operational life, for maximum compatibility with the ITER Project objectives.

Buildings			
	Commercial	Large and wide ranging contract comprising all design and monitoring activities in a "One of a kind project". Difficulties for F4E to make accurate estimates of the price of assistance contracts based on the functional requirements provided by IO.	(i) Produce clear detailed specifications; (ii) Clear selection criteria for prequalification phase; (iii) Stimulate competition by proper advertising of tender; (iv) Give access to the additional French rules in order to ensure equity; (v) Clear definition and limitation of risk transferred to companies; (vi) Prepare scope with possibility of reduction and deferral (options).
	Technological	Large number of buildings, some of nuclear type, in a relatively small space with associated large risks to manage construction site activities. Constructability risk (logistics, access, storage areas). Conflict in time and space use between construction contractors leading to delay and over cost	Standard working organization to minimize safety and health risks. (i) To launch the call for tender for site preparation in 2010 to anticipate the arrival of companies and thousands of workers in 2011-2012 . (ii) To negotiate with IO to defer assembly of equipment that are not essential. (iii) To limit interfaces between construction companies by limiting the number of contracts.
	Commercial Construction Contracts	Lack of competition for the construction contract resulting in very high costs	Attract international competition by tendering civil engineering packages of more than 200 MEUR.

QUALITY ASSURANCE (QA)

F4E-RELATED QA

The development and establishment of a Quality System in F4E is part of its overall management strategy and is included among the obligations as an items provider to the ITER and Broader Approach Projects.

The F4E Quality Management System implements, for safety relevant components and activities, the requirements of the 'Order of August 10 - 1984' (French Republic *'Arrêté du 10 Août 1984'*) and, in general, uses as a basis the IAEA Safety Requirements GS-R-3 (2006) and ISO 9001 as applicable.

The F4E Quality Management System is composed of:

- Management Systems Manual:
  a description of the QA system for F4E operations
- Specific Project Quality Assurance Programs:
  a description of the technical Quality Management System and systems integration / interface harmonization management for Broader Approach and ITER procurement items
- Processes and procedures:
  a process approach to quality management
- Forms, Templates and Records
- External Documentation

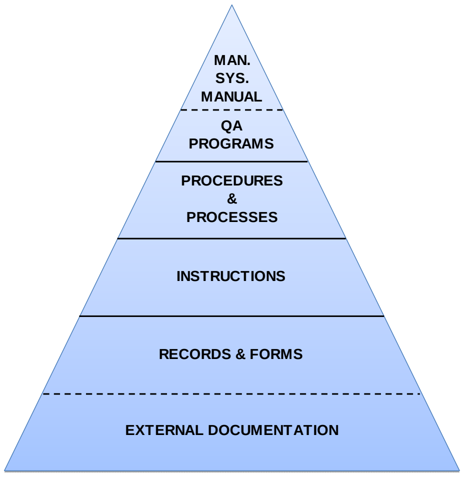


Figure 7 – QA Documentation

The Management Systems Manual encapsulates the overall management of F4E:

- Quality Assurance Policy, F4E Governance;
- F4E Organisation (OBS, Distribution of Responsibilities, PB);
- Planning, QA Management, Implementation (WBS, ITER and BA Projects, QA, Resources);
- Documentation (Quality Documents, Management System);
- Monitoring and Reporting (Internal Control Standards, Audits, Risk Management., Strategic Reviews, Reporting through the Annual Activity Report, Management reports, etc.);
- Improvement (Assessment, Configuration Management and Continual Improvement).

F4E is currently mapping its processes and developing the quality management framework through a process approach. The processes interaction in F4E is represented in Fig. 8.

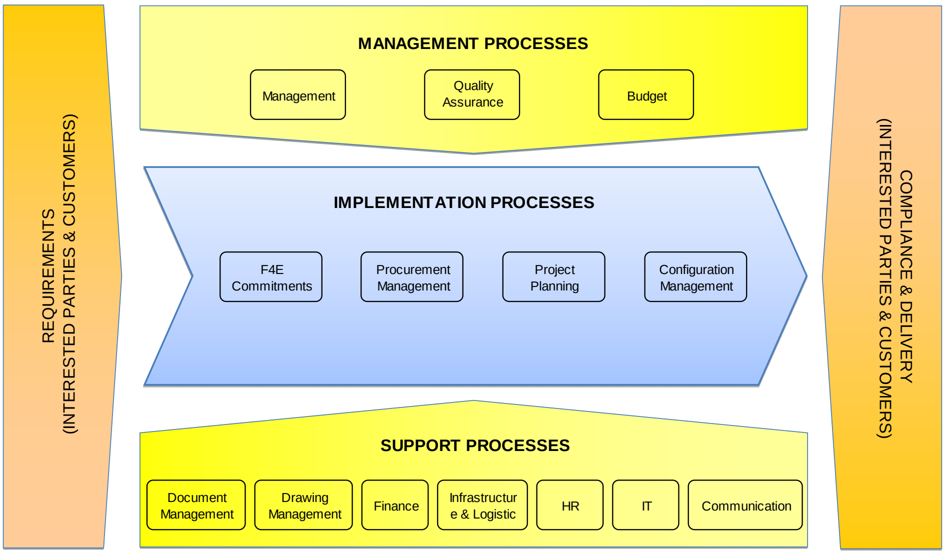


Figure 8 – F4E Process

Most of the implementation and management processes have already been defined and are being implemented. These include processes (and sub processes) to deal with Procurement Management, Nonconformities, Deviations and Configuration Changes.

Part of the support processes is simultaneously being defined with the development of software tools to manage the Human Resources, Missions and internal requests (IT, logistics, etc.).

QA RELATED TO ITER PROCUREMENTS

PROJECT QUALITY ASSURANCE

F4E has developed within its Quality System a specific QA Program for IO to establish the overall framework to achieve the quality criteria for items and services provided by F4E to the ITER project. This QA Program (for the procurement of the EU in-kind components) has been approved by the IO.

As part of the formalisation and approval of the F4E commitments toward the ITER Project, F4E develops a Strategy Proposal for each project. Based on this strategy, F4E issues a Project Management Plan describing and defining:

- the provisions implemented to comply with the customer requirements and the project reporting rules;
- all interfaces within the project and in particular those between F4E responsible officers;
- the division of the project in the various work packages that have to be contracted with economic operators.

For each work package, F4E issues a management specification at the time of the call for tender and the selected supplier needs to provide a thorough quality plan following the different points raised by F4E in their specifications.

Supplier certification according to a specific international standard is not usually required (but recommended). The quality level is accomplished through the compliance with the F4E Management Specification.

The integration of the F4E Configuration Management processes with the ITER Configuration Management F4E is dealt by a dedicated F4E-IO Configuration Management Plan (in final approval).

THE WBS SPECIFIC PART OF THE PROJECT PLAN

This part of the Project Plan is devoted to the EU in-kind contributions and activities. Specific information is provided, according, where available, to the Work Breakdown Structure (WBS) of the ITER project. The WBS prepared by IO with the support of the DAs and some minor adjustments, including the preparation of an associated WBS Dictionary is being finalized for the ITER Council meeting in November 2009.

In Annex III the WBS up to Level 5 is shown for the main systems where EU procurements are planned together with a summary of the main data, such as the date for the signature of the Procurement Arrangement (PA), the EU sharing of the component and the main procurements contracts launched to date. The table below shows a summary description of the WBS and the associated ITER credit.

WBS	**Description**	**kIUA**	**MEuro 2008**
1.1	Magnets (20% of the conductor for the TF conductor ,Winding Packs for 10 TF Coils, 10 Case-winding pack insertion, 5 PF coils – P2-PF6),	183.393	274.75
1.5	Vacuum vessel (7 sectors of the main vessel and blanket coolant manifolds)	99.36	148.86
1.6	Blanket (10% of shield modules and 30% of the first wall modules)	31.9	47.79
1.7	Divertor (inner vertical target and cassette bodies)	31.4	47.04
2.3	Remote Handling (RH) (divertor RH, part of cask transfer system, in vessel viewing and metrology system, and NBI RH)	33	49.44
3.1	Vacuum & pumping (8 torus and 2 cryostat cryopumps, panel cryopumps for the neutral beam system, valve boxes and associated cryolines, and leak detection/localisation system)	14.256	21.36
3.2	Tritium plant (consisting mainly of the Water Detritiation System (WDS) and the Hydrogen Isotope Separation System (ISS))	18.216	27.29
3.4	Cryoplant system (50%)	31.5	47.19
4.1 & 4.3	Steady-state and pulsed power supply systems (shared with other parties)	31	46.44
5.1	ICRH (equatorial port plug incorporating one ICRH antenna and spares)	3.96	5.93
5.2	ECRH (four upper port plugs incorporating EC launchers each fed by 8 waveguides + 32% gyrotron sources + 14% power supplies)	30.695	45.99
5.3	Neutral beam Heating System (100% assembly and testing and active correction and compensation coils + ~50% beam source and high voltage bushing, beam line components, pressure vessel, magnetic shielding)	46.3	69.36
5.5	Diagnostics (roughly 25% of all diagnostic systems)	34.375	51.50
6.2	Buildings (all concrete and steel frame buildings)	392.3	587.73
6.3	Waste treatment and storage	9.1	13.63
6.4	Radiological protection	4.2	6.29
	Total	**994.955**	**1490.59**

A detailed description of each WBS is provided in the following sections.

MAGNETS - TF COILS	WBS 1.1.A 89.74 kIUA

SHORT DESCRIPTION

The Toroidal Field (TF) coils will provide a total static field of 5.3 T at the plasma axis for confinement and operation. This means a peak field of ~12 T at the inner leg, thus requiring the use of Nb_3Sn strand in the conductor and cooling by supercritical He (4.5 K). These magnets are built with the Wind, React & Transfer technique. The Cable-In-Conduit Conductors (CICC), made of over 1,300 Nb_3Sn and copper strands, are wound in double pancakes on a temporary reaction mould, then heat treated (reacted) to form the Nb_3Sn, and transferred and electrically insulated into stainless steel radial plates. The conductor is electrically insulated by wrapping three half-lapped layers of dry glass/polyimide tape. The conductors are "locked" into the radial plate grooves by laser welded steel covers. The double pancake (DP) modules are then insulated with several layers of half-lapped glass-polyimide tape and vacuum pressure impregnated with epoxy resin. Finally, the coil winding pack is formed by stacking 7 DP modules together, insulating the stack with 7 mm of half-lapped glass-polyimide tape followed by vacuum pressure impregnation (VPI). In each winding pack there are 2 types of radial plates (RP). The so-called regular RP, has 11 grooves per side and the Side RP with 11 grooves on 1 side and 3 on the other. After impregnation of the winding pack and completion of the terminal area with the electrical terminals and inter-pancake joints, the cryogenic supplies and the instrumentation, the windings are enclosed in a heavy support structure called the coil-case, which is split into four sub-assemblies to allow insertion. After closure welding of the cases the gap between winding pack and case is filled with resin and the coil mechanical interfaces are finish-machined to allow final assembly in the machine. The total weight of each coil is about 300 tons.

WBS	EU obligation	Design type	Other DA involved/remarks
WBS 1.1A	Manufacture of 10 TF coils. An additional obligation, not credited yet, is the cold test for the 10 coils, including construction of the facilities.	Build to print although no previous manufacturing experience exists.	The other 9 TF coils will be provided by JA DA. The case sub-assemblies will be provided by JAEA. The conductors for these coils will be supplied by EU, CN, RF and US.

PROCUREMENT ARRANGEMENT PLANNING & STATUS

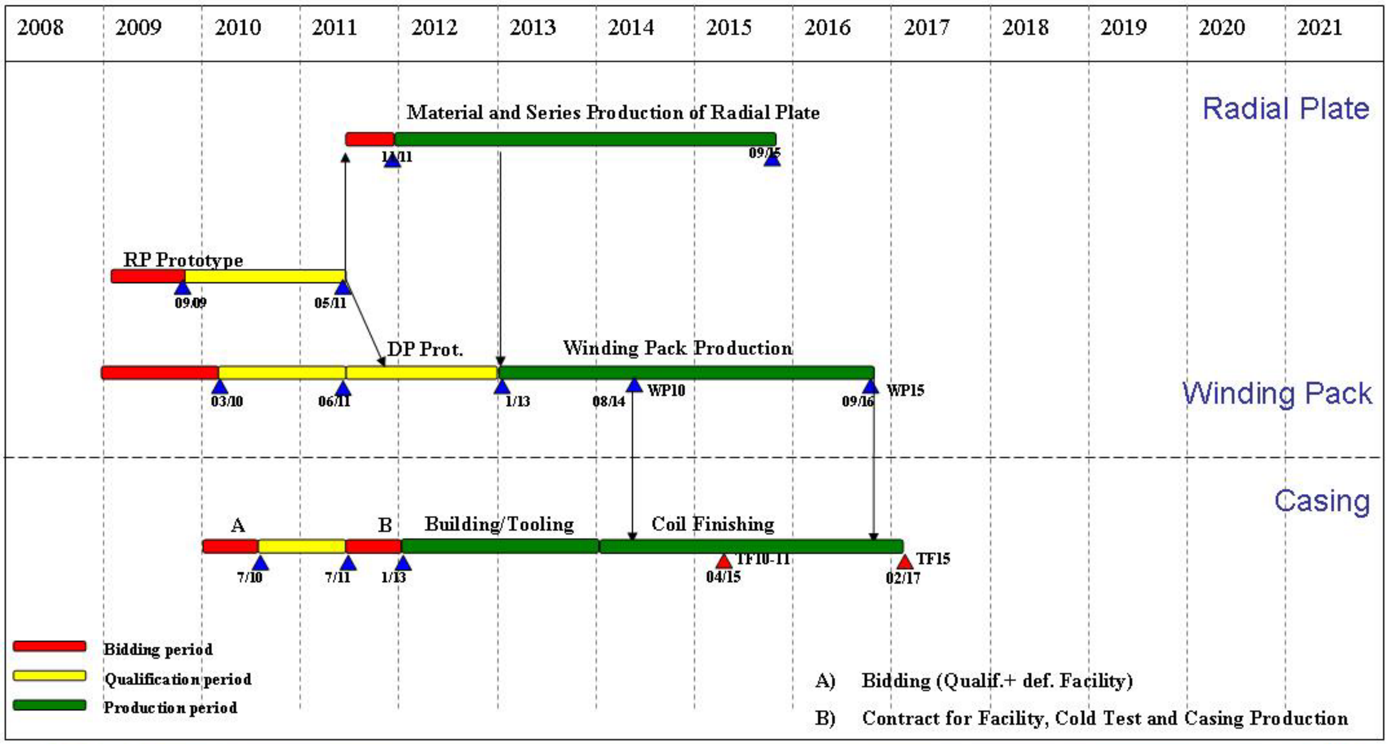
PA Title	PA signature	Credit (kIUA)
TF Coils 1.1P1A.EU.01	June 2008	89.74*

* Sum of TF Windings package credit from WBS 1.1.1A plus insertion in the case from Magnet Structures WBS 1.1.2A

MAIN MILESTONES

WBS	Milestone	DA responsible	Expected date
WBS 1.1A	Contract Signature for Prototype Radial Plate (Lot 1)	EU	September 2009
WBS 1.1A	Contract Signature for Prototype Radial Plate (Lot 3)	EU	December 2009
WBS 1.1A	Contract Signature for TF Coils Winding Packs	EU	March 2010

WBS 1.1A	Contract signature for Radial Plate procurement	EU	November 2011
WBS 1.1A	Last Radial Plate delivery	EU	October 2015
WBS 1.1A	Delivery of conductors from EU	EU	End 2013
WBS 1.1A	Delivery of conductors from CN	CN/IO	End 2013
WBS 1.1A	Delivery of conductors from RF	RF/IO	End 2013
WBS 1.1A	Delivery of conductors from US	US/IO	End 2014
WBS 1.1A	Delivery of the case sub-assemblies	JA/IO	End 2014
WBS 1.1A	Instrumentation delivery	IO	End 2012
WBS 1.1A	Radial plate prototypes completed	EU	May 2011
WBS 1.1A	Qualification mock-ups for TF coils	EU	June 2011
WBS 1.1A	Dummy double pancake completed	EU	January 2013
WBS 1.1A	Delivery of TF10/TF11 to IO	EU	April 2015
WBS 1.1A	Delivery of TF06/TF07 to IO	EU	October 2015
WBS 1.1A	Delivery of TF02/03 to IO	EU	April 2016
WBS 1.1A	Delivery of TF16/TF17 to IO	EU	November 2016
WBS 1.1A	Delivery of TF15 to IO	EU	February 2017
WBS 1.1A	Delivery of TF19 (spare) to IO	EU	May 2017
WBS 1.1A	Delivery of the TF coils (9) in IO	JA	End 2016



DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

The design can be considered at an adequate level to start the qualification phase. The TF coils design have been subjected to many design reviews.

During the final readiness review held in April 2008 in Naka (Japan), the review committee recommended the start of the qualification activities, identifying a number of analysis activities for IO to carry out in parallel. It was recommended to address the following aspects:

- Lack of quality system for the magnet design & analysis;
- No assessment of the capacity of the quench detection system to detect a quench in dynamic conditions;
- Lack of an efficient and recognised drawing management system within IO;
- Some of the tolerances are very demanding.

Regarding the drawings, IO has produced a set of drawings that, although far from being a set of manufacturing drawings, contain sufficient information to fully identify the main tolerances for the component to build. Some of these tolerances seem very demanding and it is not certain that can be achieved, but this is difficult before having gained some experience with the manufacture of a full size DP prototype.

At present there are still some analysis activities ongoing at IO concerning aspects like the neutron heat load and quench detection optimisation, that do not affect the design of the coils. The performance of the TF conductor has been validated with successful tests in the SULTAN facility. Two valid options for the radiation resistance resin have been developed and they are presently under final qualification. Tests to qualify the resins for the impregnation of the TF coils are in advanced state.

MANUFACTURING READINESS

The TF Coils are defined "build-to-print" but much pre-qualification work needs to be done in the early phase of the procurement in order to address the main technological uncertainties. On this type of coils, an intense R&D, between 1995 and 2002, was carried in the EU. In particular a reduced size (1:3) TF model coil (TFMC) was manufactured and successfully tested. Although the design of the TF coil has not changed substantially since then, the size difference leaves many aspects that are still to be addressed for the full size coils, as, for example, how to:

- manufacture a radial plates with such large dimensions and such tight tolerances (in the TFMC the radial plate was manufactured from a single steel plate, this is not possible for the full size);
- wind the double-pancake on the two sides of the winding mould;
- transfer into the two sides of a radial plate a double pancake wound in a single conductor length;
- reach such tight tolerance on the straight leg of the winding pack (0.5mm planarity over a 10m long straight leg).

These issues are being addressed by manufacturing prototypes of the most critical components, as described in the paragraph on procurement strategy.

ASSESSMENT OF RISK: see Annex II

R&D AND QUALIFICATION ACTIVITIES

The qualification activities will be carried out in the phase I of our procurements. They are organised as described below:

Radial Plate

The main scope of the R&D and qualification activities for the radial plate is:

1. Manufacture of Two Prototype Radial Plates (one side and one regular), each manufactured with a different technology. It is important to note that JADA will produce a third radial plate prototype utilizing a third different technology.
2. Identification of a viable manufacturing route for the radial plate, aimed to minimise the cost of the final production of 50+20 radial plates (the "Optimized Manufacturing Plan"). This includes the production of a report containing a detailed description of work-flow and an optimised manufacturing plan with estimated costs and schedule.

Winding Packs

The scope of the R&D and qualification work on the winding pack defines that in this phase the supplier shall:

- Qualify the manufacturing process, the tooling and the supplier by carrying out manufacturing trials and by manufacturing mock-ups and a double pancake prototype;
- Set up adequate facilities and tooling in order to support the series production of the coils according to the required schedule.

During this stage, based on the experience gained during the manufacturing trials and mock-ups, the supplier may propose changes to the reference manufacturing process. A final set of manufacturing drawings and a final manufacturing plan will be produced.

The Coil Case Insertion & Cold Test:

For this work package, the R&D and qualification work will consist of:

- Case Closure Welding Qualification;
- Case Closure Weld NDT Qualification;
- Full size Inner Leg – Case Mock-ups.

The first two tasks are part of a single call for tender.

The following table lists the planned qualification activities.

Work	R&D and Qualification activities	Status
Industrialisation and cost optimisation	Cover Plate Welding and Associated Distortion	Call for tender launched. Contract signature foreseen for March 2010.
	Radial Plate Subsections	Lot 1: Assigned. Contract signed Sept.2009. Lot 3: Negotiated procedure in progress. Contract signature foreseen December 2009.
	Radial Plate Subsection Joining	
	Insulation Impregnation Trials	Call for tender launched. Contract signature foreseen for March .2010.
	Conductor Transfer and Insulation Tooling and Qualification	
	Winding Machine and Winding Trials	
	Conductor Heat Treatment Trials	
	Full Size Joint Samples	
	Termination Region Mock-up	
	Helium Inlet Manufacture and Test	
	Full size Inner Leg – Case Mock-up	
	Case Closure Weld Procedure Development and Qualification	Call for tender launched. Contract signature foreseen for Nov.2009.
Preparation of Manufacturing Drawings		Call for tender launched. Contract signature foreseen for March 2010.
Manufacture of a Full Size Dummy Regular Double Pancake		Call for tender launched. Contract signature foreseen for March 2010.

PROCUREMENT STRATEGY

BACKGROUND INFORMATION

The most important aspects of the TF coils procurement are:

o Radial plates

- Two types of radial plates: for the F4E production where are 50 regular radial plates and 20 side radial plates.
- A radial plate of these dimensions has never been fabricated: it cannot be machined by a single plate.

o Winding packs

- The “Wind, react and transfer” technology has never been applied to such a large coil.
- The R&D and fabrication requires F4E to be working very closely with a supplier to jointly develop the correct technological solutions.

- o Coils insertion
    - Huge facilities are required due to the large dimensions and weight of the coils (300 tons)
    - There is the potential to realise savings by sharing facilities with JA DA

The market environment in which F4E has to procure these components has the following characteristics:

1) There is only one supplier that might be willing and is capable of taking over the whole production chain (e.g radial plates, winding pack and insertion of the coil in the case). Therefore there is a monopoly situation that might pose risks to F4E in terms of pricing.

2) It is very unlikely that a single company can be found with the availability of facilities large enough to contain the large number of tools required to build the coils with the required production rate.

THE STRATEGY

Based on an analysis of the market and technical environment and the risk assessment, F4E has defined a strategy based on the following main points:

- Procurement split in three smaller and more manageable work-packages in order to increase competition. This allows one to move from a monopoly situation to 3-4 potential suppliers for the winding pack and seven potential suppliers for the radial plates.
- Develop synergy with JAEA in order to obtain:
    - o Alternative technological routes during the qualification phase so as to maximize number of options to be investigated;
    - o Common suppliers and facilities during the production phases in order to minimise costs.
- Usage of phased approach, with prequalification phases and thereby postpone the large financial commitments required for final production until after the qualification has been completed, noting that this can be only be partially applied because of the schedule requirement and need to overlap qualification and production stages.

A description of the different work packages is reported below:

RADIAL PLATES

- RADIAL PLATE PROTOTYPE

    Call for tender: Open Procedure.

    Carried out in parallel by JADA and F4E.

    F4E produces two radial plates prototypes (1 regular and 1 side), while JAEA produces one regular.

    Manufacturing routes selected for the three prototypes to be different in order to explore different routes to find cheapest and best quality option.

- FULL PRODUCTION of 70 (F4E)+ 63 RPs (JADA)

    After completion of the RP prototypes, the call for tender for the series production will be based on all technologies that demonstrated to be successful with the prototypes. At that point F4E can decide whether to go alone or together with JAEA depending on the opportunities that will develop at that time.

- WINDING PACKS

Production of ten WPs split in three phases (Phase I: qualification phase, Phase II: first of a series, Phase III: series production) carried out by the same suppliers.

Open Procedure

If, based on the results obtained during the R&D & pre-qualification phase, the manufacturing process or design need to be changed, the price can be negotiated based on pre-agreed hourly rate and measured additional costs. Sharing of risks: F4E bears the technological risks, the supplier the engineering risks.

- COLD TESTS AND INSERTION OF 10 COILS IN CASE

Open Procedure

Procurement split in phases in order address the most critical issues at an early stage:

Phase 1: Qualification Coil Case Welding Technology and NDT methodology;
Phase 2: Qualification of the technology on full size mock-ups;
Phase 3: Construction of the facilities;
Phase 4: Production.

Phase 3 and 4 will be carried out by the same supplier. The same supplier (in EU) shared by F4E and JADA.

Work	**Production activities**	**Status**
Construction of ten Winding Packs	o Construction of 70 Double Pancake modules. o Stacking and impregnation in groups of 7 to form a Winding Pack o Delivery to the Coil-Insertion premise	Call for tender launched. Contract signature for Phase I foreseen for March 2010
Cold Test, Coil-Insertion and case welding	o Engineering study to define processes on : o Cold Test o Coil Insertion o Case welding	Call for tender to be launched in February 2010. Contract signature foreseen for July 2010.
	o Construction of Facilities and Tooling.	Call for tender to be launched in July 2011. Contract signature foreseen for January 2012

MAGNETS - PF COILS	WBS 1.1.3 41.4 kIUA

SHORT DESCRIPTION

The Poloidal Field system consists of six large solenoidal coils, PF1 through PF6, which will be used to start-up, shape, operate and shutdown the plasma of the ITER tokamak. The PF coils will operate up to a peak field in the order of ~6-7 T, thus requiring the use of NbTi strand in the conductor and cooling by supercritical He (4.5 K). These magnets will then be built with the Wind and Insulate technique. The Cable-In-Conduit Conductors (CICC), made of over 1,200 NbTi and copper strands, are wound two-in-hand, due to the long length of the conductor, to form double pancakes (DP). The conductor is electrically insulated by wrapping two half-lapped layers of dry glass/polyimide tape. The double pancakes are then insulated with several layers of half-lapped glass-polyimide tape and vacuum pressure impregnated with epoxy resin. Finally, the coil winding pack is formed by stacking several double pancakes together, insulating the stack with 7 mm of half-lapped glass-polyimide tape followed by vacuum pressure impregnation (VPI). After impregnation of the winding pack and completion of the terminal area with the electrical terminals, inter-pancake joints and DP jumpers, the cryogenic supplies and the instrumentation, the support clamps with the cover plates will be installed around the windings. The total weight of each coil with support clamps is in the range of 300-400 tons.

The size of the PF coils ranges in diameter from ~8 m to ~24, therefore 5 PF coils (PF2 to PF6) will be manufactured in a winding facility provided on site by the EU, while the upper and smaller coil PF1 will be provided by RF.

WBS	EU obligation	Design type	Other DA involved/remarks
WBS 1.1.3	Manufacture of five PF coils. An additional obligation, not credited yet, is the cold test for the five coils, including construction of the facilities.	Build to print although no previous fabrication experience.	The support clamps will be provided by CN. The conductors for these coils will be supplied by EU, CN and RF.

PROCUREMENT ARRANGEMENTS PLANNING&STATUS

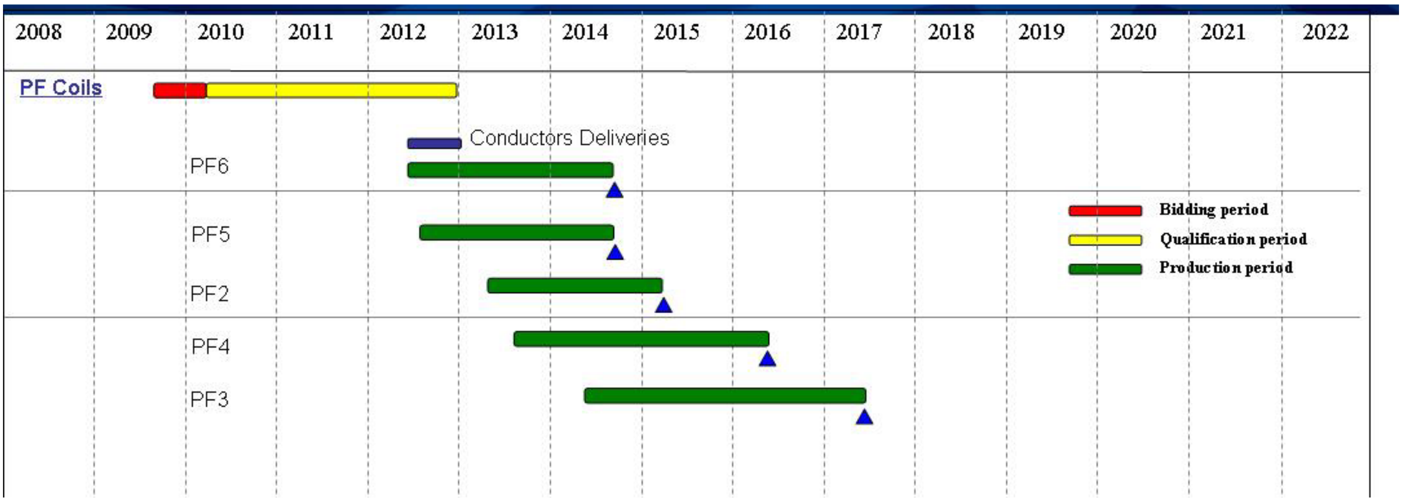
PA Title	PA signature	Credit (kIUA)
PF Coils 1.1P3A-B.EU.01	June 2009	41.4*

* Extra credit to be awarded in the PA (following PCR-164) for two double pancakes added to PF2 and PF6 coils

MAIN MILESTONES

WBS	Milestone	DA responsible	Expected date
WBS 1.1.3	Contract signature for PF coils	EU	April 2010
WBS 1.1.3	Delivery of conductors from EU	EU	End 2012
WBS 1.1.3	Delivery of conductors from CN	CN/IO	Mid 2014
WBS 1.1.3	Delivery of conductors from RF	RF/IO	End 2012
WBS 1.1.3	Delivery of clamps from CN	CN/IO	End 2016
WBS 1.1.3	Instrumentation delivery	IO	Mid 2014

WBS 1.1.3	Qualification mock-ups for PF coils	EU	March 2012
WBS 1.1.3	Qualification phase for PF5	EU	September 2012
WBS 1.1.3	Qualification phase for PF6	EU	December 2012
WBS 1.1.3	Qualification phase for PF4	EU	April 2014
WBS 1.1.3	Delivery of PF5 to IO	EU	September 2014
WBS 1.1.3	Delivery of PF6 to IO	EU	September 2014
WBS 1.1.3	Delivery of PF2 to IO	EU	February 2015
WBS 1.1.3	Delivery of PF4 to IO	EU	May 2016
WBS 1.1.3	Delivery of PF3 to IO	EU	June 2017



DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

The design can be considered at an adequate level to start the qualification phase. The PF coil design has been subjected to several design reviews.

During the final design readiness review held in February 2009 in Cadarache (France), the review committee recommended a series of design and analysis actions to be completed before the signature of the PA. In particular, it recommended that the following aspects be adressed:

- Winding pack stress and fatigue analysis: this requires incorporating the loads and stresses from 3D models (including vertical loads, ripple field loads and moments applied by the tilt of TF coils) into results obtained with 2D models. Residual stress effects were also recommended to be considered;
- Conductor tail analysis: this involved demonstrating through analysis that the current design of the conductor tail fulfils the stated mechanical objectives and meets the stress design criteria;
- Other mechanical and design issues, such as the instrumentation and the quench detection system, have

been pointed out, but they can be studied and resolved by IO after the signature of the PA.

Regarding the drawings, IO has produced a set of drawings that, although do not constitute a set of manufacturing drawings, contain sufficient information to fully identify the main tolerances for the component to build. Some of these tolerances appear very demanding and it is not certain that they can be achieved, but this is difficult to assess this before having gained some experience with the full size DP prototypes.

At present there are still some design and structural analysis activities in progress at IO which do not affect substantially the design of the coils.

The performance of the PF conductor has been validated with the successful test of the PF Insert in the Naka CSMC facility in 2008.

MANUFACTURING READINESS

The PF Coils are defined “build-to-print” but a significant amount of pre-qualification work needs to be done in the early phases of the procurement in order to address the main technological uncertainties. On this type of coils not so much R&D has been carried out in the EU, except for the manufacture of the PF conductor insert, where some of the manufacturing procedures and technologies could be tested, but the design and size of the coil were considerably different. Experience has also been accumulated in the EU for the manufacture of thick-walled square conductors. However, the large size difference leaves many aspects still to be addressed for the full size coils, as, for example:

- How to wind two-in-hand double pancake with such a heavy wall conductor, large dimension and such tight tolerances of planarity (of the order of 2 mm)
- How to wind the double-pancake on the two sides of the winding mould;
- How to impregnate such a large winding under vacuum.

In order to address these aspects before starting the final production, three procurement phases for the PF coils have been identified (according to the PA definition):

- Phase III: During which many mock-ups are manufactured and tested to qualify the main components. This will also serve as a qualification for a good part of the manufacturing process, tooling and supplier;
- Phase IV: During which full size Double Pancake (DP) modules are manufactured;
- Phase V: Series production of the five PF coils.

R&D AND QUALIFICATION ACTIVITIES

The qualification activities will be carried out in Phase II, which is defined in Annex B of the Procurement Arrangement 1.1P3A-B.EU.01. During this phase the supplier shall:

- Design and procure the tooling for the construction of the winding pack according to the specifications presented in this document;
- Qualify the manufacturing process and tooling by carrying out manufacturing trials and by manufacturing mock-ups and a double pancake prototype;
- Set up adequate facilities and tooling in order to support the series production of the coils within the required schedule.

During this stage, based on the experience gained during the manufacturing trials and mock-ups, the supplier may propose changes to the design and to the reference manufacturing process. A final set of manufacturing drawings and a final manufacturing plan will be produced. Only one supplier will be selected to carry out the full manufacture of the five PF coils. The following table lists the qualification activities planned in Annex B of the Procurement Arrangement. These activities will have to be completed by March 2011 in the frame of the Qualification Mock-up phase.

Item	**Acceptance point**
Helium inlet fabrication qualification test report	HP
Dummy joint fabrication qualification report	HP
Full-size joint fabrication test plan (each)	ATP
Full-size joint fabrication and test report (each)	HP
Turn insulation material qualification test report	ATP
Turn insulation 3x3 mock-up sample fabrication and test plan report	ATP
Turn insulation qualification tests report on 3x3 mock-up	HP
Tail qualification sample fabrication plan report	ATP
Tail qualification test report	HP

PROCUREMENT STRATEGY

Since the main work is winding, insulating, impregnating and final acceptance, it is recommended to use a single supplier for the whole manufacturing process to enforce its technical responsibility. This will also allow a more efficient and optimized use of the winding facilities and tooling required for the parallel manufacture of several coils. The supplier will be responsible to use the PF winding building provided by F4E under the PA 6.2.P2.EU.01.

A staged contract with first phases of R&D and qualification to mitigate the technological risks will be used. Cold testing, if approved by the ITER Council, will be carried out in a separate facility located next to the PF winding building. At this stage it is foreseen that this activity will be awarded to another, more specialized, supplier.

MAGNETS – PRE-COMPRESSION RINGS	WBS 1.1.2A 0.6 kIUA

SHORT DESCRIPTION

In order to suppress an undesirable "breathing" effect and ensure that the keys do not become loose in their slots, each TF Coil is put under a centripetal load of approximately 60 MN (30 MN at the top and bottom curved regions) at operating conditions by two sets of pre-compression rings. This pre-compression substantially reduces the toroidal loads in the intermediate OIS, thus increasing the machine fatigue life significantly beyond the 60,000 design cycles with an allowable defect size of 100 mm^2 in the bulk material. The requirements are:

- the resulting centripetal radial force applied as close as possible to the Inter Inner coil Structure (to minimize the load needed to maintain together the facing keyways during the pulse),
- a material with thermal expansion close to or higher than stainless steel (not to relax the assembly pre-load at operating conditions),
- a material with a Young's modulus lower than that of the case of the TF coils (to provide a higher elongation during pre-tensioning in order to minimize the influence of TF coil assembly tolerances and/or settlement effects) and
- eddy currents suppression (to eliminate heat dissipation at operating conditions due to magnetic flux variations).

Unidirectionally wound glass fibre/epoxy composite rings have been perceived as the most suitable due to their very high strength and electrical resistive nature. The material has significantly lower integrated thermal expansion compared with steel, but the high strength compensates it.

EU obligation	**Design type**	**Other DA involved/remarks**
Manufacture of 3 sets (including one spare set) of 3 Pre-Compression Rings. An additional proposal, not credited yet, is the manufacturing of 3 spare rings, as well as the construction of the full size testing facility and one prototype ring.	Build-to-Print	None

PROCUREMENT ARRANGEMENTS PLANNING & STATUS

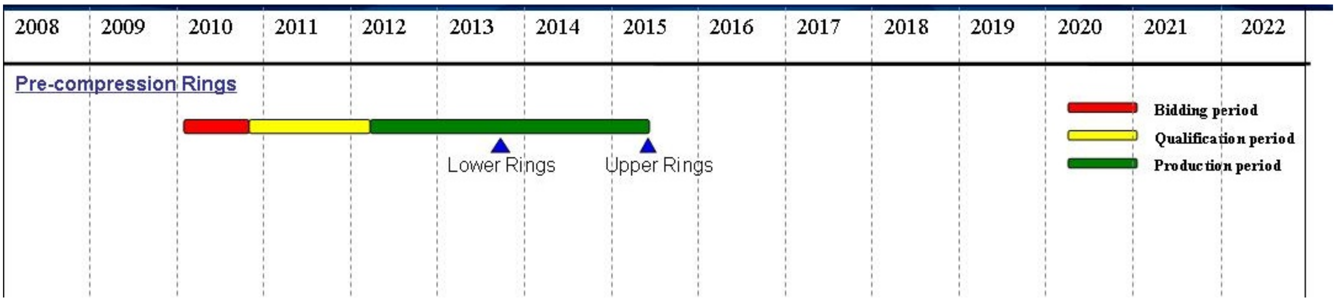
PA Title	**PA signature**	**Credit (kIUA)**
Pre-compression rings "1.1P2A.EU.01"	January 2010	0.6*

* This does not include DCR-48 changes (from 4 rings to 9 rings), prototype ring and testing, as well as 3 spare rings.

MAIN MILESTONES

WBS	**Milestone**	**DA responsible**	**Expected date**
1.1 2A	Manufacture and testing of full-scale prototype	EU	February 2012
1.1 2A	Delivery of 6 lower pre-compression rings to IO (3 + 3 spares)	EU	October 2013

1.1 2A	Delivery of upper 3 pre-compression rings to IO (proposal: + 3 spares)	EU	April 2015



DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

The design can be considered to be at an adequate level to start the qualification phase. The Pre-compression ring design was subjected to many design reviews.

Regarding the drawings, the IO is responsible for producing a set of drawings that contain sufficient information to fully identify the main tolerances for the component to be built. At present there are still some ongoing testing activities by IO concerning design and material performance aspects.

MANUFACTURING READINESS

The Pre-compression rings are defined "build-to-print", but much pre-qualification work needs to be done in the early phase of the procurement in order to address the main technological uncertainties. In order to address these aspects before starting the final production, three procurement phases have been identified for the Pre-compression rings.

- Phase I: Finite Element analysis with expert tools of composite behaviour, definition of best fabrication process to optimize performance; design, procurement installation, and commissioning of tooling; manufacturing drawings and procedures, process definition; full scale qualifying prototype; full mechanical characterization from samples extracted from the prototype; development of adequate NDE techniques.
- Phase II: Fabrication of full scale ring, NDE and rupture test.
- Phase III: Serial fabrication.

These three phases may be overlapped, with the principle that none of the manufacturing steps of a subsequent phase will start before the same manufacturing step has successfully carried out in the previous phase.

R&D AND QUALIFICATION ACTIVITIES

The qualification activities will be carried out in the Phase I of the procurement. The objectives of Phase I are to choose the best fabrication process to optimise the mechanical performance during the 20 years of design life, design and build adequate tooling, qualify processes and determine the rupture stress of the first of the series produced ring. The following sub-tasks are needed to be carried out:

- FE analysis of composite behaviour
- Design definition and best fabrication process to optimize performance
- Rupture test program

- Design, qualification and commissioning of final tooling
- Materials qualification
- Development of adequate NDT techniques
- Full scale qualifying prototype
- Full mechanical characterization from samples extracted from the prototype
- Full characterisation of composite

PROCUREMENT STRATEGY

Based on an analysis of the market and technical environment and the risk assessment, the procurement strategy is based on the following main points:

- One single procurement which includes the final design / qualification and the manufacturing of the rings.

- A phased approach to release the final production only after the qualification is completed; although this may be only applied partially due to the need to overlap qualification and production stages (same raw materials with limited shelf life will be used).

MAGNETS – PF AND TF CONDUCTORS	WBS 1.1.6A & 1.1.6C 54.62kIUA

SHORT DESCRIPTION

Procurement Type: Build-to-Print for the design and layout of the conductor; functional specifications for the strand.

EU Contribution and Sharing:

The EU will supply around 14% of the PF conductor (equivalent to about ¾ of a coil). They will be used for the PF6 coil. Other conductor lengths for the PF6 will be provided by RF and for the PF2 to PF5 coils by CN.

For the TF conductor the EU will supply around 20% of the total amount (equivalent to about 4 coils). Other conductors for the EU TF coils will be provided by CN, RF and US.

Procurement Strategy:

PF conductor: The Procurement Arrangement 1.1P6C.EU.01.0 for the manufacture of the PF conductors was signed on 4th May 2009. On the basis of a bilateral agreement with the RF-DA signed in September 2009 (Procurement Implementation Agreement, PIA), the NbTi cables will be supplied by RF whereas EU will provide jacketing for all conductor lengths of PF1 and PF6 coils.

TF conductor: The Procurement Arrangement 1.1P6A.EU.01.0 was signed on 18th December 2007. The procurement has started and is sub-divided into four main contracts to meet the schedule and minimise risks:

- One supply contract for Cu strand signed in April 2009;
- Two supply contracts for Nb_3Sn strand in order to meet the schedule and reduce risks of manufacture; a first contract was signed in August 2009 and the second one is expected to be signed by the end of 2009.
- One single contract for cabling/jacketing including jacketing for both PF conductors; the call-for-tender has been launched in August 2009.

The PF and TF conductor unit lengths to be provided by EU are listed below.

WBS	EU obligation	Design type	Other DA involved/remarks
WBS 1.16C	10 PF conductor unit lengths for PF6, which need about 40 tons of superconducting NbTi strand. EU will provide jacketing for all conductor lengths of PF1 and PF6.	Build to print	The NbTi cables will be supplied by RF. The conductors for the coils PF2 to PF5 will be supplied by CN and about 2/5 of PF6 conductors by RF.
WBS 1.16A	27 TF conductor unit lengths (for about four TF coils), which need about 95 tons of superconducting Nb3Sn strand and 70 tons of Cu strand.	Build to print	The conductors for these coils will be supplied by EU, CN, RF and US.

PROCUREMENT ARRANGEMENTS PLANNING & STATUS

PA Title	PA signature	Credit (kIUA)
PF Conductor	May 2009	11.23
TF Conductor	December 2007	43.39

MAIN MILESTONES

WBS	Milestone	DA responsible	Expected date
TF coils			
WBS 1.1.6A	Contract signed for Cu Strand Production	EU	April 2009
WBS 1.1.6A	Contract signed (supplier A) for SC Strand Production	EU	August 2009
WBS 1.1.6A	Contract signed (supplier B) for SC Strand Production	EU	November 2009
WBS 1.1.6A	End of Cu strand production	EU	April 2011
WBS 1.1.6A	Delivery of conductors from EU	EU	End 2013
WBS 1.1.6A	Delivery of conductors from CN	CN/IO	End 2013
WBS 1.1.6A	Delivery of conductors from RF	RF/IO	End 2013
WBS 1.1.6A	Delivery of conductors from US	US/IO	End 2014
PF Coils			
WBS 1.1.6C	NbTi strand delivery	RF	
WBS 1.1.6C	Conductors for PF6 coils delivery	EU/RF	End 2012
WBS 1.1.6C	Conductors for PF5 & PF2 delivery	CN	Middle 2013
WBS 1.1.6C	Conductors for PF3 & PF4 delivery	CN	Middle 2014

DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

The designs of the PF and TF conductors are ready. Both conductor layouts were updated from the FDR2001 designs. For the PF conductor the update was due to more detailed thermohydraulic and superconductor analyses. In the case of the TF conductor, the diameter was increased and the strand design was updated to achieve higher critical current density and improved superconductor performance. The PF conductor layout is very similar to that of the conductor used for the manufacture of the PF Conductor Insert coil. The current design of the TF conductor was qualified by several successful Conductor Performance Qualification Sample (CPQS) tests at the SULTAN facility.

MANUFACTURING READINESS

The manufacture of PF and TF conductors is based on similar conductors respectively produced for the PF Conductor Insert coil and for the TF model coil.

The main manufacturing process steps for both PF and TF conductors are:

- The supply of standard NbTi (PF) and copper and Nb_3Sn (TF) strands;
- The cabling of the strands - this is a complex process (five cabling stages) but it should be a standard procedure. Previous R&D activities already provided around 100 m of such cables;
- The jacket assembly includes the welding of thin-walled stainless tubes by means of standard orbital TIG machines without filler material (for TF conductors) and with a suitable filler material (for PF conductors);
- The Jacketing and Compaction step includes the insertion of the cable into the jacket. This insertion seems to be challenging on such a length (~ 800 m), although this was already performed in Russia in the past.

In the case of PF conductors, both NbTi strands and cables will be supplied by RF-DA in the frame of the PIA. F4E will take care of jacket assembly, jacketing and compaction of the conductors.

R&D AND QUALIFICATION ACTIVITIES

The supply of PF and TF conductors will be based on a vigorous process qualification. The scope of the process qualification is the manufacture of copper dummy and superconductor qualification lengths. The copper dummy produced at this stage will later be used by the coil manufacturer to perform winding trials. The exact scope of activity for the conductor manufacturing process qualification is as follows:

- To produce Cu dummy qualification lengths;
- To produce superconductor conductor qualification lengths.

The process qualification lengths shall be manufactured in agreement with the subcontractors, the component design and the work schedule that will be disclosed to F4E and that will be used by the supplier throughout the whole conductor production. The production steps of the copper dummy qualification lengths shall be interspaced with a number of Procedure Qualification Notification and Hold Points in order to allow for a close follow-up by F4E.

Qualification of Cu dummy conductor

Cabling procedure qualification

The purpose of this qualification is to make sure that the proposed cabling procedure and the nominal cabling twist pitches are capable of providing cables with the required properties and to validate the cabling interface with the jacketing operation, especially the extent to which the cable is pre-compacted before insertion into the jacket and final compaction steps.

Weld procedure qualification

The welding of empty jacket sections shall be qualified in accordance with ASME requirements. Three full size butt weld specimens shall be qualified under tensile load at room temperature after 8 % of cold work and, for the TF jackets only, aging for 200 hours at 650 °C. Additional bending tests shall also be performed. Tensile tests shall be performed on at least three butt weld specimens in helium cryogenics environment after at least 8 % cold work and, for the TF jackets only, aging for 200 hours at 650 °C. For the PF conductors only, low-cycle fatigue tests shall also be performed on at least three butt weld specimens in helium cryogenics environment after 8 % of cold work. After at least 30,000 cycles to 500 MPa, all three samples are required to retain mechanical integrity. Following the fatigue test, NDE/NDT tests shall be repeated. Upon completion of the qualification tests, the supplier shall request a Weld Procedure HPC before proceeding to the assembly of the Cu dummy jacket.

Cable insertion procedure qualification

The purpose of the cable insertion procedure qualification is to establish that the proposed cable insertion procedure and jacketing line are capable of providing conductors with the required properties. The insertion of the cable into the jacket is performed by pulling the cable through the conduit on the straight bench. The cable is attached at one end to a pulling rope or cable of smaller dimension which is used for pulling through the jacket. The rope attachment design shall be such that contamination of the cable by external material (e.g. brazing) is not possible. The use of lubricant to ease the cable insertion is prohibited. The cable tension shall be monitored to confirm the absence of abrupt changes that could indicate possible strand damage. Once the procedure is qualified, an upper limit of the pulling force to be applied during production will be derived by common agreement with F4E. The minimum qualification length will correspond to the maximum length that needs to be fabricated during the production phase of a conductor type (i.e. between 700 and 800 m for both PF and TF conductors).

Conductor compaction and spooling procedure qualification

The purpose of this qualification is to establish that the proposed jacket dimension prior to compaction, compaction procedure and equipment and spooling equipment are capable of providing compacted jackets with the required dimensions and to achieve the define void fraction and the maximum pressure drop.

Qualification of superconductor

Cabling, Jacket manufacture and jacketing of the conductor qualification lengths shall be carried out following the qualified procedures. Once the superconductor qualification length is produced and all relevant documents submitted to F4E, the Conductor Hold Point Clearance shall be requested.

PROCUREMENT STRATEGY

For the **PF conductor**, the main activities performed are:

- Supply of NbTi and Cu strand;
- Cabling;
- Supply of Jacket material;
- Jacketing and Compaction;
- Strand Performance Verification Test.

The procurement strategy is based on the PIA between F4E and the RF-DA. It provides a common strategy for F4E and the RF-DA deliveries for the PF1 and PF6 conductors. Following the same principle as for the PFCI Coil Project, it is foreseen that F4E receives the complete cables from the RF-DA and in exchange performs the jacketing and compaction of all PF1 and PF6 conductor unit lengths which fall under the responsibility of F4E or the RF-DA through the PAs 1.1.P6C.EU.01 and 1.1.P6C.RF.01. As a consequence, the fabrication of the PF conductors will be based on the following contracts:

- Conductor Supply Contract
  Main contract covering the procurement of jacket sections, jacketing and compaction, transportation of all conductor unit lengths and final acceptance tests.
- Strand Performance Verification Test
  One contract covering the standard strand tests (Ic, losses) and the extended strand characterization (Ic(B,T)) as specified in Annex B of the PA.
- Conductor Sample Manufacture
  One contract covering the sample preparation for the full size conductor tests at the SULTAN facility.
- Conductor Test

One contract covering the conductor tests at the SULTAN facility.

- PIA – Bilateral agreement
  The supply of NbTi and Cu strand plus cabling will be provided by RF-DA as free-issued items.

No staging of the contracts are foreseen. The main conductor supply contract is combined with the supply of F4Es share of the ITER TF conductors and the JT-60SA conductors due to economic considerations. According to the PA, the successful completion of a CPQS is a precondition to the start of Phase II. The complete cable for the CPQS is expected to be delivered by RF DA in November 2009. The contracts for the preparation of the sample and the test in the Sultan facility are being processed.

For the **TF conductor**, the main activities performed are:

- Supply of Nb_3Sn and Cu strand;
- Cabling;
- Supply of Jacket material;
- Jacketing and compaction;
- QC tests.

The TF conductor procurement into three main groups of contracts:

- Strand (Cu and superconducting);
- Conductor (cabling, jacketing, jacket material);
- QC (single strand tests, Sultan sample tests, follow-up).

The rationale for having separate strand contracts is the following:

- The superconducting strand production is seen as the most critical one in view of production time and costs. A direct control through F4E is required in order to react quickly in case of problems.
- There are few potential strand suppliers in Europe. Pure strand contracts enable the best competition among them and taking into account that the strand costs are more than two third of the total costs, a real competition is essential. For this purpose, the Call for Tender was launched worldwide.

Strand Procurement

Three separate contracts are planned: one for the Cu and two for the superconducting strands.

Cu Strand

The TF conductors require about 62 tons of Cr plated copper strand. This amount includes the dummy conductor length of Phase I and excess material to cover losses during conductor manufacture. The specification is fixed and not dependent on any qualification or stages.

Tendering procedure:
Best value-for-money procedure. The contract was awarded in April 2009.

Options: An option was added to the contract allowing for more material to be ordered at a fixed price per unit (i.e. ton) in case the IO requests it. The option should foresee extra material up to 50 % of the contractual amount with the same production capacity (tons per month).

Superconducting Strand

About 95 tons of Cr plated Nb_3Sn strands are required which include 15 % of excess material to cover losses during conductor manufacture. This is one of the most critical components of this PA. In order to reduce the risk of late deliveries and delays in the project, at least two different strand suppliers will be involved in the supply of strands for the EU TF conductors.

Tendering procedure:
Two technically acceptable suppliers will be selected. A strand type is qualified by having a T_{cs} in a full size conductor Sultan sample of >5.7 K + tolerance. In case one supplier cannot fulfill its contractual commitments the second supplier can take over the supply without delays. A first contract for ~60 % of the total strand amount was awarded in August 2009. A second contract for the remaining quantity will be awarded in the coming months.

Conductor Manufacture

One contract is foreseen for the manufacture of 19 regular double pancake conductors (rDP), eight side double pancake conductors (sDP) and two dummy lengths required for the qualification of the jacketing and winding lines. The Cu and superconducting strand will be provided by F4E. All other components have to be procured in the frame of this contract:

- Cabling including tooling (if not existing);
- Installation of jacketing line;
- Welding;
- Procurement of jacket tubes, wraps and spiral;
- Insertion, compaction, leak testing and spooling.

Build-to-print specification is available and qualification is complete.

Tendering procedure: Best value-for-money procedure.

Options: An option will be added allowing ordering more material at a fixed price per unit (i.e. sDP and rDP unit length) in case the IO requests it. The option should foresee the production of up to eight additional rDPs and 8 additional sDPs with the same production speed (DPs per month).

Quality Control

The actual number of separate contracts will depend on the tenders. It is assumed that there will be least four contracts.

<u>Strand QC</u>

The strand QC is divided into the following parts:

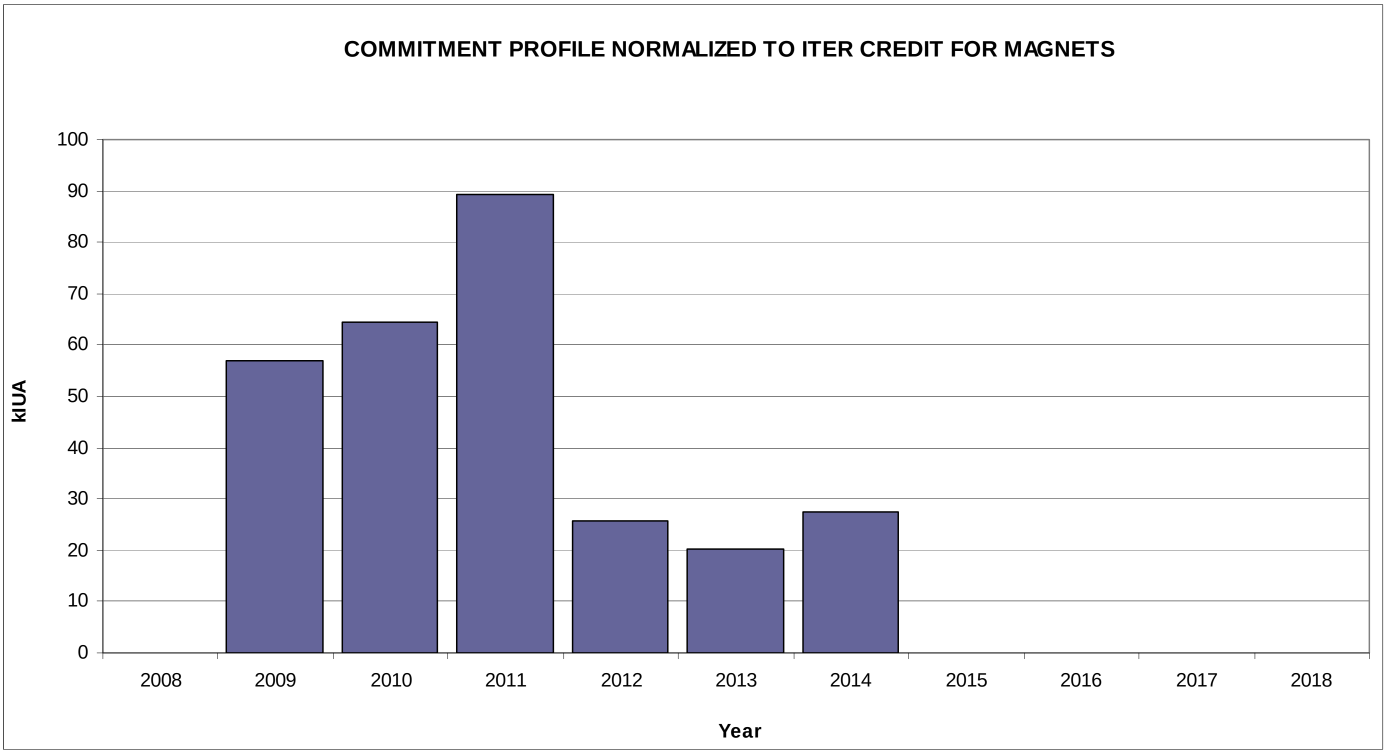
1) Extended strand characterization ($J_c(B, T, \varepsilon)$) of the ITER TF strands.
Sampling: Each strand type once every year.
2) Cross-checking of acceptance tests (I_c, layout, losses)
Breakdown: ~1500 I_c samples
~700 layout samples
~700 hysteresis loss samples

<u>Conductor QC</u>

According to the PA at least six full size SULTAN sample tests are required. The SULTAN sample assembly and testing will be done according to the agreed specification. The conductor QC is divided into the following parts:

1) Sultan samples assembly;
2) Sultan samples tests;
3) Test evaluation.

NORMALIZED COMMITMENT PROFILES – MAGNETS



VACUUM VESSEL	**WBS 1.5** **99.36 kIUA**

SHORT DESCRIPTION

The Vacuum Vessel (VV) is a torus shaped double wall structure divided in nine sectors to be joined at ITER site. Among the primary functions of the VV are the provision of a high quality vacuum for the plasma and the first confinement safety barrier of radioactive materials. Because of this it is required to be manufactured to high standards, using the RCC-MR Code, and supervised by the Agreed Notifed Body, selected by the French Nuclear Authorities. The VV also supports the in-vessel components and their loads during operation. Along with other in-vessel components, the VV provides adequate radiation shielding against overheating of the Superconducting Coils. The main components that make up the VV are the main vessel, the port structures supplied by the RF-DA and KO-DA and the in wall shielding plates, IWS, supplied by IN-DA. The port structures are used for equipment installation, utilities, vacuum pumping, and inside access. The VV ports consist of the port stub, which is integral to main vessel, the stub extension and the port extension. The weight of each sector is about 450 tons, comprising of 240 tons of stainless steel fabrication and 210 tons of bolted-on IWS plates.

The contract is designated as build-to-print, with the VV Supplier having the responsibility of deciding the manufacturing method and manufacturing drawings. The Procurement Package 1.5 (Vacuum Vessel) comprises the following PAs:

- Main Vessel including Blanket Manifolds and Hydraulic Connectors with EU and KO;
- Neutron Shielding with IN: Equatorial and Lower Ports with KO: Upper Ports with RF.

EU procures and delivers to the IO site seven of the nine sectors, including the items from the other parties. The Procurement is divided into several contracts as follows in order of placement:

- Main Sector Contract, Seven Sectors. The supply includes the manufacture of the mock ups, the procurement of the material for Sector 5 and the engineering required for the whole of the seven sectors. The manufacturing of all the seven sectors and the procurement of material for the remaining six sectors are placed in stages;
- Blanket Manifolds;
- Ancillary Items, e.g., installation of instruments.

A modified procurement sharing between EU and Korea has been recently proposed. This would foresee a reduction from seven to six VV sectors to be manufactured by EU.

SCOPE OF THE SUPPLY

The scope of the supply for the procurement arrangement includes the procurement and delivery of seven Sectors (with features for ELM coils included) and nine sets of Blanket Manifolds (two to be sent to Korea).

To spread the commitment profile, the supply is split into 22 Stages, a first design stage followed by three stages for each Sector (5, 4, 3, 2, 9, 8 and 7). The three Stage types fro each Sector are as follows:

- **M -** Material procurement
- **D -** Manufacture of 'D' shape
- **F -** Sector Finishing

SUPPLY IN STAGES

<u>Stage 1 Scope of the Supply</u>

Design (for all sectors), Front-End Engineering and Mock ups

The scope of the Stage 1 supply includes all the following activities:

- Structural verification analysis;
- Compilation of IPR reporting;
- Derivation and engineering justification;
- Technical and management reporting;
- Planning and scheduling;
- Checking of design, manufacturing (including materials), welding and NDT required by the ANB;
- Development of NDT procedures;
- Manufacturing method and design;
- Procurement of jigs and fixtures for support and restraints for the control of distortion & testing;
- Detailed design and manufacturing drawings for all sectors;
- Front-End Engineering and mock ups.

<u>Scope of supply for the remaining stages</u>

For each Sector, there are three types of stages; material procurement, manufacture of 'D' shape and sector finishing. The scope of the remaining stages supply includes the procurement and delivery of all the items listed in Table 1 and comprises all the following activities:

<u>Material Procurement</u>

Material procurement will be subcontracted by the VV Supplier and will be followed up by F4E. Material procurement will include over-range quantity to allow for later mitigating actions in the event of reject problems.

<u>Manufacture of 'D' shape</u>

- Manufacturing of jigs and fixtures;
- Fabrication of 'd' shape sector;
- Preparation of assembly and testing manuals;
- Liaison and acceptance with in da and assembly into the sector of the free-issued shielding blocks;
- Quality assurance;
- Liaison with ANB.

<u>Sector Finishing</u>

- Liaison and acceptance with RF DA and KO DA and welding to the 'D' shaped vessel of the central port stub extensions;
- Cutting, Grinding, Surface finishing and machining of Support features and Sector edges;
- Leak and pressure testing;
- Installation of Inboard Manifolds and Instruments;
- Dimensional and Factory acceptance tests;
- Quality Assurance;
- Packing and transportation to Cadarache;
- Liaison and remote support with IO for the final inspection at Cadarache;
- End of Manufacturing report including certificate of compliance.

OPTIONS

Several options are included in the Tender related to material procurement, filler material, machining of splice plates etc.

STAGES DESCRIPTION

Stage 1

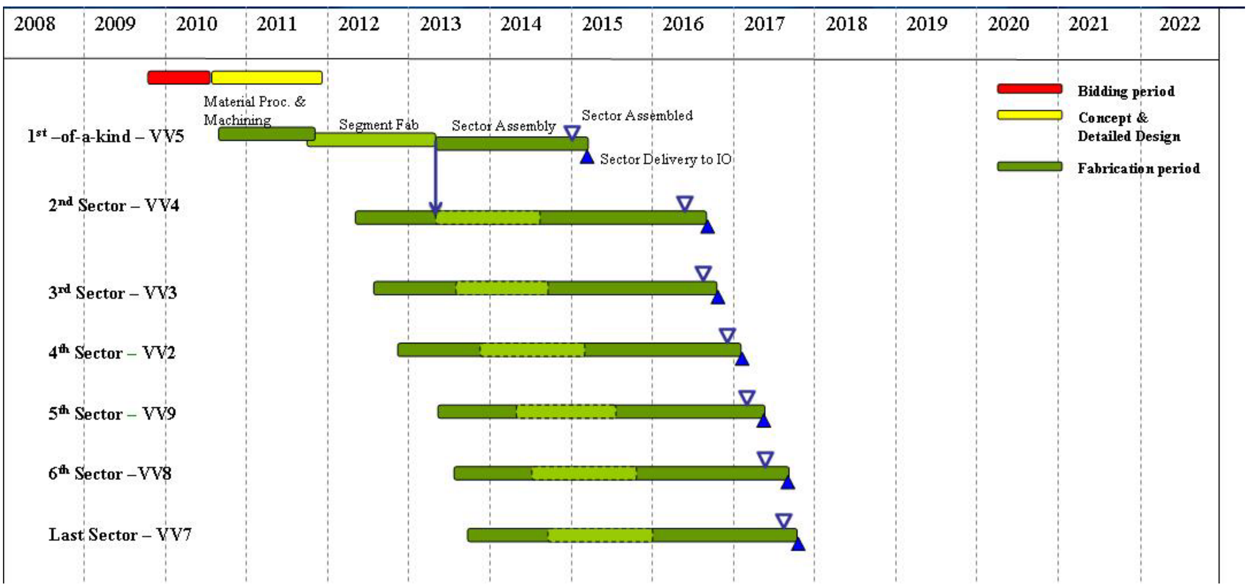
The scope of the Stage 1 supply comprises the design of all sectors, manufacturing of mock ups and Front-End engineering. The following items are delivered in stages.

Table1 Stages M, D and F for the supply of Hardware items manufactured and delivered by the Supplier

Stage Type	Description	Other DA involved/remarks
M	Material procurement for Sectors	Material Procurement will be Subcontracted by VV Supplier
D	Sectors Detailed Engineering and Fabrication (D shape)	IWS blocks will be delivered by IN DA.
F	Finishing Sectors (Weld port stubs, Pressure test, Vacuum test, Final machining etc.) & Delivery	Upper Ports Stub Extensions delivered by RF-DA. Lower Ports Stub Extensions delivered by KO-DA

PROCUREMENT ARRANGEMENTS PLANNING & STATUS

PA Title	PA signature	Credit (kIUA)
Vacuum Vessel Sector Production	November 2009	99.36



MAIN MILESTONES

WBS	Milestone	DA responsible	Expected Date (Delivery)
WBS 1.5 1A	Contract Signature for Main VV Sectors	EU	September 2010
WBS 1.5 1A	In-Wall Shielding delivery (segments 2,3,4 for Sector 5)	IN	October 2012
WBS 1.5 1A	In-Wall Shielding delivery (segment 1 for Sector 5)	IN	November 2012
WBS 1.5 1A	Start of Sector 5 Assembly	EU	April 2013
WBS 1.5 1A	Start of Sector 3 fabrication	EU	June 2013
WBS 1.5 1A	Sector 5 Delivery	EU	January 2015
WBS 1.5 1A	Start of Sector 9 assembly	EU	September 2015
WBS 1.5 1A	Sector 3 Delivery	EU	October 2016
WBS 1.5 1A	Sector 2 Delivery	EU	January 2017
WBS 1.5 1A	Sector 9 Delivery	EU	April 2017
WBS 1.5 1A	Sector 8 Delivery	EU	July 2017
WBS 1.5 1A	Sector 7 (last of 6 sectors) Delivery	EU	September 2017

DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

- Although the basic design is well established the design of the ELM coils still continues to alter the interface to the VV and will not be complete until the middle of 2010 so that that the final design will not be ready until contract placement. CAD models are an issue since the multi-body models issued by ITER have to be re-modelled by F4E to produce adequate 2-D models. Compliance with Safety Licensing requirements is well under way.
- An existing framework Contract will be utilised for for the improvement of the VV Technical Specification and the production of the 2-D drawings for the contract phase.
- A major concern remains the status of the VV load Specification and Stress Analysis. The analysis by ITER is not considered by F4E to be consistent and reproducible. If there are modifications to the original build-to-print design, it is the obligation of F4E and VV Supplier to justify these changes with analysis. At present this does not seem possible in a reasonable manufacturing time scale (2 weeks). Contracted work is ongoing to improve the situation with the preparation of FEM solid ANSYS models. However IO has stated that it is not possible to prepare an unambiguous load specification to be applied in a FEM model.
- The tight tolerances mean that there is a high probability of additional costs being incurred by F4E for rework and rejection.
- Partial full-scale Validation Mock-ups are planned for vital areas, such as segment joining and to allow for correct pre-compensation of welding distortion to achieve the tight tolerances.

Due to the risk that changes to the design through change notices to the supplier may be required by IO after contract signature, causing F4E extra costs which are difficult to control, IO has implemented an In Vessel to VV Interface Risk Assessment Workbook. The circumstances which may lead to significant later VV changes are as follows:

- Nuclear heating of TF coils too high;
- In-Vessel Coils to VV interface design may change;
- Blanket to VV interface design (including forces with thicker inboard modules);
- Inboard Manifolds overstress VV support point ;
- New, stiffer multilink VV supports present higher stress in VV.

MANUFACTURING READINESS

- All aspects of feasibility, fabricability, maintainability, etc. have been partially validated by R&D. Further R&D work is needed to further ratify the details of distortion analysis, UT inspection, material corrosion and treatment, and EB welding technology.
- The manufacturing capacity is already available and established but, due to the volume of work, it is likely that a consortium (in Europe) will be required to carry out the work.
- Due to the lack of a full-scale prototype during the R&D phase, absence of a fully qualified fabrication methodology that can achieve the prescribed tolerances is seen as a risk. For this reason the fabrication of the first sector i.e. Sector 5 will act as input to the remaining series production since fabrication of the next sector starts 16 months later.

ASSESSMENT OF RISK: see Annex II

R&D AND QUALIFICATION ACTIVITIES

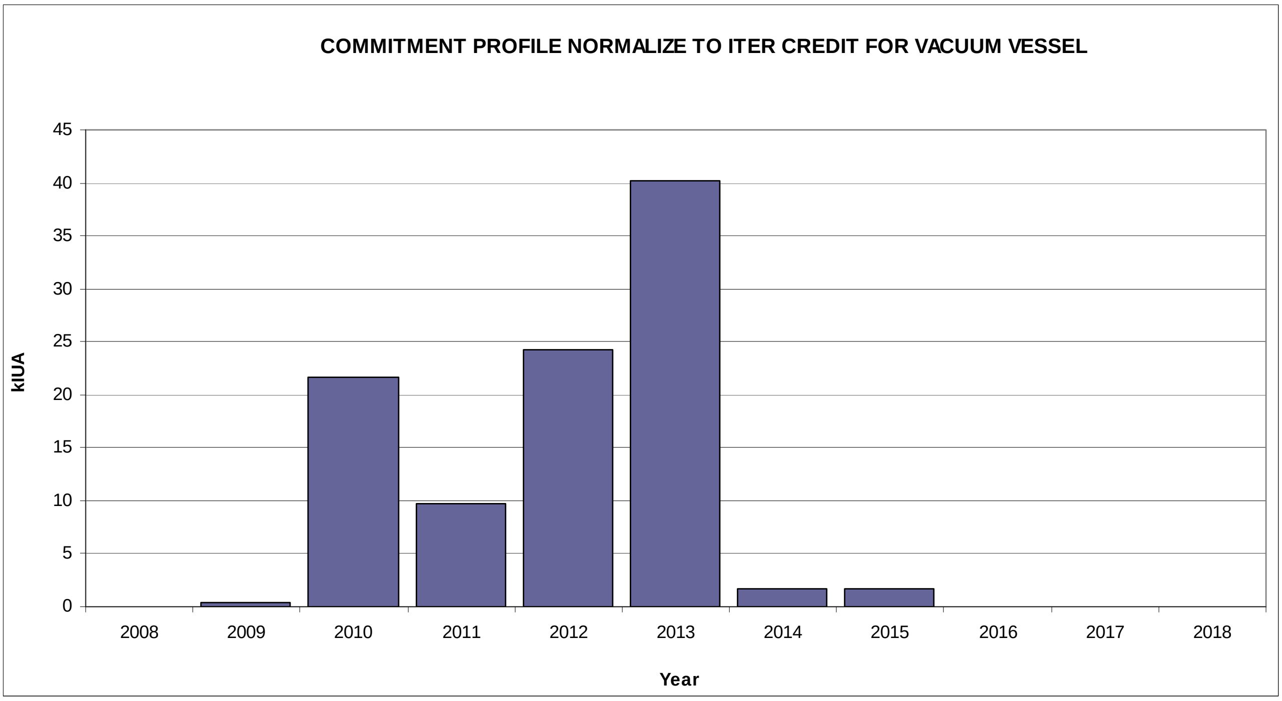
In order to reduce further this risk full-scale Validation Mock-ups are planned for vital areas, such as joining segments together (segment joining), vacuum surface, IWS, weld modelling, one-sided welding, local machining, special welding etc.

PROCUREMENT STRATEGY

- A schedule has been developed following the finished segment manufacturing route although the VV supplier will decide on the optimum method to be utilized for the manufacturing of the VV Sectors.
- Neutron Beam segment manufacturing difficulties (Sectors 2 and 3) have not been studied in detail due to late input from ITER.
- The cost assessment reflects the schedule assumptions, with the exception of some items (latest inclusion of ELM coils and difficulties of irregular sectors /NB ports).
- Due to the high number of parallel activities, it is likely that one company will not have the required capacity and so the main contract will be awarded to a consortium of companies
- Due to the lack of a full-scale prototype during the R&D phase, the fabrication of the first sector will verify the production parameters of the later sectors, starting 16 months later.
- Full-scale Validation Mock-ups will be produced for vital areas, such as joining segments together, vacuum surface, IWS, weld modelling, one-sided welding, local machining , special welding.
- Although the VV Supplier will decide on the optimum method to be utilized for the manufacturing of the VV Sectors the finished segment approach has been implemented in the project schedule
- Three lines of production for segments per each sector are requested.
- Sectors are assembled in three assembly lines, sharing erection frames with a three months average lag between subsequent sector fabrications.

Material pre-procurement is no longer required since world market conditions (recession) have reduced demand and production and delivery lead times

NORMALIZED COMMITMENT PROFILES – VACUUM VESSEL



COMMITMENT PROFILE NORMALIZE TO ITER CREDIT FOR VACUUM VESSEL
kIUA
45
40
35
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2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Year

Blanket First Wall	WBS 1.6 43.5 kIUA

SHORT DESCRIPTION

The original procurement package for the blanket modules (WBS1.6) was split into two packages: WBS1.6.1 A for the First Wall (FW) and WBS1.6.1 B for the Shield. The former procurement sharing for the ITER Blanket agreed at the Interim ITER Council of 11-12 July 2007 at Tokyo was split between 6 different Domestic Agencies (DA) and in particular the EU contribution for the blanket system was 30 % for the FW and 10% of the Shield. The corresponding ITER credits were 26.1 kIUA and 5.8 kIUA respectively. In order to decrease the fabrication cost and minimise the procurement risk, new procurement sharing proposals are under consideration within the Blanket Integrated Project Team (BIPT). The latest proposal available is as follows:

- FW: 50% EU, 40% RF, 10% CN,
- Shield: 50% CN, 25% US, 25% KO.

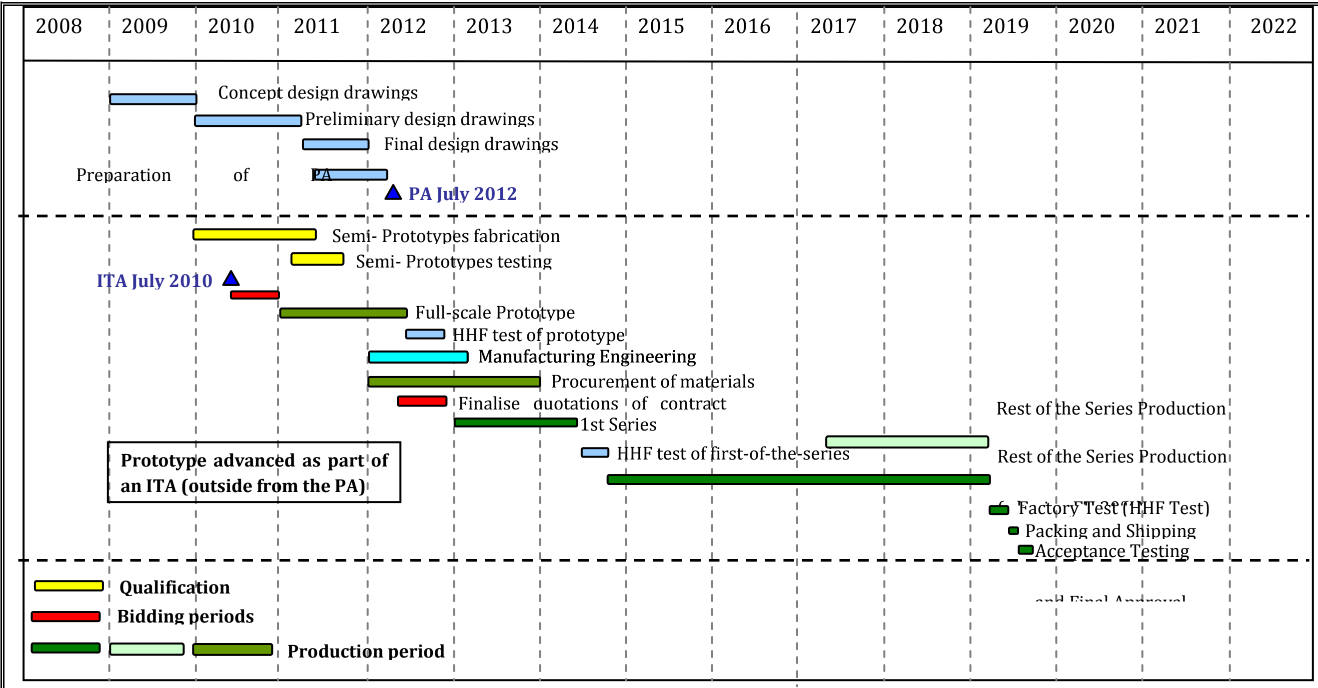
The procurement type has remained "build to print".

PROCUREMENT ARRANGEMENTS PLANNING&STATUS

PA Title	PA signature	Credit (kIUA)
1.6.1.A Blanket First Wall	July 2012	43.5

MAIN MILESTONES

WBS	Milestone	DA responsible	Expected date
1.6.1 A	Contract for semi-prototype signed	EU	Feb2010
1.6.1 A	Semi-prototype tested	EU	Jul 2011
1.6.1 A	Contract for prototype signed	EU	Jan 2011
1.6.1 A	PA Signature	EU	July 2012
1.6.1 A	Contract for series signed	EU	End 2012
1.6.1 A	1st series delivered	EU	October 2015
1.6.1 A	Series delivered	EU	End 2019



DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

One of the major outputs of the ITER Design Review in 2007 was the reconsideration of the FW design for two main reasons: a "conductive plasma flux" is now assumed and the first wall maintenance was difficult and entailed the risk of delays during repair.. The IO has consequently redesigned the blanket system with the objective to have, in particular, in-vessel separable FW panels, less access holes facing the plasma, toroidal FW fingers to reduce halo current loads.

In April 2009, the on-going conceptual design (named reference) has been stopped to study an alternative design. After the Design Comparison in July, the reference design has been kept and the design work restarted. Today, the status of the design can be summarised as follows:

- The FW design is still at a conceptual phase, basically the panels of 2 modules have been designed;
- A conceptual design review is planned for February 2010;
- There is still significant design and analysis work to be done;
- Important choices among options – as the one described here below- still need to be made.

Two heat flux configurations are under consideration. In the present configuration, two different FW designs are proposed to cope with two power levels depending on the location of the FW panels inside the plasma chamber. The first design for a heat flux level of about 1 MW/m^2 is named Low Heat Flux (LHF) design and would cover about 50% of the surface of the FW. The second design for a heat flux level of about 5 MW/m^2 is named Enhanced Heat Flux (EHF) design and would cover the remaining 50% of the FW. A study has been launched in Europe to estimate and compare the cost of both variants.

MANUFACTURING READINESS

With reference to the FW panels, the fabricability of the former design, close to the current LHF design, was demonstrated in Europe as the outcome of a comprehensive 10-year R&D program including in particular the manufacture of five full scale FW panel prototypes. Two companies have been "qualified" in the EU for the manufacture of the FW panels by solid Hot Isostatic Pressing (HIPping). This fabrication technique offers the great advantage of avoiding any seal welds exposed to the vacuum, increasing therefore the reliability of the components during operation.

In the present schedule the PA signature is planned for July 2012, by which time the supporting manufacturing R&D programme should have been completed and the qualification passed. Today, the tests of the EU phase1-qualification mock-up –based on the LHF FW design have been successfully completed.

Phase 2 of the qualification programme consists of manufacturing and testing FW semi-prototypes, that should allow the selected technology applied to the final component geometry and constraints to be checked. This phase will span the period from the end of 2009 to July 2011. This step is minor if we remain with the well-known LHF FW design. It is bigger in the enhanced heat flux configuration.

R&D AND QUALIFICATION ACTIVITIES

Objectives: Final material characterization and qualification in accordance with the latest agreed fabrication process, determination of acceptance criteria for defects, final technology development to support semi-prototypes fabrication and testing as phase 2 of the qualification process

WBS	**EU obligation**	**Other DA involved/remarks**
WBS 1.6.1 A	High heat flux testing of FW mock-ups before and after irradiation, including transportation	ITER Task Agreement on Acceptance Criteria
WBS 1.6.1 A	CuCrZr powder-solid HIP development	Material characterization and qualification (included in ITA on Acceptance Criteria)
WBS 1.6.1 A	Continuation of Be/CuCrZr HIP joining development	Qualification: Adapt the FW fabrication technology to the new requirements of EHF panels.
WBS 1.6.1 A	Irradiation and testing of powder HIPped 316L SS material and joints	Material characterization and qualification
WBS 1.6.1 A	Mechanical characterization of irradiated and unirradiated CuCrZr alloy	Material characterization and qualification
WBS 1.6.1 A	Ultrasonic testing of Be-coated FW mock-ups	ITA on Acceptance Criteria
WBS 1.6.1 A	High heat flux testing of FW semi-prototypes	Qualification
WBS 1.6.1 A	Continuation of technology development for enhanced FW design (5MW/m2)	Qualification: Further develop, if needed, the FW fabrication technology to the new requirements of EHF panels.
WBS 1.6.1 A	Completion of Be/CuCrZr joint repair technique	Qualification
WBS 1.6.1 A	Mechanical characterization of CuCrZr/316SS joint	Material characterization and qualification

PROCUREMENT STRATEGY

During the last 15 years, one of the key objectives of the EU has been to develop at least the technological capacity of at least two and possibly more industrials companies or consortia in order not to face a monopoly situation at the time of the call for tender for the supply of the blanket components. Considering:

- the type of supply and the technical and economical risks associated with it,
- the present configuration of European industrial expertise in the critical blanket/FW technologies,
- the need to avois risks of conflict of interest;

the following procurement strategy has been put in place.

1) Options

The contract could be awarded with several options including both design (manufacturing design) and realisation. The latter shall be structured as follows: option for the fabrication of the full-scale prototype, if there is enough time to implement it, option for the fabrication of the first-of-series and various options for the realization of the modules corresponding to a number of separate fabrication lots.

After the first option, a period of testing is required (test of a prototype, realised according to the design that is obtained at the end of the design phase). The different lots corresponding to the different quantities of modules to realise are optional. The consistency of the lots (quantity of modules to deliver) should be defined when the prices are known. The division in lots that are optional is also a tool to avoid an agreement on price between the different competitors.

2) Procurement Procedure:

Due to the need of a technical dialogue before a possible quotation of price for the realization can be done, the possibility of having a competitive dialogue procedure is envisaged. This procedure would also allow the transfer of knowledge betwen research and industrial organisations. The major steps of the procedure will be as follows:

- Publication of a contract notice - call for expressions of interest => short list of candidates,
- Dialogue with the selected candidates => potentially reduced short list of candidates,
- Call for tender => technical and commercial proposals,
- Evaluation and award of the contract => final short list of qualified Companies.

3) Market Survey:

Today two EU companies appear to be in a good position to participate to this dialogue, having participated for more than 10 years in the EU fusion technology R&D programme. These companies have informed F4E about their interest in participating to the bids as a consortium, the legal form of which is not yet defined. The possibility to extend the competition worldwide could be an important parameter of the procurement. Another action to open the market and mitigate schedule and cost risks would be to identified additional consortia, with at least the leading company being from the EU.

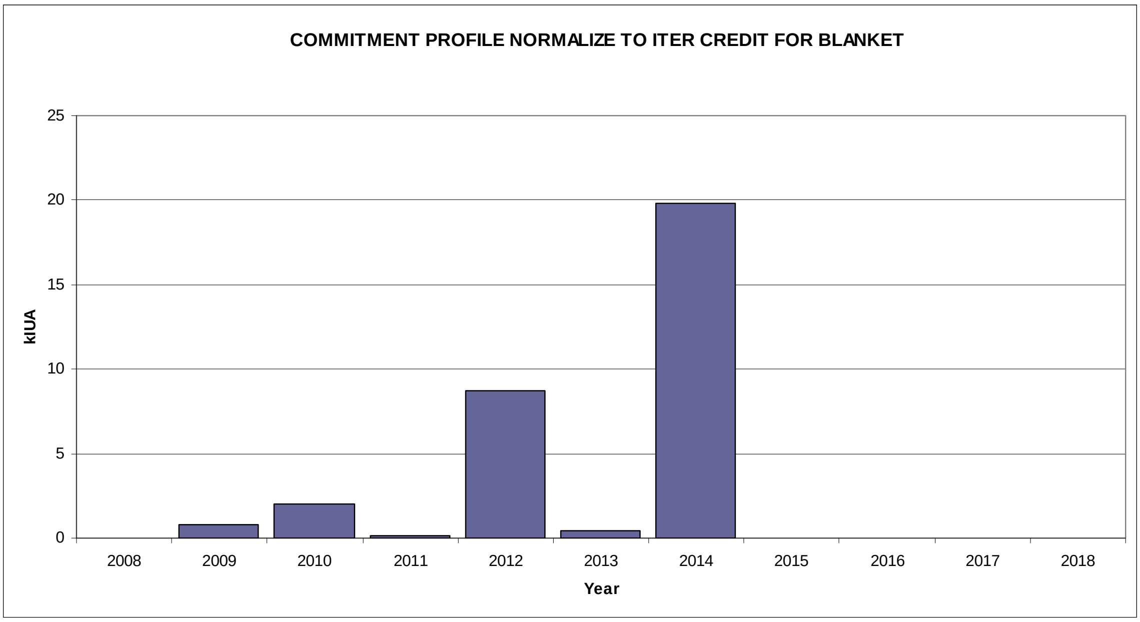
Additional Comments

<u>Heat loads</u>: the design is still under analysis and the design requirements, in particular the heat load requirements, are not completely defined yet; freezing of the heat loads is urgent and must be final.

<u>Remote Handling (RH)</u>: The FW is RH class 1 , that is the feasibility of the operations shall be demonstrated on mock-ups: today this is the highest technical risk perceived on the blanket programme, due to the possible important impact that feedback from the RH studies and demonstration activities may have on the design.

<u>Interface with the VV</u>: Conceptual design of the coils , manifolds and attachment of the modules is far from being finalised: this should be considered as a top priority, as it has potentially important impacts on the module/panel design as well.

NORMALIZED COMMITMENT PROFILES – BLANKET



DIVERTOR – CASSETTE INTEGRATION	WBS 1.7.1 11.2 kIUA

SHORT DESCRIPTION

The Procurement Package 17.P1 concerns the manufacturing of 54 divertor cassette bodies (CB) plus six spares and the integration, on them, of the Plasma Facing Components (PFCs) and diagnostics. The CB is the supporting structure of the Plasma Facing Components (PFCs) and provides the coolant distribution to them. The CB is a component of about six tons made of 316L austenitic stainless steel plates and forged pieces. Each of the three PFCs is supported from the cassette body using two pairs of remotely maintainable attachments.

The ITER divertor requires an extensive set of diagnostic systems to provide several key functions in support of the design goals: protection of the device, input to plasma control systems, evaluation and analysis of plasma performance. Sixteen of the 54 CBs are dedicated to various diagnostics. There are five "Diagnostic Cassettes" and eleven "Instrumented Cassettes". The diagnostics are supplied by the ITER Parties but the integration on to the CBs is also object of the present procurement. The 32 CBs without any instrumentation or modifications are also referred to as "Standard Cassettes". Several diagnostics are allocated to the same cassette.

The Procurement type is build to print, i.e. "the design is fully specified and the performance responsibility lies with IO. Suppliers use the design exactly as it is provided to develop fabrication/shop drawings. Suppliers can request changes to the design, if necessary during fabrication, but those changes have to be analyzed and approved by ITER. Manufacturing issues and acceptance tests are in general well defined. The development of divertor diagnostics is still on-going at DAs, thus the procedures for diagnostic integration on to the cassette body, and their acceptance/qualification tests are not fully defined yet. QA requirements are well defined for cassette body manufacturing and integration of plasma facing components; this is not the case for diagnostic integration.

One must consider that Remote Handling procedures for divertor installation into the Vacuum Vessel, which is part of the dedicated Procurement Package, still need to be corroborated. The results of this activity could have a strong impact on the Divertor design. The EU Contribution and Sharing of the Cassette integration obligations are summarized as follows:

WBS	EU obligation	Design type	Other DA involved/remarks
WBS 1.7.1	Manufacturing of: - One full-scale cassette body prototype. This is a full scale, full features standard cassette body; - 54 cassettes including 32 standard cassette, five diagnostic cassettes, 11 instrumented cassettes and six in-vessel viewing system cassettes; - Six spare cassettes (standard and diagnostics) Assembly of all the plasma-facing components (PFCs) onto the cassettes, Assembly of the diagnostic	Build to print	JA (outer vertical target) RF (dome) Other DA for diagnostics

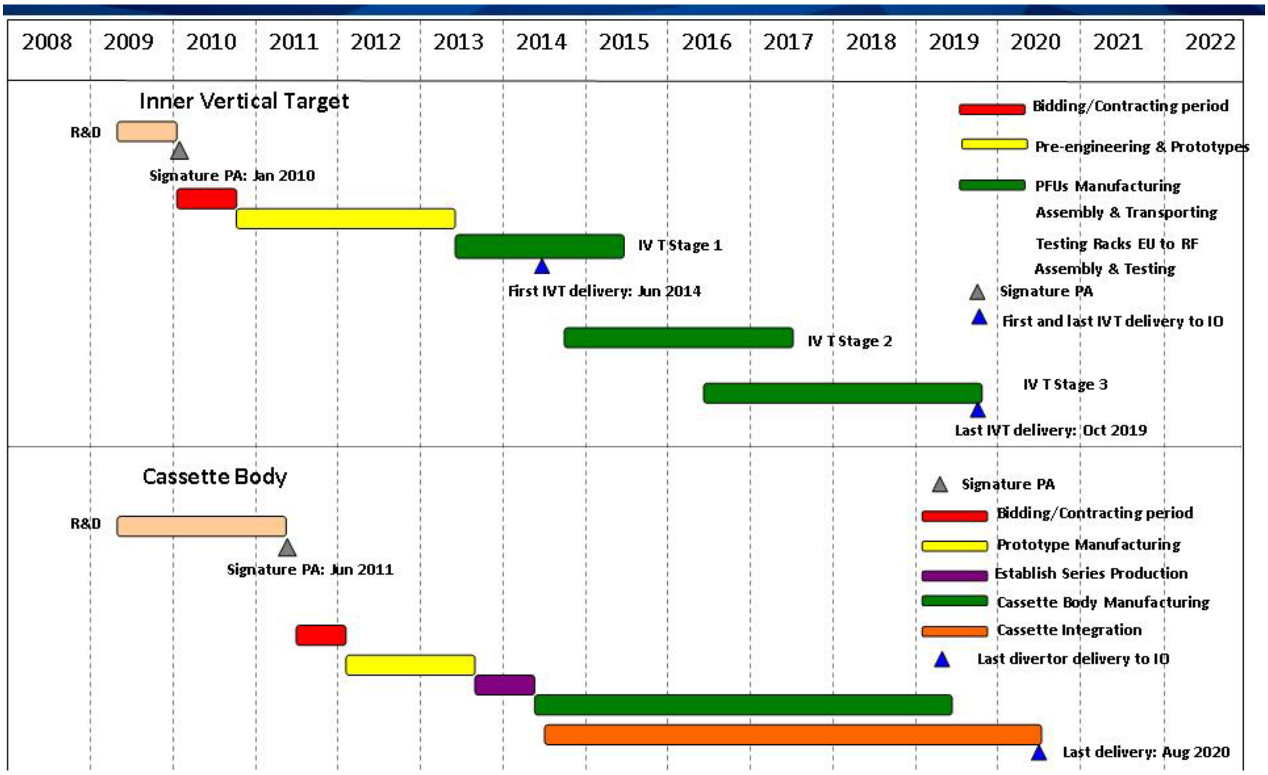
	equipment onto the 16 diagnostics and instrumented cassettes, which are delivered to the manufacturer as free issue items.		

All the assembly operations shall be performed in the integration site.

PROCUREMENT ARRANGEMENT PLANNING & STATUS

The PA planning is summarized in the following table:

PA Title	PA signature	Credit (kIUA)
1.7.P2B.EU.01.0 – Cassette Integration	June 2011	11.2



MAIN MILESTONES

WBS	Milestone	DA responsible	Expected date
1.7.1	Technical specification:	EU	June 2011;
1.7.1	PA Signature	EU	June 2011;
1.7.1	Contract award:	EU	January 2012
1.7.1	Manufacturing of Cassette Prototype	EU	September 2013
1.7.1	Batch 1 – Manufacturing of 6 CB	EU	April 2015
1.7.1	Batch 2 – Manufacturing of 18 CB	EU	August 2016

1.7.1	Batch 3 – Manufacturing of 36 CB	EU	May 2019
1.7.1	Last integration of Divertor Cassette	EU	August 2020

SCHEDULE ASSUMPTIONS

It is assumed that the Cassettes will be delivered in three batches with manufacturing and testing of components at factory but final cassette assembly/testing at ITER site. The materials procurement strategy foresees a two step procurement, for prototype and series production respectively. The material delivery time is driven by the availability of AISI 316 L (N) IG. The fabrication approach is as follows:

- Production and test of a prototype;
- Preparation for the series production after prototype;
- Continuous production and delivery as three batches;
- Constant production rate.

DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

The detailed design of cassette body is being finalized. The first draft of the detailed design drawings was given by IO in April 2009. Electromagnetic and mechanical analyses have been carried out in 2007 and 2008. Design activities are being performed according to ITER QA. The dialogue with the Safety Licensing authorities is progressing. The Cassette to vacuum vessel interface design needs refinement.

MANUFACTURING READINESS

Most of all the feasibility and manufacturing issues have been addressed, in the frame of EFDA contracts, by manufacturing the cassette full scale prototype whose features are the same of the final cassette. In addition, the manufacturing of a final full size prototype is part of the procurement package. PFC to cassette body integration design solutions need to be improved. A contribution to the confirmation/revision of CB-vacuum vessel interfaces will come from ongoing R&D in the EU. Diagnostic integration issues cannot be addressed with sufficient detail. The activities foreseen in this procurement package do not require special technologies. Manufacturing capacity for this procurement package is available in the EU.

R&D AND QUALIFICATION ACTIVITIES

The most important qualification activity for the Divertor CB consists of the manufacturing and testing (integration, RH) of a full size prototype. The successful completion of this activity and in particular the Remote Handling validation will release the Series Stage 1 manufacturing.

PROCUREMENT STRATEGY

The Procurement foresees the following phases:

- Manufacturing of a full size prototype;
- 1st Stage of the series' production (10%);
- 2nd Stage of the series' production (30%);
- 3rd Stage of the series' production (60%).

The present strategy is based on one contract for the manufacturing of the CB Prototype, CB series manufacturing and integration to be launched in January 2012.

DIVERTOR – INNER VERTICAL TARGET	WBS 1.7.2B 20.2 kIUA

SHORT DESCRIPTION

The inner vertical target (IVT) is an actively cooled Plasma Facing Component (PFC) devoted to sustain the heat and particle fluxes during normal and transient operations as well as during disruption events. The target consists of a supporting structure onto which the High Heat Flux (HHF) units are mounted. The supporting structure is a welded component made from 316L austenitic stainless steel plates and forged pieces. The HHF units consist of a plasma-facing material, the armour, which is made of either carbon fibre reinforced carbon composite (CFC) and tungsten (W). The armour is joined onto an actively cooled substrate, the heat sink, made of precipitation hardened copper alloy CuCrZr. CFC is the current armour material design solution for the lower part of the target; tungsten is the solution for the upper part.

The Procurement type is build to print, and the suppliers shall use the design exactly as it is provided to develop fabrication/shop drawings. Suppliers can request changes to the design, if necessary during fabrication, but those changes will have to be analysed and approved by ITER.". Manufacturing issues and acceptance tests are very demanding but in general well defined. The development of divertor diagnostics is still on-going at ITER DAs but this has very limited impact on inner vertical target. QA requirements are in general well defined.

The EU obligations can be summarized as follows:

WBS	EU obligation	Design type	Other DA involved/remarks
WBS 1.7.2B	Manufacture of: 1 inner vertical target prototype; 54 inner vertical targets; 6 spare inner vertical targets.	Build to print	RF for thermal fatigue acceptance tests to be performed in the ambit of a different ITER procurement package (to be confirmed).

PROCUREMENT ARRANGEMENT PLANNING & STATUS

PA Title	PA signature	Credit (kIUA)
1.7.P2B.EU.01.0 – Inner Vertical Target	January 2010	20.2

MAIN MILESTONES

WBS	Milestone	DA responsible	Expected date
1.7.2-B	Technical specification	EU	January 2010
1.7.2-B	Procurement Arrangement Issue Date	EU	January 2010
1.7.2-B	Procurement of CFC:	EU	May 2016
1.7.2-B	IVT contract award (Prototype):	EU	September 2010
1.7.2-B	Manufacturing and testing of IVT Prototype	EU	December 2012
1.7.2-B	IVT contract award (Series):	EU	May 2013

1.7.2-B	Stage 1 – Manufacturing of 6 IVTs	EU	April 2015
1.7.2-B	Stage 2 – Manufacturing of 18 IVTs	EU	June 2017
1.7.2-B	Stage 3 – Manufacturing of 36 IVTs	EU	October 2019

SCHEDULE ASSUMPTIONS

It is assumed the Inner Vertical Target manufacturing will be be performed in three stages. As soon as completed, each individual target will be delivered to the cassette assembly place at ITER site. The Procurement of CFC is divided in batches according to the inner vertical target procurement batches and is performed by F4E itself. No contingencies are included. No special provisions are envisaged to meet the schedule. No staging is foreseen for the procurement of AISI 316 L(IG) material which will be procured at the start of the series production.

DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

The design of inner vertical target has been finalised. The latest version of the design drawings has been released in March 2009. Electromagnetic and mechanical analyses have been carried out in 2007 and 2008. Design activities are being performed according to ITER QA. Dialog with Safety Licensing authorities is being completed. Remote handling requirements are being addressed. The EU costing exercise was performed on the basis of the experience gained during the manufacturing of mock ups and prototypes.

MANUFACTURING READINESS

Most of all the feasibility and manufacturing issues have been addressed by manufacturing divertor qualification prototypes and the full size dummy armour prototypes. In addition, the manufacturing of a final full size-real armour prototype is part of the Procurement Arrangement. Manufacturing capacity for this Procurement Arrangement is available in EU.

Since the pre-qualification phase was successful for both of the EU companies involved, no monopoly situation is expected to occur for this procurement, provided both companies respond to the call.

R&D AND QUALIFICATION ACTIVITIES

The most important qualification activity for the Divertor IVT consists in the manufacturing and testing of a full size prototype (with CFC and W armour). The successful completion of this activity, which is foreseen in the IVT Procurement Package, will release Stage 1 of the series production.

F4E has independently decided to launch an R&D program aimed at the development of a full W divertor which includes also the manufacturing and testing of a full size prototype. This program is not foreseen in the ITER Procurement Package but can provide potential cost savings if ITER can start with a full W divertor.

Complementary R&D activities (such as study of thermal performances or assessment of repair technologies) will be also launched.

PROCUREMENT STRATEGY

The Procurement foresees the following phases:

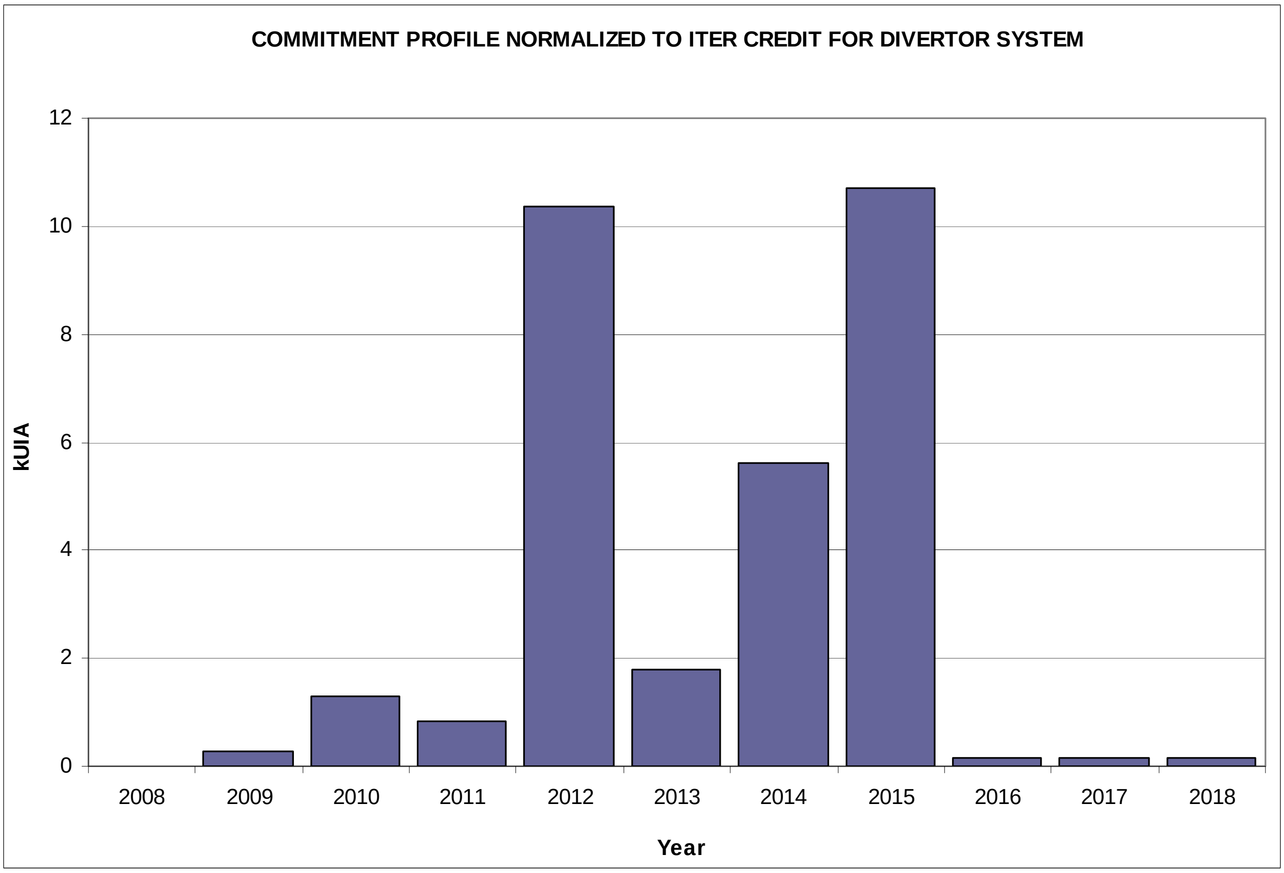
- Manufacturing of a full size prototype;
- 1st Stage of the series' production (10% of PFC);
- 2nd Stage of the series' production (30% of PFC);
- 3rd Stage of the series' production (60% of PFC).

The present EU strategy is based on 3 procurement phases:

- manufacturing of CFC Material to be launched by the end of 2009;
- manufacturing of the IVT Prototype to be launched by September 2010;
- manufacturing of the IVT Series to be launched by May 2013.

For the divertor target procurement, F4E will establish an open competition among the EU industries, not only for the manufacturing technologies, but also for supplying the armour materials with the final aim to reduce costs and technical risks. This is the outcome of a successful R&D programme aiming at qualifying more than one company. The competition can be maintained even during the procurement by awarding "phased contracts" with several possible options of fabrication lots for the series production.

NORMALIZED COMMITMENT PROFILES – DIVERTOR (Cassette Integration + Inner Vertical Target)



DIVERTOR REMOTE HANDLING	**WBS 23.2** **12 kIUA**

SHORT DESCRIPTION

The Divertor Remote Handling (procurement package 23.2) consists of a series of movers, which are able to travel from the Transfer Cask System docked to the VV equatorial ports 2, 8 and 14, to the working positions and to remove the 54 divertor cassettes, plus the diagnostic racks and the primary closure plates, by using a series of specialised end effectors.

Two types of movers are envisaged, the Cassette Multifunctional Mover CMM and the Cassette Toroidal Mover CTM, each one being the combination of moving machinery, end effectors, manipulator arm, tooling, viewing system, umbilical, cubicles, control system. The current scope of supply for this WBS includes:

- One Cassette Multi-functional Mover (CMM, consisting of CMM tractor, end effectors and umbilical) and one spare;
- One right-hand-side cassette toroidal mover (CTM) and umbilical and one spare;
- One left-hand-side cassette toroidal movers (CTM) and umbilical and one spare;
- One set of tools for cassette cooling pipes and one spare;
- One set of tools for cassette locking system and one spare;
- Two Manipulator arms (MAM) and one spare.

The scope has to be reviewed and finalized between IO and F4E. In fact, there are areas of uncertainties, like:

- There could be the need for a dust cleaning system on board the CTM;
- The need for additional rescue systems depends on the design of the CMM and CTM and their failure modes and consequences;
- To simplify design integration and interfaces, there could be a shift of in-cask platform hosting the DIV RH inside the Transfer Cask System from 23.3 TCS to 23.2 DIV RH (if EU takes 100% of the TCS this could be "cost neutral")
- More generally, IO should undertake a value engineering exercise in order to rationalize the in-vessel RH strategy, because at the moment the various tasks are allocated to different devices (Blanket Remote Handling System, DIV RH, and the new Multipurpose Device (MPD) and there is scope for revisiting all the various RH systems and for reshuffling their role and content).

Furthermore, on the one hand the procurement of some of the above components could be deferred to after the start of ITER operation, and on the other hand other prototypes could be included in the package (in addition to the one already in the Divertor Test Platform DTP2 in Finland), manufactured and tested before being sent to ITER as component of the RH cold test facility. Therefore, from now until the PA will be signed (see below), there will be a systematic review of the DIV RH procurement package.

WBS	**EU obligation**	**Design type**	**Other DA involved/remarks**
WBS 23.2	Detailed design and manufacture of the DIV RH, up to final acceptance in a test stand at the ITER site.	Functional specifications supported by conceptual design	CN DA was originally involved for the DIV RH transfer cask, if the new TCS sharing is confirmed (100% EU) these interfaces will be internally managed in the RH group..

PROCUREMENT ARRANGEMENTS PLANNING & STATUS

PA Title	PA signature	Credit (kIUA)
DIV RH 2.3.P2	February 2011	12*

* It should be reassessed based on the final scope, see section 1

MAIN MILESTONES

WBS	Milestone	DA responsible	Expected date*
WBS 2.32	Conceptual design review done	IO/EU	October 2010
	PA signature	IO/EU	February 2011
	EU procurement contract starts	EU	July 2012
	Start of test in DTP2 with ITER relevant CTM prototype	EU	January 2015
	DIV RH manufacturing design completed and approved	EU	September 2015
	DIV RH manufactured and tested at the supplier site	EU	December 2016
	DIV RH delivered to ITER site, installed, accepted and handed-over to IO	EU	August 2017

*Tentative dates

DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

The conceptual design, in support of the functional specification, has to be completed. The functional specifications have been drafted in the SRD (ITER System Requirement Document) but still the complete package of documents accompanying the PA must be prepared.

The design itself of such complex machinery is a complex exercise and there are elements of novelty that have to be taken into account:

- Many technologies (moving machinery, force-feedback manipulator, tooling, umbilical, viewing system, virtual reality, control system) to be nuclearised and integrated for the first time in a complete, reliable, fail safe and recoverable design;
- Severe space constraints and large number of interfaces;
- The nature and difficulty of the RH tasks (multi-tons components to be handled with millimetric accuracy in a hostile environment).

Some changes to the design could come from the Divertor design activities, and from the results of the tests performed in the Divertor Test Platform (in Finland). Nevertheless, there are no major uncertainties in the engineering the divertor RH concept.

MANUFACTURING READINESS

The DIV RH, as all the other RH packages, will be delivered by IO as a functional specification supported by a reference conceptual design and interface specifications. The preliminary design, final design and manufacturing design are therefore under the responsibility of the EU.

In general terms, provided that a sound design is developed by the DIV RH industrial supplier (see Procurement Strategy Section below), there should not be major manufacturing concerns, apart from the issue of radiation tolerance of the DIV RH components.

R&D AND QUALIFICATION ACTIVITIES

The R&D and qualification activities are organised as follows

- Perform tests in the DTP2 on the existing DIV RH mock-ups
- Complete the irradiation programme on motors, pressure sensors and electronics already on going (EFDA task TW6-TVR-RADTOL2)
- Perform an extensive market survey to assess the availability of rad-hard components suitable for use in DIV RH, and run other irradiation qualification tests ("RADTOL3") on other components if needed
- Design, procure and tests the remaining DIV RH prototypes (Cassette Toroidal Mover, force-feedback Manipulator, tooling, etc.) in order to verify experimentally the design

The above activities will be performed through grants, Engineering support Contract (Lot 3 – Remote Handling), Grants are to be launched for RADTOL3, and a procurement contract for the DIV RH prototypes (see strategy below).

PROCUREMENT STRATEGY

IO will release the procurement package in form of functional specifications supported by a conceptual design and complemented by interface requirements. The main elements of the procurement strategy are the following:

- F4E will outsource the design and procurement of the DIV RH to an industrial integrator/supplier, which will have the duty of developing a design where the various technologies (from specialized companies/sub-suppliers) are integrated. It will be a **"turn-key contract"** to be placed after the PA signature
- The industrial supplier will have to design a prototype first, to be tested in a test facility (DTP2 in this case) in order to verify that the design proposed is working ("green light" to the final production)
- The supplier will be fully responsible for the design, and in particular will be responsible for qualifying the rad-hard components (in an irradiation test facility TBD by them) to be used for the DIV RH.
- The design of the real DIV RH will be finalized after the prototype tests have been satisfactory. Improvements to such design could come from these tests.
- The DIV RH will be tested at factory (FAT) and at the ITER site (SAT) in an ad-hoc test stand. The DIV RH will be accepted by F4E after the SAT and will be immediately handed over to IO.
- The prototypes tests will continue after the "green light" to the final production in order to: 1) develop the ITER 1st assembly sequences; 2) train personnel (in view of a possible recruitment as part of the IO

RH team; 3) introduce the needed hardware/software updates (if any)

- The prototypes will be delivered to ITER site in order to form part of the so called cold RH test facility (will become ITER assets – TBC)
- The contract could be staged in order to limit the commitment at the beginning, and in order to release the various phases only after the successful completion of the previous one. This approach would give a smoother commitment profile (and little effect on the expenditure profile), and a more conservative management of the procurement by F4E, but could induce some delays/extra-costs; on the other hand there could be savings if the price will be renegotiated at certain stages.

REMOTE HANDLING – TRANSFER CASK SYSTEM	**WBS 2.2.3** **16.4 kIUA**

SHORT DESCRIPTION

The Transfer Cask System (TCS) consists of a fleet of units able to move from Hot Cell to Tokamak Building, dock to the various ports/docking stations, install and remove in-vessel components (divertor cassettes, blanket modules, plugs, cryopumps, IVVS-GDC, NB) with the in-cask devices. Among these in-cask devices (usually tractors able to transport cantilever the to-be-handled components) there is also the DIV RH that is treated as a separate EU procurement package (WBS 2.3.2).

Each unit is composed of the Air Transfer System (i.e. the movable platform suspended on air cushions), the interface pallet and the cask itself which is a leak tight envelope hosting the in-casks parts. The maximum payload of the system is 50 tons (equatorial plug), for a total weight of 100 tons. The current scope of supply for 23.3 includes:

- 14 (and one spare) cask platforms with enclosure, front and rear double shield doors and air transfer systems (ATS)
- up to seven rescue cask platforms with enclosure, front and rear double shield doors and transfer systems
- 14 (and one spare) in-cask handling systems (e.g. for divertor RH and divertor cassettes)
- up to seven (and one spare) in-rescue cask handling systems
- Four (and one spare) Hot cell adaptors
- Spares (30% of supply – spare parts)

This is an evolution of the original 2001 scope of supply, with six more units included. The scope has to be reviewed and finalised between IO and F4E and there are areas of uncertainties including:

- There could be the need for the casks for the extra in-vessel transporter recently added in the ITER baseline;
- There could be the need for the transfer cask for the so-called Multi-Purpose-Deployer (MPD) that is being added in the ITER baseline;
- To simplify design integration and interfaces, there could be the shift of in-cask platform hosting the DIV RH inside the Transfer Cask System from 23.3 TCS to 23.2 DIV RH (EU is taking 100% of the TCS, so this could be "neutral");
- More generally, IO should undertake a value engineering exercise in order to rationalize the in-vessel RH strategy, because at the moment the various tasks are allocated to different devices (Blanket Remote Handling System, DIV RH, and the new Multipurpose Device (MPD) and there is scope for revisiting all the various RH systems and for reshuffling their role and content.

Furthermore, on the one hand the procurement of some of the above components could be deferred to after the start of the ITER operation, and on the other hand other prototypes could be included in the package (to be tested in a to-be-built TCS test facility, host laboratory TBD), manufactured and tested before being sent to ITER as component of the RH cold test facility. Therefore, from now until the PA will be signed (see below), there will be a systematic review of the TCS procurement package.

A new sharing is being discussed between EU and CN DA changing the original sharing of 50%-50% to 100% for EU.

WBS	EU obligation	Design type	Other DA involved/remarks
WBS 23.3	Detailed design and manufacture of the TCS, up to final acceptance in a test stand at the ITER site (on site integration between TCS and other RH like DIV RH still TBD).	Functional specifications supported by conceptual design	If the new TCS sharing is confirmed (100% EU) there will be interfaces with JA DA for the blanket RH system.

PROCUREMENT ARRANGEMENTS PLANNING & STATUS

PA Title	PA signature	Credit (kIUA)
TCS RH 2.3.P3	March 2011	16.4*

* It should be reassessed based on the final scope, see section 1

MAIN MILESTONES

WBS	Milestone	DA responsible	Expected date*
WBS 2.33	Conceptual design review done	IO/EU	December 2010
	PA signature	IO/EU	March 2011
	EU procurement contract starts	EU	September 2012
	Manufacturing and installation of a full TCS prototype in a facility (host lab TBD)	EU	March 2015
	Final TCS 1st Batch casks for ITER manufacturing design completed and approved	EU	April 2016
	TCS batch 1 (extent TBD) manufactured and tested at the supplier site	EU	April 2017
	TCS batch 1 delivered to ITER site, installed, accepted and handed-over to IO: (batch 2 could follow 2 years later, TBC)	EU	October 2017

*Tentative dates

DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

Still the conceptual design, in support of the functional specification, has to be completed. The functional specifications have been drafted in the SRD (ITER System Requirement Document) but still the complete package of documents accompanying the PA must be prepared.

The design is very complex machinery and there are several novel elements that have to be taken into account:

- Many technologies (moving machinery, tooling, umbilical, navigation system, air cushion technology, viewing system, virtual reality, control system) to be nuclearised and integrated for the first time in a complete, reliable, fail safe and recoverable design;

- Space constraints and number of interfaces;
- Nature and difficulty of the RH tasks (multi-tons components to be handled with millimetric accuracy in a hostile environment);
- Nuclear safety issues being the TCS a Safety-important-component.

Some changes to the design could come from the design activities of other ITER components (hot cell, VV ports, to-be-handled components), and from the results of the tests performed in the TCS test facility (still to come). Having said that, there are some uncertainties facing F4E for the engineering the TCS concept and this will be discussed below.

MANUFACTURING READINESS

The TCS, as all the other RH packages, is provided by IO in the form of a functional specification supported by a reference conceptual design and interface specifications. The preliminary design, final design and manufacturing design are therefore under the responsibility of the EU.

In general terms, provided that a sound design is developed by the TCS industrial supplier (see section 4.1 above and Procurement Strategy Section below), there should not be major manufacturing concerns, apart from the issue of radiation tolerance of the TCS components (see also sections 5, 6 and 7 below) and the issue of the TCS double door (sections 5 and 6 for more details).

R&D AND QUALIFICATION ACTIVITIES

The R&D and qualification activities are organised as follows

- Specify and design a TCS test facility where to validate the TCS prototype design
- Complete the irradiation programme on motors, pressure sensors and electronics already on going (EFDA task TW6-TVR-RADTOL2)
- Perform an extensive market survey to assess the availability of rad-hard components suitable for use in TCS (shared with DIV RH), and run other irradiation qualification tests ("RADTOL3") on other components if needed
- Design, procure and tests the TCS prototype (ATS, pallet, cask with in-cask plug tractor) and all related hardware/software in order to verify experimentally the design

The above activities will be performed through grants (including test facility laboratory preparation), Engineering support Contract (Lot 3 – Remote Handling), Grants to be launched for RADTOL3, and procurement contract for the TCS prototypes (see strategy below).

PROCUREMENT STRATEGY

The main elements of the procurement strategy are the following:

- F4E will outsource the design and procurement of the TCS to an industrial integrator/supplier, which will have the duty of developing a design where the various technologies (from specialized companies/sub-suppliers) are integrated. It will be a **"turn-key contract"** to be placed after the PA signature;
- The industrial supplier will have to design a prototype first, to be tested in a test facility (TCS test facility, host laboratory TBD) in order to verify that the design proposed is working ("green light" to the final production);
- The supplier will be fully responsible for the design, and in particular will be responsible for qualifying

the rad-hard components (in an irradiation test facility TBD by them) to be used for the TCS;

- The design of the real TCS will be finalized after the prototype tests have been satisfactory. Improvements to such design could come from these tests;
- The TCS will be tested at factory (FAT) and at the ITER site (SAT) in an ad-hoc test stand. The TCS will be accepted by F4E after the SAT (the integration of other RH systems like DIV RH and the Japanese Blanket RH system is TBD) and will be immediately handed over to IO;
- The prototypes tests, on the other hand, will continue after the “green light” to the final production in order to: 1) develop the ITER 1st assembly sequences; 2) train personnel (in view of a possible recruitment as part of the IO RH team; 3) introduce the needed hardware/software updates (if any);
- The prototypes will be delivered to ITER site in order to form part of the so called cold RH test facility (will become ITER assets – TBC);
- The contract pricing strategy has still to be defined: after the qualification of rad-hard parts/components, and of the prototypes in the test facility, the risk/uncertainties are greatly reduced, therefore the initial price could be renegotiated (see also below);
- The contract could be staged in order to limit the commitment at the beginning, and in order to release the various phases only after the successful completion of the previous one. This approach would give a smoother commitment profile (and little effects on the expenditure profile), and a more conservative management of the procurement by F4E, but could induce some delays/extra-costs; on the other hand there could be savings if the price will be renegotiated at certain stages;

REMOTE HANDLING- IN VESSEL VIEWING SYSTEM (IVVS)	**WBS 23.4** **6.8 kIUA**

SHORT DESCRIPTION

The In-Vessel Viewing System (IVVS) system consists of six identical units (plugs), each one composed basically of the following components:

- IVVS probe, capable of performing the laser-based in-vessel viewing and metrology, connected to, and fed by, its deployment system;
- Glow Discharge Cleaning (GDC) electrode (also called GDC probe), capable of producing glow discharge in the VV, connected to/fed by its deployment system;
- IVVS Deployment system, capable of moving the IVVS along the tube from the parking position up to the various working positions;
- GDC Deployment system, basically a system able to move the GDC in 3 positions, i.e. parked (rear), shielding position, and working position (front) above the divertor cassette dome;
- Housing structure, provided with an end flange closing the VV port and equipped with feed-troughs for the various services given to the deployment systems and to IVVS and GDC (signals, electrical power and water); the housing tube is also provided with heating cables for baking purposes.

The current scope of supply for this WBS defined in 2001 included also a snake arm that now has disappeared and a different breakdown of the system.

Furthermore, on the one hand the procurement of some of the above components could be deferred to after the start of the ITER operation, and on the other hand an IVVS prototype could be included in the package (to be tested in a to-be-built IVVS test facility, host laboratory TBD), manufactured and tested before being sent to ITER as component of the RH cold test facility. The initial procurement could include a provisional IVVS probe (while the final ones, fully nuclearised, would be deferred after the prototyping phase).

The scope has to be reviewed and finalized between IO and F4E. Therefore, from now until the PA will be signed (see below), there will be a systematic review of the IVVS procurement package.

WBS	**EU obligation**	**Design type**	**Other DA involved/remarks**
WBS 23.4	Detailed design and manufacture of the IVVS, up to final acceptance in a test stand at the ITER site	Functional specifications supported by conceptual design	CN DA is involved in the procurement of the GDC probe, supply lines and control cabinet. The GDC probe, supply lines and feed-troughs must be integrated into the IVVS-GDC plug (details TBD). If the TCS new sharing is accepted (100% EU) there are no other DAs involved.

PROCUREMENT ARRANGEMENTS PLANNING & STATUS

PA Title	PA signature	Credit (kIUA)
IVVS 2.3.P4	April 2011	6.8*

* It should be reassessed based on the final scope, see section 1

MAIN MILESTONES

WBS	Milestone	DA responsible	Expected date*
WBS 2.34	Conceptual design review done	IO/EU	April 2011
	PA signature	IO/EU	July 2011
	EU procurement contract starts	EU	March 2013
	Manufacturing and installation of a full IVVS prototype in a facility (host lab TBD)	EU	January 2016
	IVVS-GDC plugs (with provisional IVVS) for ITER: manufacturing design completed and approved	EU (interface with CN DA for GDC)	December 2014
	IVVS-GDC plugs (with provisional IVVS) manufactured and tested at the supplier site	EU	April 2016
	IVVS-GDC plugs (with provisional IVVS) delivered to ITER site, installed, accepted and handed-over to IO (final IVVS should follow ~2.5 years later, TBC)	EU	March 2017

*Tentative dates

DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

Still the conceptual design, in support of the functional specification, has to be completed. The functional specifications have been drafted in the SRD (ITER System Requirement Document) but still the complete package of documents accompanying the PA must be prepared.

The design itself of such complex system that has to stay permanently in the ITER primary vacuum is a complex exercise and there are elements of novelty that have to be taken into account:

- Many technologies (deployment system, umbilical, laser-based viewing and metrology) to be nuclearised and made compatible with vacuum, radiation, temperature and magnetic field for the first time in a complete, reliable, fail safe and recoverable design;
- Space constraints (limited port opening).

Some changes to the design could come from the design activities of other ITER components (the GDC probe, the

IVVS Transfer Cask System), and from the results of the tests performed in the IVVS test facility (still to come). Having said that, there are still some uncertainties facing F4E for the engineering the DIV RH concept that will be discussed later .

MANUFACTURING READINESS

The IVVS, as all the other RH packages, will be provided by IO in the form of a functional specification supported by a reference conceptual design and interface specifications. The preliminary design, final design and manufacturing design are therefore under the responsibility of the EU.

In general terms, provided that a sound design is developed by the IVVS industrial supplier (see section above and Procurement Strategy Section below), there should not be major manufacturing concerns, apart from the issue of radiation tolerance of the IVVS components and the issue of the compatibility with magnetic field.

R&D AND QUALIFICATION ACTIVITIES

The R&D and qualification activities are organised as follows:

- Complete the current laboratory tests
- Specify and design a test facility where to validate the IVVS prototype design
- Perform an extensive market survey to assess the availability of rad-hard components suitable for use in IVVS (shared with DIV RH), and run other irradiation qualification tests ("RADTOL3") on other components if needed
- Evaluate if it is needed to qualify the same components under vacuum, temperature and magnetic field
- Design, procure and tests the IVVS prototype and all related hardware/software in order to verify experimentally the design

The above activities will be performed through grants (including test facility laboratory preparation), Engineering support Contract (Lot 3 – Remote Handling), Grants are be launched for RADTOL3, and a procurement contract for the IVVS prototypes (see strategy below).

PROCUREMENT STRATEGY

The main elements of the procurement strategy are the following:

- F4E will outsource the design and procurement of the IVVS to an industrial integrator/supplier, which will have the duty of developing a design where the various technologies (from specialized companies/sub-suppliers) are integrated. It will be a **"turn-key contract"** to be placed after the PA signature;
- The industrial supplier will have to design a prototype first, to be tested in a test facility (IVVS test facility, host laboratory TBD) in order to verify that the design proposed is working ("green light" to the final production);
- The supplier will be fully responsible for the design (and design integration with GDC), and in particular will be responsible for qualifying the rad-hard components (in an irradiation test facility TBD by them) to be used for the IVVS;
- The design of the final IVVS will be finalized after the prototype tests have been satisfactory. Improvements to such design could come from these tests;
- The supplier will have to deliver the IVVS-GDC units with a provisional, simplified IVVS (TBC/TBD) in order to respect the ITER schedule constraints;
- The IVVS will be tested at factory (FAT) and at the ITER site (SAT) in an ad-hoc test stand. The TCS will be accepted by F4E after the SAT (the integration with GDC is TBD) and will be immediately handed

over to IO;

- The IVVS prototype tests, on the other hand, will continue after the validation of the final IVVS design in order to: 1) develop the ITER viewing/metrology sequences with the final IVVS; 2) train personnel (in view of a possible recruitment as part of the IO RH team; 3) introduce the needed hardware/software updates (if any);
- The prototype will be delivered to ITER site in order to form part of the so called cold RH test facility (will become ITER assets – TBC);
- The contract could be staged in order to limit the commitment at the beginning, and in order to release the various phases only after the successful completion of the previous one. This approach would give a smoother commitment profile (and little effects on the expenditure profile), and a more conservative management of the procurement by F4E, but could induce some delays/extra-costs; on the other hand there could be savings if the price will be renegotiated at certain stages;
- It has still to be defined the role of the national laboratory owner of the present IVVS proof-of-principle mock-up and owner of the know-how for the viewing and scanning hardware/software, and its integration with the industrial supplier.

NEUTRAL BEAM REMOTE HANDLING SYSTEM	WBS 23.5 6 kIUA

SHORT DESCRIPTION

The NB RH system consists of a series of devices able to operate remotely in the NB cell to perform maintenance tasks on the NB injectors and on the upper Diagnostic tubes:

- 50-ton monorail crane, serving the full NB cell and lifting interfaces;
- NB source-accelerator cradle, able to install the 26-tons source in the NB injectors;
- Manipulator arm and tooling (for pipelines, lip seals, cabling, etc.);
- Storage racks, ground-based vehicle;
- Cs Oven tooling;
- Rescue system (TBD);
- Viewing system.

The current scope of supply for this WBS defined in 2001 was significantly different and has been modified following the DCR-49. The value of the package has been estimated to be doubled (see later). Furthermore, prototyping was not originally included.

The scope has to be reviewed and finalized between IO and F4E. Therefore, from now until the PA will be signed (see below), there will be a systematic review of the IVVS procurement package in parallel with the conceptual design activities.

WBS	EU obligation	Design type	Other DA involved/remarks
WBS 23.5	Detailed design and manufacture of the NB RH, up to final acceptance in the NB cell at the ITER site	Functional specifications supported by conceptual design	-

PROCUREMENT ARRANGEMENTS PLANNING&STATUS

PA Title	PA signature	Credit (kIUA)
NB RH 2.3.P5	April 2012	6*

* DCR-49 has doubled this value, furthermore a re-assessment should be done based on the final scope, see section 1

MAIN MILESTONES

WBS	Milestone	DA responsible	Expected date*
WBS 2.35	Conceptual design review done	IO/EU	December 2011
	PA signed	IO/EU	April 2012
	EU procurement contract starts	EU	June 2013
	NB RH 1st priority items (monorail crane and others TBD) manufacturing design	EU	July 2015

	completed and approved		
	NB RH 1st priority items (monorail crane and others TBD) manufactured and tested at the supplier site	EU	September 2016
	NB RH 1st priority items (monorail crane and others TBD) delivered to ITER site, installed, accepted and handed-over to IO (2nd priority items should follow ~1 year later, TBC)	EU	April 2017

*Tentative dates

DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

The conceptual design, in support of the functional specification, has to be completed. The functional specifications have been drafted in the SRD (ITER System Requirement Document) but still the complete package of documents accompanying the PA must be prepared.

The design of such a complex system that has to be integrated in the NB cell is a complex exercise given the number of interfaces and components to be handled. Some changes to the design could come from the design activities of other ITER components (the NB injectors, the DIA plugs). Nevertheless, there are no major uncertainties facing F4E for the engineering the NB RH.

MANUFACTURING READINESS

The NB RH as all the other RH packages, will be delivered by IO in the form of a functional specification supported by a reference conceptual design and interface specifications. The preliminary design, final design and manufacturing design are therefore under the responsibility of the EU.

In general terms, provided that a sound design is developed by the NB RH industrial supplier (see section 4.1 above and Procurement Strategy Section below), there should not be major manufacturing concerns.

R&D AND QUALIFICATION ACTIVITIES

The R&D and qualification activities are organised as follows:

- Perform an extensive market survey to assess the availability of rad-hard components suitable for use in NB RH (shared with DIV RH), and run other irradiation qualification tests (“RADTOL3”) on other components if needed;
- Design, procure and tests the Cs Oven tool prototype (charging the industrial supplier to do so).

The above activities will be performed through grants, Engineering support Contract (Lot 3 – Remote Handling), Grants to be launched for RADTOL3, and industrial procurement contract for the NB RH prototype (see strategy below).

PROCUREMENT STRATEGY

The main elements of the procurement strategy are the following:

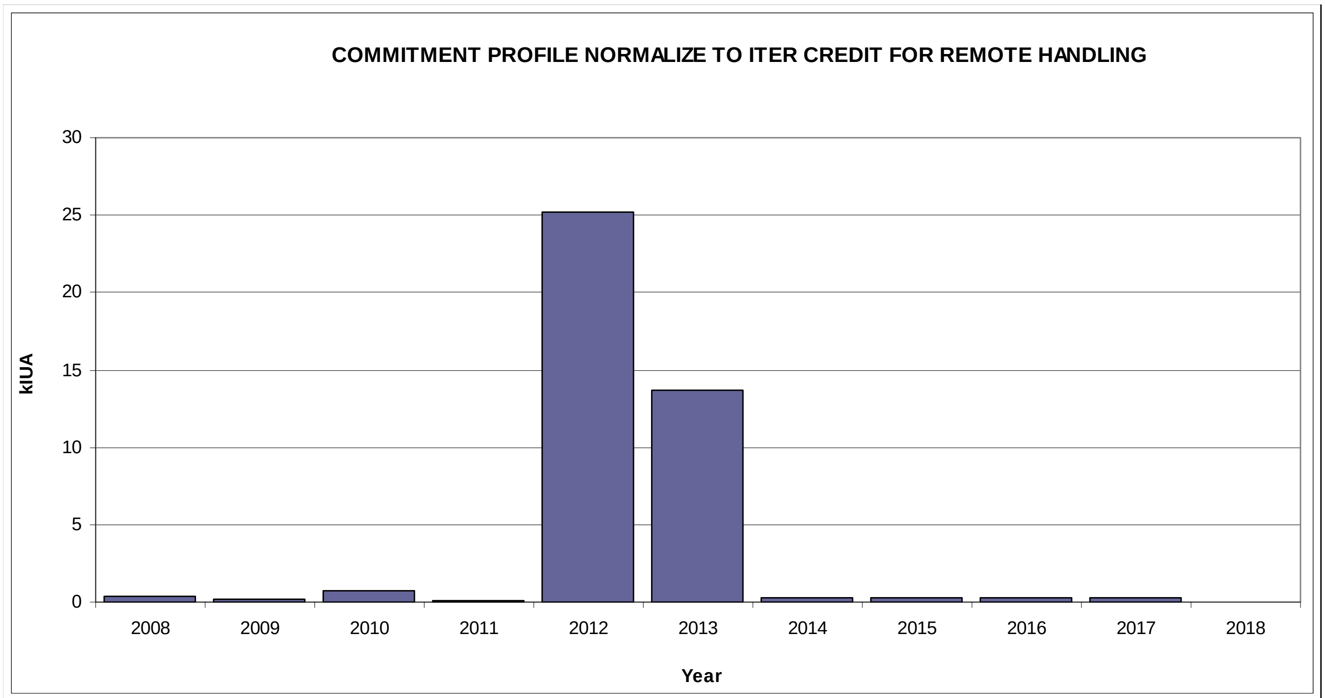
- F4E RH will outsource the design and procurement of the NB RH to an industrial integrator/supplier, which will have the duty of developing a design where the various technologies (from specialized companies/sub-suppliers) are integrated. It will be a **"turn-key contract"** to be placed after the PA signature;

- The industrial supplier will have to design also a CS oven tool prototype, to be tested in a test facility at its premises in order to verify that the design proposed is working ("green light" to the final production);
- The supplier will be fully responsible for the design and in particular will be responsible for qualifying the rad-hard components if needed (in an irradiation test facility TBD by them) to be used for the NB RH;
- The NB RH will be tested at factory (FAT) in an ad-hoc test stand and at the ITER site (SAT) in the NB cell. The NB RH will be accepted by F4E after the SAT and will be immediately handed over to IO;
- The CS Oven tool prototype will be delivered to ITER site in order to form part of the so called cold RH test facility (will become ITER assets – TBC);
- The contract pricing strategy has still to be defined;
- The contract could be staged in order to limit the commitment at the beginning, and in order to release the various phases only after the successful completion of the previous one. This approach would give a smoother commitment profile (and little effects on the expenditure profile), and a more conservative management of the procurement by F4E, but could induce some delays/extra-costs; on the other hand there could be savings if the price will be renegotiated at certain stages.

It must be said that, if during the next conceptual design, the need of a more extensive prototyping and testing will be identified, this will have to be included in the planning and in the procurement strategy.

NORMALIZED COMMITMENT PROFILES – REMOTE HANDLING

NB: The commitment profile, as already said, could be smoothened by staging the procurement contracts.



VACUUM PUMPING AND FUELLING	WBS 3.1.1 10.76 kIUA

SHORT DESCRIPTION

The "Vacuum Pumping & Fuelling" System includes[8]:

- Cryopumps (EU, ITER-IO)
- Roughing Pumps (US, ITER-IO)
- Leak Detection (EU, ITER-IO)
- Standard Components (US, ITER-IO)
- Pellet Injector (US, ITER-IO)
- Gas Injector Valve Boxes and Glow Discharge Cleaning Conditioning System (CN, ITER-IO)

The Cryopumps (PP3.1.1) and The Leak Detection (PP3.1.3) packages have to be supplied in-kind by EU (88% EU, 12% Fund)..

The key components of the ITER high vacuum system are its cryopumps[9]. Eight Torus-, two Cryostat- and four Neutral Beam (NB) cryopumps (three for heating and one for diagnostic purposes) will provide UHV conditions to the Torus, Cryostat and Neutral Beams, respectively. In addition each of these cryopumps requires a Cold Valve Box (CVB) to supply the cryogens at the correct mass flows, temperatures and pressures for the various operational needs of the pumps. There are 14 CVBs in total and in the related procurement package, the associated cryojumpers (cryogenic lines from the CVBs to the served pumps) are incorporated.

The Torus Cryopumps (TCPs) will be installed in the port cells to pump hydrogen isotopes, helium and impurities. The Cryostat cryopumps (CCPs) are identical to the TCPs and will be installed to the Cryostat vacuum vessel, to pump possible helium, water and air leaks into vacuum and any other gases reaching the cryopumps. Finally the NB cryopumps (3 HNBCPs and 1 DNBCP) will be connected to the NB boxes to pump the gas fed to ion sources and neutralisers of the NBs.

Supercritical He (ScHe) at 4.3 K and 0.4 MPa will be used for the cooling of the cryosorption panels, while He at 1.8 MPa will be employed for the thermal shields. The design of the cryopumps will also permit regeneration of hydrogen isotopes at 100 K, of air-like impurities at 300 K and water-like ones at 470 K. In addition the design of the CVBs is such as to provide and control a strict sequence of operation and regeneration steps of the cryopumps to maximize performance and satisfy safety requirements with respect to hydrogen concentration limits and non-deflagration requirements.

The eight TCPs and 2 CCPs consist of the following parts. The cryosorption panels which are cooled by the ScHe at 4.3 K, 0.4MPa and are covered by activated charcoal that acts as sorbent material. The 80 K thermal shields cooled by 80 K 1.8 MPa He gas. An integral cryopump inlet vacuum valve, cooled by 80 K 1.8 MPa He gas and capable of controlling the pumping speed, as well as an outer shell normally at ambient temperature.

The three HNBCPs and the DNBCP consist mainly of the low temperature circuit cooled by ScHe at 4.6K and 0.5 MPa, and the thermal shields cooled by 80 K 1.8 MPa He gas.

In principle, all vacuum pumping components, apart perhaps of the NB ones, are required for the first pump down of the vacuum vessel.

The EU contribution on vacuum pumping consists of four packages:

[8] "Status of the Cryogenic Interface of the ITER Cryopumps"C. Mayaux et al, 25th Symposium of Fusion Technology, Sept, 2008, Rostock, Germany.

[9] Common Understanding on procurement Allocation, EUR(05) CCE-FU31/2.1, N-12 ROM Att.5.1

- The 8 TCPs;
- The 2 CCPs;
- The 3 HNBCPs;
- The 1 DNBCP.

Each package includes the necessary CVBs while the TCPs and CCPs include also instrumentation and control (I&C). ITER IO has introduced also the cryogenic equipment, needed for the supply of the cryogens to the three US Pellet Injection Systems (PISs), into three of the CVBs for the TCP. An agreement on the costs, risks schedules for these additional equipment needs to be established between US, DA, F4E and ITER IO. In principle, EU is willing to implement this work as part of the EU effort for the CVBs depending on the agreement.

In order to minimize the technological risk related to the TCPs and CCPs, a Pre-production cryopump (PPC) of the same design has been agreed to be manufactured and tested. In addition a test cryopump (MITICA) will also be produced and tested to minimize any risk related to the NB cryopumps. It should be clarified that the mechanical design of the equipment in the table below is "build-to-print", while the CVBs and I&Cs" are "detailed design".

WBS	**EU contribution**	**Design type**	**Other DAs involved/Remarks**
3.1.1	Torus Cryopumps and related equipment	Build-to-Print	CVBs and I&C (detailed design) included US equipment (pipework, valves, instrumentation, etc.) to be installed in 3 Torus CVBs.
3.1.1	Cryostat pumping system	Build-to-Print	CVBs and I&C (detailed design) included
3.1.1	NB pumping system	Build-to-Print	CVBs (detailed design) included
3.1.1	DNB pumping system	Build-to-Print	CVB (detailed design) included

Leak detection

In the Leak Detection Package, no discussion of leak localisation occurs. In fact leak localisation was considered as missing item and is now included as an Additional Direct Investment (ADI). It is currently agreed that IO will support R&D activities and that F4E will be responsible for the supply of these components. However, no agreement was achieved up to now on who will be responsible for the cost of these still to be developed components as the costs are presently not known.

It should be clearly noted that a significant and challenging R&D effort will be required to define the technical details of an efficient leak localization system in the demanding ITER environment. Such a system should be able for the first time, to localize, in situ, He, air or water leaks in order to minimize the necessary repair interventions. In addition, it should incorporate effective draining and drying hardware as well as procedures that permit detection of water leaks at the required high resolution in the complex pipework/component systems. In addition, He leaks should be localized, despite large He backgrounds

The Leak Detection system components to be supplied by EU are listed below.

WBS	EU obligation	Design type	Other DAs involved/remarks
WBS 3.1.3	The scope of work covered by this procurement package includes[10] procurement and testing of 6 Mass Spectrometry Leak Detection (MSLD) assemblies in a secondary confinement glove box. The MSLD assemblies are to be allocated as follow: One MSLD equipment for torus roughing line in vacuum pumping room One MSLD equipment for cryostat roughing line in vacuum pumping room One MSLD equipment for the NB/DNB injectors Three MSLD equipments for service vacuum system	Functional Specification	No other DA involved

The details given above are taken from DDDs 2001 and earlier DDD versions. It is clear that the leak detection and leak localization systems have to be considered together as they interact strongly. This could mean that the type and accuracy of the components listed in the table above could change drastically. These possible changes need to be considered and as a consequence it is very important to develop the techniques to be used for leak localization.

PROCUREMENT ARRANGEMENTS PLANNING &STATUS

Cryopumps

PA Title	PA signature	Credit (kIUA)
Torus and Cryostat Cryopumps	30/06/2013	7.24
CVBs (including cryojumpers)	01/07/2012	1.01
NB and DNB cryopumps	TBD	2.51

It should be noted that part of the US in-kind PIS front cryogenic distribution system has been incorporated into CVBs for the TCPs. This part is to be supplied by US and it is not part of the EU supply to ITER IO.

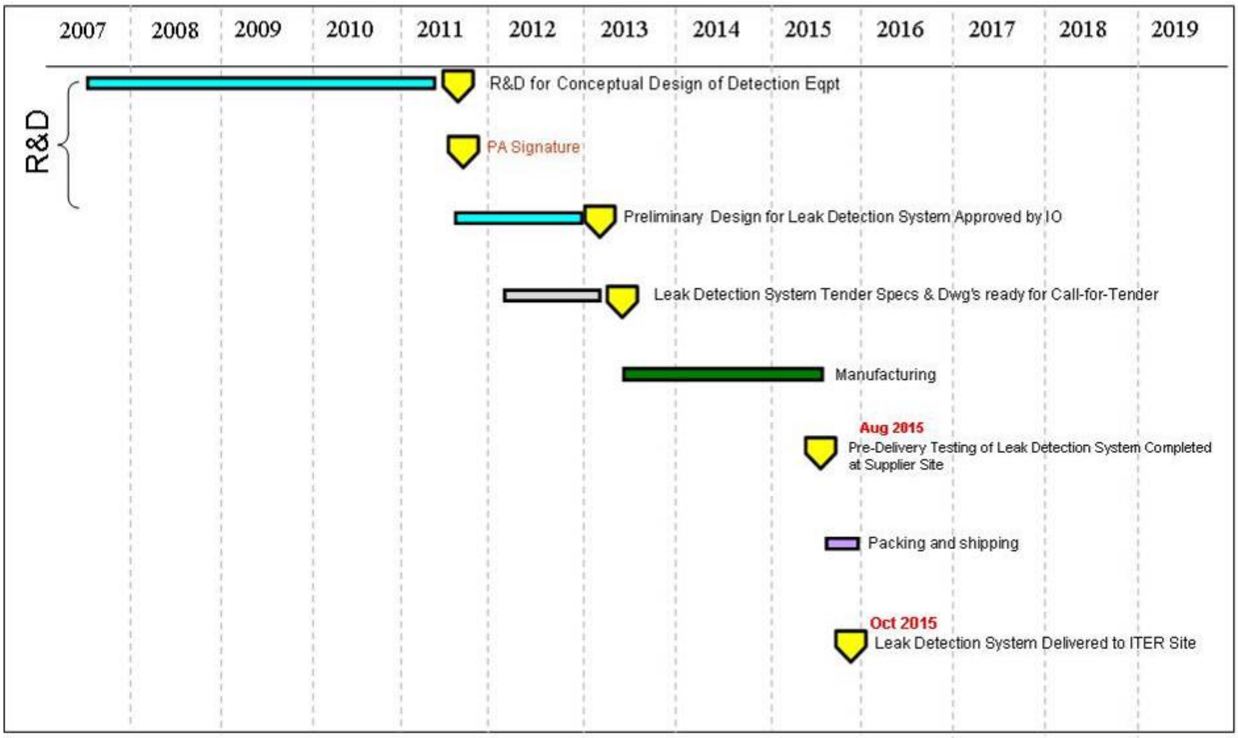
Leak detection

PA Title	PA signature	Credit (kIUA)
Leak Detection and Localisation components	Apr-2011	4.46

The scope of this Procurement Package is, strictly speaking, limited to the procurement of systems to detect leaks

[10] Procurement Description Document [ftp site://ITER FDR 2001 costing/iter-budget/2/34-Cryoplant Main Text ITER D262C6S v1.doc

and tracers to a high level of sensitivity. The systems needed, as well as the necessary R&D effort, to localise leaks are not included in the package and are still to be defined by ITER IO. They are also not reflected in the date of the PA signature above and in the planning diagram below. See also the comments made in the previous section.



MAIN MILESTONES

Cryopumps

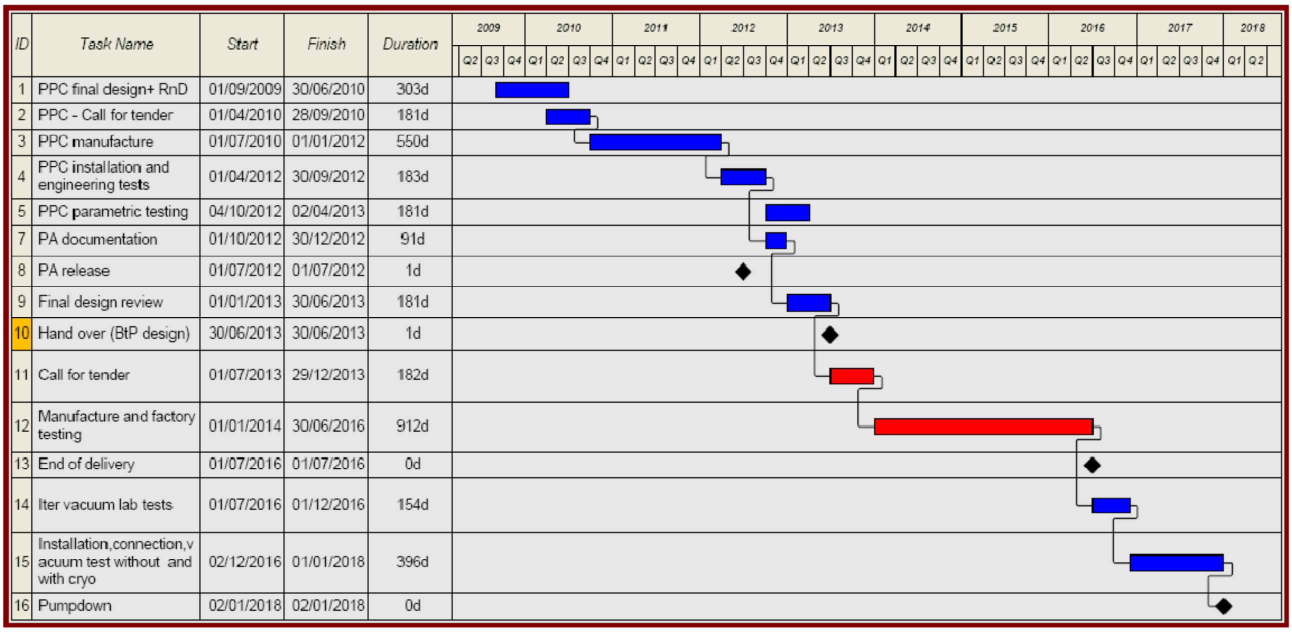
WBS	Milestone	DA responsible	Expected date
3.1.1	Torus Cryopumps and related equipment: completion of manufacture of PPC	IO/EU	Apr-2012
3.1.1	Torus Cryopumps and related equipment: testing of PPC completed	EU	Oct-2012
3.1.1	Torus Cryopumps and related equipment: PA signed	IO/EU	Jul-2013
3.1.1	Torus Cryopumps and related equipment: End of delivery	EU	Jul-2016
3.1.1	CVBs: Final design and document review completed	IO/EU	Dec-2012
3.1.1	CVBs: end of delivery	EU	Jul-2015
3.1.1	NB pumping system: procurement of MITICA cryopump completed.	IO/EU	Sept-2014 (tentative)

3.1.1	NB pumping system: testing of MITICA cryopump completed.	EU	Mar-2015
3.1.1	HNB & DNB pumping system: end of delivery	EU	Apr-2020

3.2. Leak detection

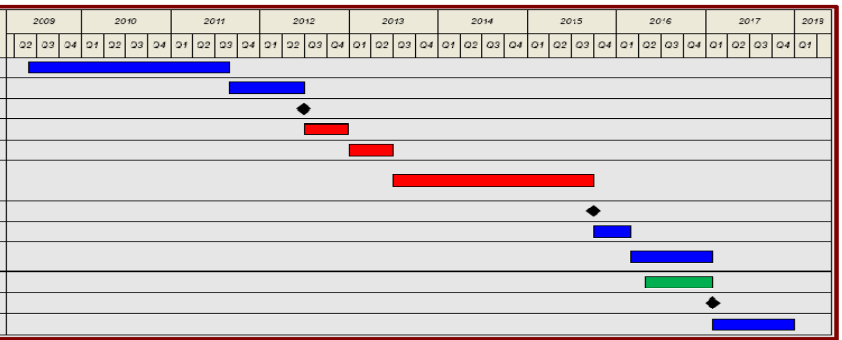
WBS	**Milestone**	**DA responsible**	**Expected date**
WBS 3.1.3	PA issued	IO/EU	Apr 2011* *Likely critical and not achievable as leak localisation needs to be considered at the same time.
WBS 3.1.3	Design Review of Preliminary design	EU/IO	Feb-2013
WBS 3.1.3	Start contract for manufacturing LD system	EU	Aug-2013
WBS 3.1.3	Delivery of LD system to ITER site	EU	Oct-2015

Torus and Cryostat cryopumps tentative schedule, 23/07/2009



CVB and cryojumpers tentative schedule, 23/07/2009

ID	Task Name	Start	Finish	Duration
1	New R&D task	01/06/2009	01/09/2011	823d
2	PA documentation	01/09/2011	01/07/2012	305d
3	PA release	01/07/2012	01/07/2012	0d
4	Detail design+ final review	01/07/2012	30/12/2012	183d
5	Call for tender	01/01/2013	01/07/2013	182d
6	Manufacture and factory testing	01/07/2013	01/10/2015	823d
7	End of delivery	01/10/2015	01/10/2015	0d
8	Iter vacuum lab tests	01/10/2015	01/03/2016	153d
9	Installation and commissioning	01/03/2016	01/02/2017	338d
10	Connection to cryoplant	01/05/2016	01/02/2017	277d
11	Cryosupply required	01/02/2017	01/02/2017	1d
12	Ready for cryopump tests	01/02/2017	01/01/2018	335d



The time schedule gives details for the PP leak detection under no consideration of any leak localisation issues. As stated above Leak detection and leak localisation have to interact very strongly meaning that they cannot be addressed separately. However, very little information is presently available on Leak Localization systems. The R&D is planned to be completed in 2012. In principle, this should be the correct time to start the PA for the Leak detection and localization systems.

DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

<u>Cryopumps</u>

TCPs and CCPs: A half size (model) cryopump of similar design has been produced and tested. This model pump was designed with the same pumping and cryogenic characteristics and its tests confirmed the required pumping performance. However some of its operational parameters, like the pressure drop performance, had not been recorded and tests with the incorporated integral valve could not be performed under real operating conditions up to the agreed cycle number. For this reason the design readiness of these pumps is complete to about 75% level. The still open issues will be tackled by the construction and testing of the Pre-Production Cryopump (PPC).

CVBs: A previous EFDA contract has progressed the design to approximately 80% level. Completion of the design requires definition of all the PFDs and P&IDs together with all safety related provisions.

NBCPs and DNCP: Previous research contracts have progressed the design to about 60% level and in view of the construction of similar high capture probability cryopumps at JET, completion of the design, mainly on geometric and interface issues appears rather straightforward, so that no prototype for these pumps is needed, apart from the MITICA pump.

With this design readiness, it has been decided that with basically only four Grants (one per group of components as above and one for the instrumentation) to complete the design and be ready for procurement.

<u>Leak Detection</u>

The design is defined at level of Functional specifications. The level of remote handling, interfaces, QA and QC aspects have not been considered so far. MSLD with high sensitivity have been built, although some features such as compatibility to Tritium and magnetic fields are unique.

MANUFACTURING READINESS

<u>Cryopumps</u>

The previous manufacture of similar pumps and CVBs at JET without significant problems and the construction and testing of the model TCP pump, result in a relatively enhanced degree of confidence for the related technologies and manufacturing readiness. In addition the performance of the sorbent material has been proven during the tests of the model cryopump. However for the first time, a cryopump with highly cycled integral vacuum valve will be produced and this feature introduces a significant uncertainty/risk in the manufacturing readiness. This aspect is addressed with the manufacture and testing of a PPC.

<u>Leak detection</u>

Presently available technologies can be used such as mass spectrometry, vacuum technology, instrumentation, cryogenics, getters, molecular sieve, glove box, vacuum pumps. Companies with experience in the fabrication of these subsystems exist. Due to the limited pieces of MSLD equipment required, no real difficulties are expected with respect to the manufacturing capacity.

With respect to leak localization a workshop was organized by ITER IO and various methods were proposed, many of them needing further R&D and checks of their capabilities for functioning in an ITER environment. ITER IO has to propose the most efficient methods to be used. As long as this is not done, the issue of manufacturing readiness cannot be discussed.

R&D AND QUALIFICATION ACTIVITIES

<u>Cryopumps</u>

For the successful finalization of the design and procurement of all the ITER cryopumps and related equipment, a clear R&D strategy is implemented with four grants as indicated in section 4.1 above. The definition of the grant technical specifications is and will continue to be done in close collaboration with the IO and mirrors exactly the technical part of the related agreement.

The main outstanding technological issue, namely the definition of the valve for the TCPs and CCPs, is already tackled with an already placed grant placed in which a specialist valve manufacturer contributes as third party. Other outstanding technical issues like safety provisions to avoid migration of Tritium in the cryogens will be dealt with the new grant for the CVBs, in agreement with the ITER IO, if necessary.

<u>Leak detection</u>

Limited R&D is planned for the LD system as defined in the Procurement Package Description. On the other side, large R&D programme is needed for Leak Localisation. The programme to be carried out by IO with EU involvements is presently defined as follow:

Phase 1(2009-2010)

- Modelling of ITER relevant water leaks into vacuum and development of requirements for model verification test rig;
- Theoretical and practical demonstration of time of flight plugged flow technique for thermal shield helium leaks;
- Diverter pipe worm feasibility study;
- Characterisation and demonstration of spectroscopic water leak localisation methods;
- Integration study for light weight fast deployment arm.;
- Definition of water pressure variation requirements.

Phase 2 (2010-2011):

- In 2010 it is the expectation that at least 3 R&D items would show sufficient promise to warrant commencing development into more ITER relevant demonstration;

- Next step study into a rapid deployment, light weight, manipulating arm;
- Development of quick response radiation compatible sensing technology for either the in-vessel transport or the quick deployment arm;
- Port plug sensing and integration study including the possible need to develop novel sensors;
- First stage development of sensors matrices for the Cryostat;
- Compact and suitably leak tight water valve development.

Phase 3 (2011-2012)

- Aim is to concentrate on equipment development and ITER relevant demonstration;
- The program has to be responsive to the previous work but will require high cost due to the need to manufacture relevant prototype hardware.

The time plan of this preliminary R&D proposal suggests that the PA for leak detection and leak localization can certainly not be signed before 2012 and that the expected due-dates given for the "Main Milestones" Section cannot be kept.

PROCUREMENT STRATEGY

Cryopumps

The cryopump procurement strategy is clear and simple. The already defined grants will finalize the design and produce all necessary documentation for the related procurement. Due to the extremely tight schedule related to the TCPs+CCPs, parallel manufacture and testing may need to be employed. Attention will be paid to the selection of the manufacturing companies which should preferably (perhaps at cost) have cryogenic experience. These manufacturing companies should also finalize the design and manufacture the necessary test vessels for at least 80 K testing at their premises. A strategy that was successfully employed at JET.

Another possibility for reducing the (parallel) manufacturing and testing efforts could be to supply to ITER IO only four TCPs. Four TPCs are enough to perform the required pumping of the vacuum vessel during 400 s plasma pulses, because during long pulses anyway only four pumps will be connected to the vacuum vessel whereas the other four ones are regenerated with the valves closed to the vacuum vessel.

Furthermore, the HNB systems are also not required for the first plasma scenarios relaxing therefore also the time schedule for their supply including the one of the cryopanels.

Leak detection

The Leak Detection and Localisation procurement strategy is:

ITER IO performs R&D in order to write the Procurement Arrangement for Leak Detection and Localization.

A) Leak Detection System (EU performs this work as part of the agreed sharing in 2001)

- Development of the "build-to-print" design for leak detection in accordance with ITER IO requirements prior to manufacture leak detection equipment;
- Manufacturing and testing of the leak detection equipments at Supplier site (procurement may be split among different suppliers);
- Delivery of the leak detection equipments to ITER site (installation is ITER-IO responsibility).

B) Leak Localization Systems:

- Development of the "build-to-print" design for leak localization in accordance with ITER IO requirements prior to manufacture leak localization systems;

- Manufacturing and limited testing of the leak localization equipments at Supplier site (procurement may be split among different suppliers);
- Delivery of the leak localization equipments to ITER site (installation is ITER-IO responsibility).

The costs for the work and the procurements mentioned under B) still needs to be determined and agreed as well as who is finally responsible for the payment.

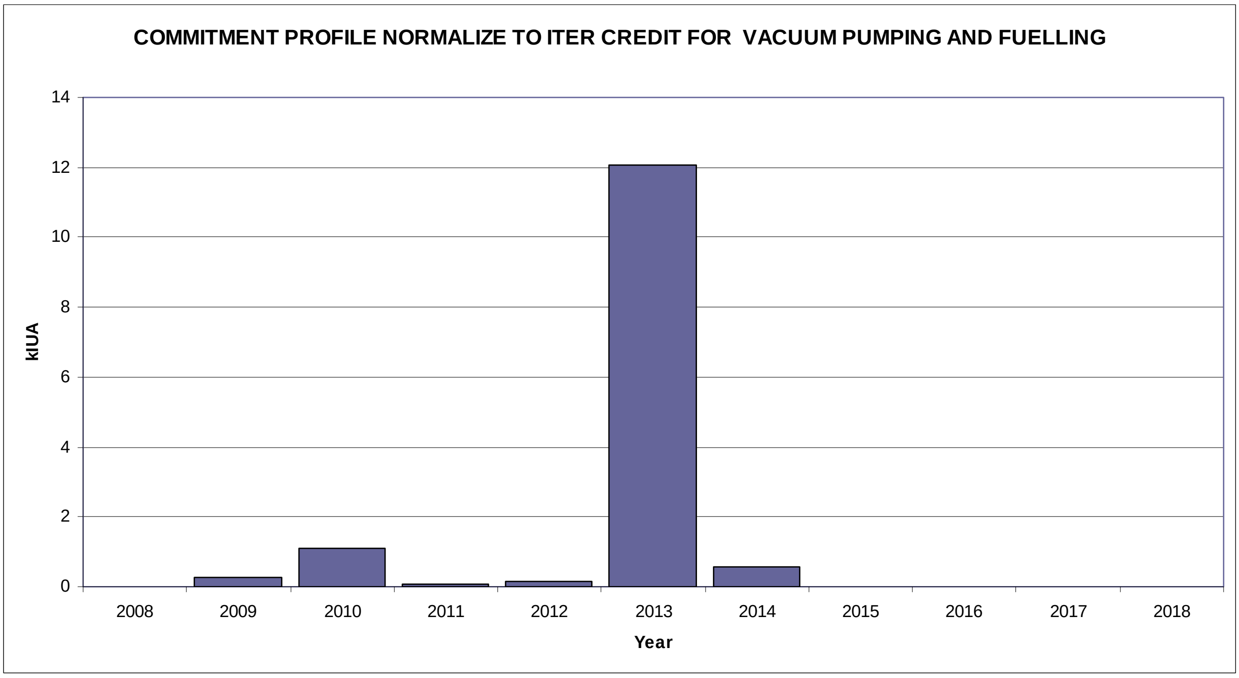
ADDITIONAL COMMENTS

Concerning Leak Detection and Localisation it should be noticed that high level of uncertainty is introduced in the LD package by being strictly linked to the Leak Localisation system. This is because the elements of an efficient leak localization system need to be defined by ITER IO.

Clearly the design of possibly leaking components and their segregation by other means is of high importance and can simplify the leak localisation process.

On the other side after leak detection and leak localisation there might be no simple repair mechanisms available as e.g. presently for leaks in in certain locations of the cryostat . Therefore the design and installation of these systems (e.g. 80 K shield in the cryostat, etc.) has to be done with an extremely high level of reliability, installing e.g. not only one, but a few redundant systems for the circulation of 80K He.

NORMALIZED COMMITMENT PROFILES – VACUUM PUMPING



TRITIUM PLANT	WBS 3.1.3 18.137 kIUA

SHORT DESCRIPTION OF EU CONTRIBUTION/OBLIGATION

ITER will be operated with tritium plasma therefore a Tritium Plant will be built to support ITER operations with the following main functions:

- processing of the gases returned from the machine and from other sources within ITER in order to recover the deuterium and tritium and to release the other however detritiated gases into the environment;
- preparation, storage and transfer of certain hydrogen isotope to the various gas injection systems;
- safety functions particularly with respect to tritium confinement and containment.

The Tritium Plant is divided in the following packages[11]:

- Tokamak Exhaust Processing (TEP) System; (US, ITER-IO);
- Storage and Delivery Storage system (SDS)(KO, ITER-IO);
- Hydrogen Separation System (ISS) (EU, ITER-IO);
- Atmosphere and Vent Detritiation System (ADS/VDS) (JA, ITER-IO);
- Water Detritiation System (WDS) (EU, ITER-IO);
- Tritium Plant Analytic System (ANS) (ITER-IO);
- Control System (ITER-IO).

In the frame of the ITER procurement sharing, for both Isotope Separation System (PP3.2.3) and Water Detritiation System (PP3.2.5), 88% of the package is assigned to EU (in-kind contribution) and the remaining 12% to Fund (directly managed by ITER-IO).

WBS	EU obligation	Design type	Other DAs involved/remarks
Isotope Separation System The Hydrogen isotope separation system separates by cryo-distillation the hydrogen isotopes in the mixtures received from TEP, WDS and Neutral Beam Injectors and produces specific hydrogen isotopic streams to be provided to the Storage and Delivery system and to the Water Detritiation System.			
WBS 3.1.3	Isotope Separation System (ISS) Cryogenic distillation columns	Detailed Design Specifications	No other DAs involved
WBS 3.1.3	Large cold box	Detailed Design Specifications	No other DAs involved
WBS 3.1.3	large hard shell enclosure containing all process pumps, equilibrators, valves, pipes, instruments	Detailed Design Specifications	No other DAs involved
WBS 3.1.3	Large expansion tank	Detailed Design Specifications	No other DAs involved
WBS 3.1.3	Helium refrigeration unit	Detailed Design	No other DAs involved

[11] 1. Common Understanding on Procurement Allocation, EUR(05) CCE-FU31/2.1, N-12 ROM Att.5.1

		Specifications	

Water Detritiation System

During ITER operation, including maintenance campaigns, tritiated water will be generated by various sources, and accumulated in amounts far beyond the values that can be discharged within authorised limits. This tritiated water will be stored on site and processed in the WDS where it will be converted to gaseous hydrogen and oxygen streams using the Combined Electrolysis Catalytic Exchange (CECE) technology. The produced tritiated hydrogen isotope mixtures will be sent to ISS, whereas detritiated protium and oxygen will be discharged into environment within the authorised release limits. The ITER WDS will be located in the Tritium Plant Building and will comprise the tritiated water holding tank system for temporary storage of tritiated water waste in dedicated tanks according to its tritium concentration or in 300 m^3 large emergency tanks in case of accidents and the main WDS for processing this water.

WBS 3.1.5	Tritiated Water Holding Tank System (storage and emergency)	Detailed Design Specifications	No other DAs involved
WBS 3.1.5	Front End Process System	Detailed Design Specifications	No other DAs involved
WBS 3.1.5	Electrolyser System;	Detailed Design Specifications	No other DAs involved
WBS 3.1.5	Catalytic Exchange Towers	Detailed Design Specifications	No other DAs involved
WBS 3.1.5	Membrane Permeator System	Detailed Design Specifications	No other DAs involved
WBS 3.1.5	Oxygen Process System	Detailed Design Specifications	No other DAs involved
WBS 3.1.5	Exhaust Processing System	Detailed Design Specifications	No other DAs involved
WBS 3.1.5	Utility	Detailed Design Specifications	No other DAs involved
WBS 3.1.5	Drain System	Detailed Design Specifications	No other DAs involved
WBS 3.1.5	Secondary Containment	Detailed Design Specifications	No other DAs involved

PROCUREMENT ARRANGEMENTS PLANNING&STATUS

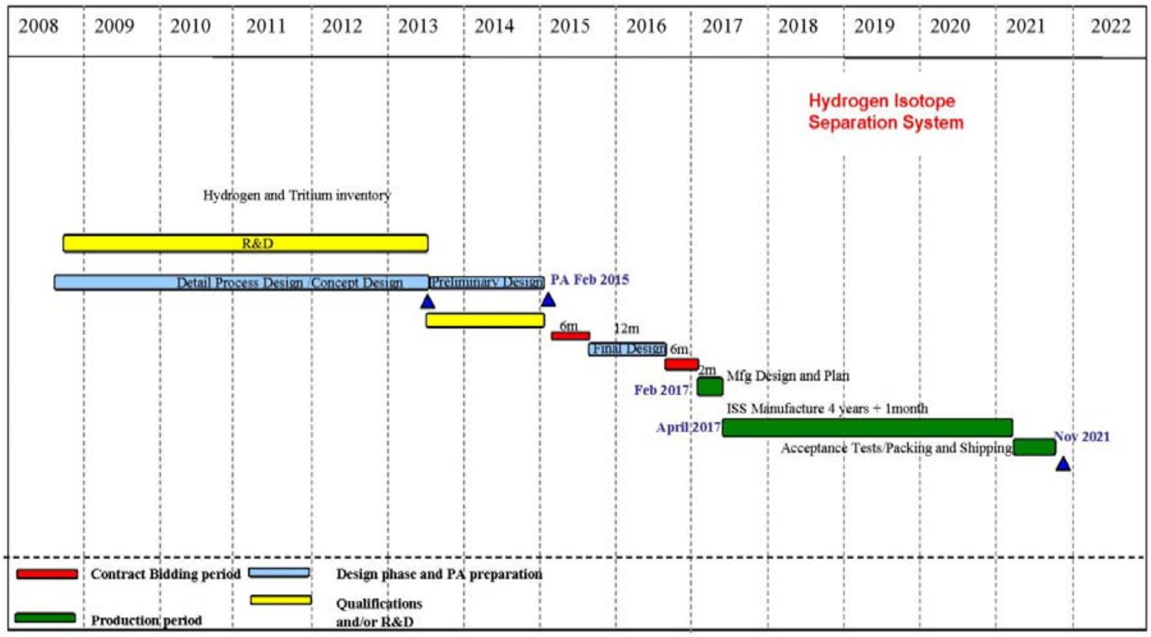
PA Title	PA signature	Credit (kIUA)
WDS PA 1st part: Tritiated water holding tanks (storage and emergency)	June 2010	4.78
WDS PA second part: residual WDS system (process components without tritiated water holding tanks)	December 2013	7.948
ISS PA	February 2015	5.409

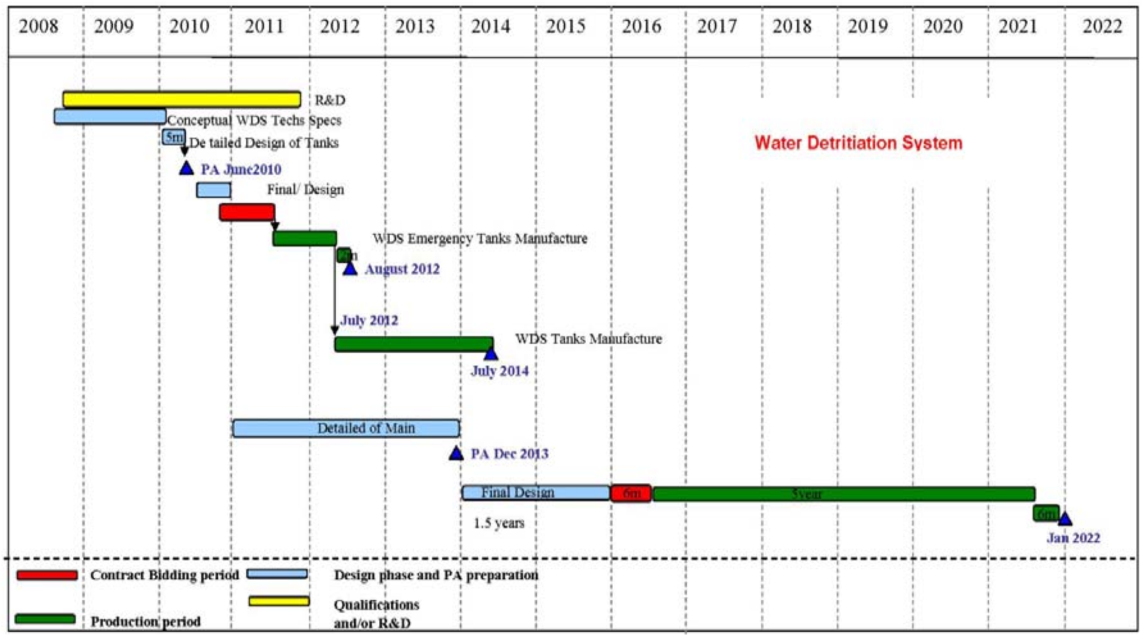
Activities to be launched in 2009 and 2010 cover:

- Assessment of the 2001 reference baseline design for ISS.
- Conceptual and Detailed Design of ISS and WDS
- R&D s in support of the Detailed Design of ISS and WDS;
- Preparation of technical specifications for procurement of WDS tritiated water holding tanks

MAIN MILESTONES

WBS	Milestone	DA responsible	Expected date
ISS milestones			
WBS 3.2.3	Design review of conceptual design	IO/EU	June 2013
WBS 3.2.3	Design review of Preliminary* Design completed and Issuer of PA	IO/EU	Feb 2015
WBS 3.2.3	Design review of Final Design.	EU/IO	Aug 2016
WBS 3.2.3	Start of Manufacturing of components.	EU	Apr 2017
WBS 3.2.3	ISS delivered to ITER site	EU	Nov2021
* The adjective "Preliminary" has been adopted by IO to indicate the Design level previously defined as "Detailed"			
WDS milestones			
WBS 3.2.5	Design Review of Detailed Design of WDS water holding Tanks (both emergency and storage tanks) and issue of 1st part of PA	IO/EU	June 2010** **It is very unlikely that this milestone is met. Remedy action is planned
WBS 3.2.5	Design Review of Final Design of WDS water holding tanks (both emergency and storage tanks)	EU	Jul 2011
WBS 3.2.5	Manufacturing of WDS Emergency tanks and delivery to ITER site	EU	August 2012
WBS 3.2.5	Manufacturing of tritiated water holding tanks and delivery to ITER site	EU	Jul 2014
WBS 3.2.5	Design review of Detailed design of residual WDS(process components without water holding tanks) and issue of 2nd part of PA	IO/EU	Dec 2013
WBS 3.2.5	Design review of Final Design of residual WDS	EU/IO	Dec 2015
WBS 3.2.5	Manufacturing of residual WDS and delivery to ITER site	EU	Jan 2022





These are the versions agreed between F4E and IO in the IPS workshop in July 2009.

DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

Hydrogen Isotope Separation System

The design has not reached the "Detailed Design" stage yet. Actually, even the 2001 baseline design is presently questioned due to too high inventory expected as a consequence of recent experimental results showing an up to 3 times higher liquid hydrogen hold-up in the cryodistillation columns. Cryogenic tritium isotope separation systems were built at other places (e.g. JET, Los Alamos). However, it has to be considered that ITER ISS is unique in that it has to cope with varying feeding conditions due to the pulsed operation of the ITER machine, whereas most of the ISS in the world were/are operated under stationary conditions. This can influence the product quality and the availability of the products due to the time response of the whole ISS system on gradients.

In June 2009, R&D was launched in order to assess the behaviour of packing for the cryodistillation columns. The overall main goal is to provide to the designers the essential, but still missing information on tritium/hydrogen inventory in ISS so that, if necessary, the system design can be adapted in order to fulfil stringent inventory requirements imposed by ITER IO on the total hydrogen as well as tritium inventories.

The Detailed design will be carried out by F4E within the frame of ITER task agreements (ITAs) after re-assessing the 2001 reference baseline conceptual design and considering the newly required changes in the feed and product streams recently requested/proposed by IO (such as the removal of the 50% D/50% T product from cryo-distillation Column 4).

Water Detritiation System

The design has not reached the "Detailed Design" stage yet. A R&D programme is being started together with some design activities in order to prepare the Procurement Arrangement. The most critical parts are the tritium-compatible electrolysers of relevant size. It has been decided to take the solid polymer Naphion type membrane based electrolyser as the baseline one. Also the demonstration of the performance of catalysts/packing for Liquid Phase Catalytic Exchange column needs to be addressed for ITER use.

MANUFACTURING READINESS

Hydrogen Isotope Separation System

R&D is planned to define/validate various aspects of feasibility, maintainability, control, etc. No prototype is required before series production: in fact a one column ISS system exists at Tritium Laboratory Karlsruhe (TLK) and will be combined with a simplified WDS to allow in the near future combined runs of TLK ISS and TLK WDS to simulate in a reduced scale the interaction between ITER ISS and ITER WDS).

- Manufacturing capacity has to be re-established. Danger of "near" monopoly may exist with limited know-how in industries. Worldwide tendering recommended and even then the number of suppliers may be limited.
- The online analyses of the isotopic composition in the various products might be necessary to obtain a clear on-line picture of the whole performance of the ISS. Up to now only analyses at limited times are foreseen via the Analytical system. The installation of local ionisation chambers or Laser Raman tools could support those analytical needs.

Water Detritiation System

No 1:1 prototype is presently planned before series production with the possible exception of the production and testing of an electrolyser. At TLK a reduced size mock-up (TRENTA) already exists that uses two electrolysers, each of 1 m^3/h throughput, and one LPCE column, and is upgraded for the operation of water with all three hydrogen isotope molecules. With the exception of the electrolysers and catalyst/packing, for which dedicated R&D is planned, the WDS system is in principle a simple combination of pipes, vessels, columns, water circulating pumps and manufacturing is not expected to cause problems. However part of the diagnostics, especially the accurate online determination of tritium in water (to monitor the tritium concentrations in the tanks and the tritium profiles along the LPCE column) is still considered to be not simple.

R&D AND QUALIFICATION ACTIVITIES

Since the technical risks are limited for both ISS and WDS, only a few activities are foreseen. There will be limited

R&D activities on the electrolysers, for the assessment of packing and packing/catalyst mixture for ISS and WDS columns, respectively, and possibly for specific analytical needs (see sections above). The detailed design work will be done using know-how available in EU laboratories in the frame of ITAs. Build-to-print and manufacturing drawings will be produced as part of the procurement contracts of the various subsystems

PROCUREMENT STRATEGY

Hydrogen Isotope Separation System

In the first phase, EU will support ITER-IO in the finalization of the Procurement Arrangement through manufacturability studies and a focused R&D programme:

- Test of further type column packings (CY) for the Isotope Separation System because the up to now investigated packing showed a too high tritium inventory;
- Possibly tests of specific analytical tools;
- TRIMO (computational code to describe the ITER Fuel Cycle in a simplified but nearly dynamic way) development with benchmarking against experimental results of the code predictions for tritium inventory and dynamic response.

Once the PA is issued by ITER IO, the procurement steps are:

- Manufacturing and testing of the components constituting the HISS. There could be a number of parallel contracts for groups of components e.g. cold box with all internal components (columns, heat exchangers, etc.), expansion tanks, hard shell with all internal components (pumps, catalysts, valves, diagnostics, etc.), refrigerator, software development, etc.. Further contracts could cover the procurement of more-or-less standard catalogue items (pumps, valves, instruments, packing, catalysts, etc.) to be issues as free items to the fabrication companies;
- System test/approval phase: the system is tested (electrical, pressure, etc.) to assure it is ready for installation. Part of testing will actually be carried out/repeated at IO site;
- Delivery of the system to ITER site;
- Installation (including QA/QC);
- System-Plant integration phase: individual system is installed into the ITER tritium plant and tested to make sure it functions with Plant utilities (procurement phase completed). The tests to be performed need still to be agreed with ITER IO because at this stage it will be very likely that tritium experiments cannot be performed.

The next steps (integrated commissioning of the integrated ISS system) will be carried out by ITER-IO and EU will act likely only in a supervisory/advisory role.

- System-System Integration: system is tested and commissioned with H and/or D together with other systems. Aim of testing is to assure the Regulator that the system can move to the active tritium testing phase;

- Integrated Commissioning with Tritium: systems will have tritium introduced in a logical and sequential manner to minimize risk to other systems starting with very low concentration of Tritium in hydrogen. Successful testing will allow full license to the Tritium Plant.

Water Detritiation System

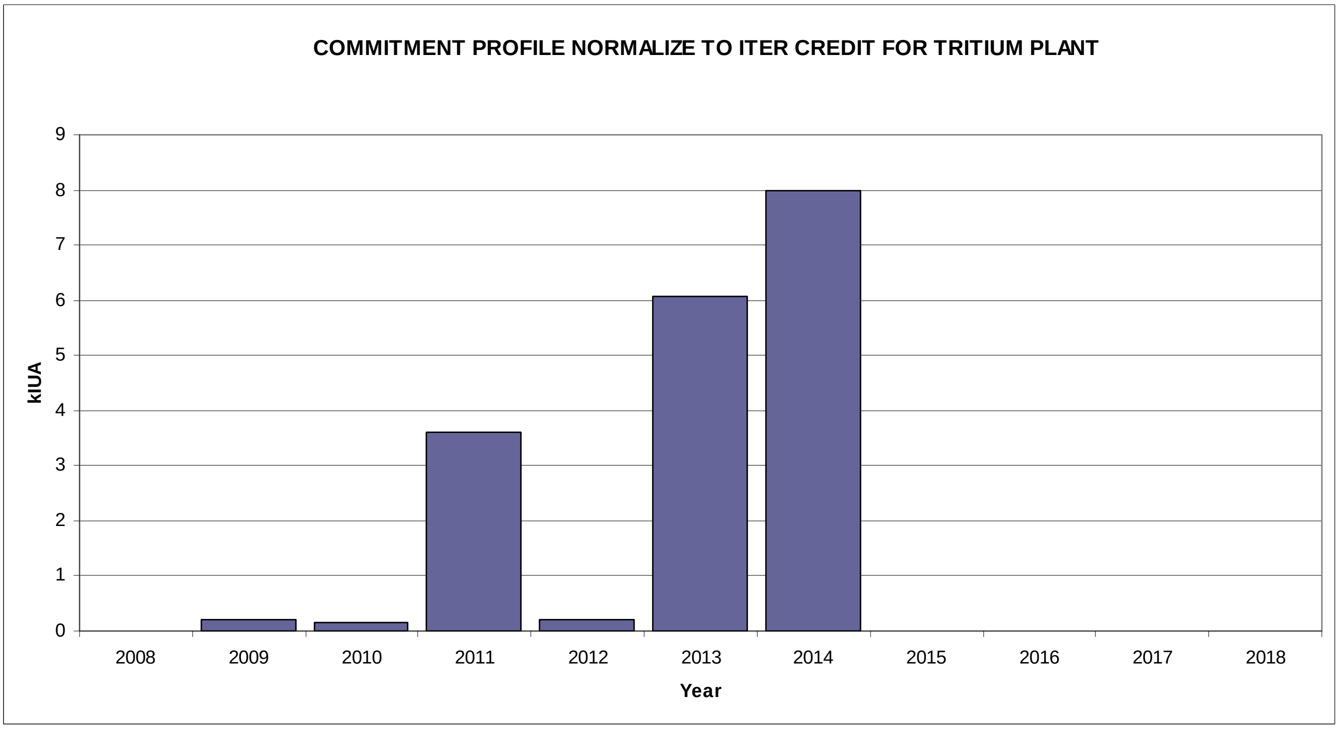
In the first phase, EU will support ITER-IO in the finalization of the Procurement Arrangement in the frame of ITAs. This will be achieved through a focused R&D programme. Once the Procurement Arrangement is issued by ITER IO, as this is a detailed design, and manufacturability studies are proposed to be done in parallel to R&D, the fabrication of the system could be released in one step. However, the necessity to install the Water holding tanks before the buildings are closed has required splitting the procurement in two parts, one quite early related to the Water holding tanks and the other for the procurement of the main system. For the main system, there will be a number of parallel contracts for groups of components, some contracts will cover the procurement of more-or-less standard catalogue items (pumps, valves, instruments, etc.)

- Manufacturing and testing of WDS Tanks at manufacturer's site ;
- Delivery, installation and tests of WDS-Tanks at ITER;
- Manufacturing, testing at Manufacturer's site, delivery, installation and tests at ITER site of the components constituting the main WDS;
- Installation (including QA/QC) of WDS and tests to make sure it functions with Plant Utilities (system-Plant integration phase)

Additional comments

In the case of WDS, the delivery of the emergency tanks may be late with respect to the closure of the level B2 of the Tritium building where the tanks should be installed according to the IPS (July 2009). This can cause delay in the installation of the tanks because alternative installation approaches have to be adopted such as either allowing a hole in the floor above the tanks which will be closed after their installation or in-situ assembly using as large as possible and as much prefabricated parts of the tanks to minimize the number of welds to performed at the installation location of the ITER site.

NORMALIZED COMMITMENT PROFILES – TRITIUM PLANT



CRYOPLANT	WBS 3.4.1 30.12kIUA

SHORT DESCRIPTION

The procurement of the ITER cryogenic system (PP34) is divided in three packages: cryoplant (PP34.P1), cryodistribution components (PP34.P2) and cryolines (PP34.P3). The procurement sharing for the cryoplant procurement package is assigned 50% to Fund (directly managed by ITER IO) and 50% to EU (in-kind supply by F4E). The cryodistribution and cryolines procurement packages are fully assigned to India DA.

The cryoplant procurement package as described in the procurement description document is composed of:

- The LHe cryoplant including three LHe process modules (cold boxes) and associated warm compressor stations;
- The LN_2 plant including two identical LN_2 process modules (cold boxes) and associated warm compressor stations;
- The 80K Helium loop including two identical process modules (cold boxes) and associated warm compressor stations;
- Gas storage systems including warm Helium tanks and cold Helium tanks (~80K) for quench recovery;
- Liquid Helium and Nitrogen Storage Dewars;
- He gas purification unit;
- Instruments, cubicles and local controllers for above systems;
- Master control system for the overall cryoplant system;
- Spare parts for all systems mentioned above.

These components, with the exception of the equipment mentioned under the first and last two bullet points have to be supplied in-kind by the EU.

According to the sharing agreement with ITER IO signed in early 2009[12], the EU will contribute in-kind the LN_2 plant, 80K loop and auxiliary components

PROCUREMENT ARRANGEMENTS PLANNING&STATUS

PA Title	PA signature	Credit (kIUA)
LN_2 Plant	December 2010	
80 K Loop	December 2010	
Auxiliaries	December 2010	
	Total	30.12

An overall conceptual design review for the whole cryogenic system is scheduled for December 2009 with the main aim to define all interfaces with the cryogens users. During the second half of 2009 and in 2010 F4E is addressing EU procurement related issues with experts.

[12] IO-EU Procurement sharing proposal for cryoplants procurement package (WBS 3.4.0) – ITER IDM reference 27W99Mv2.3

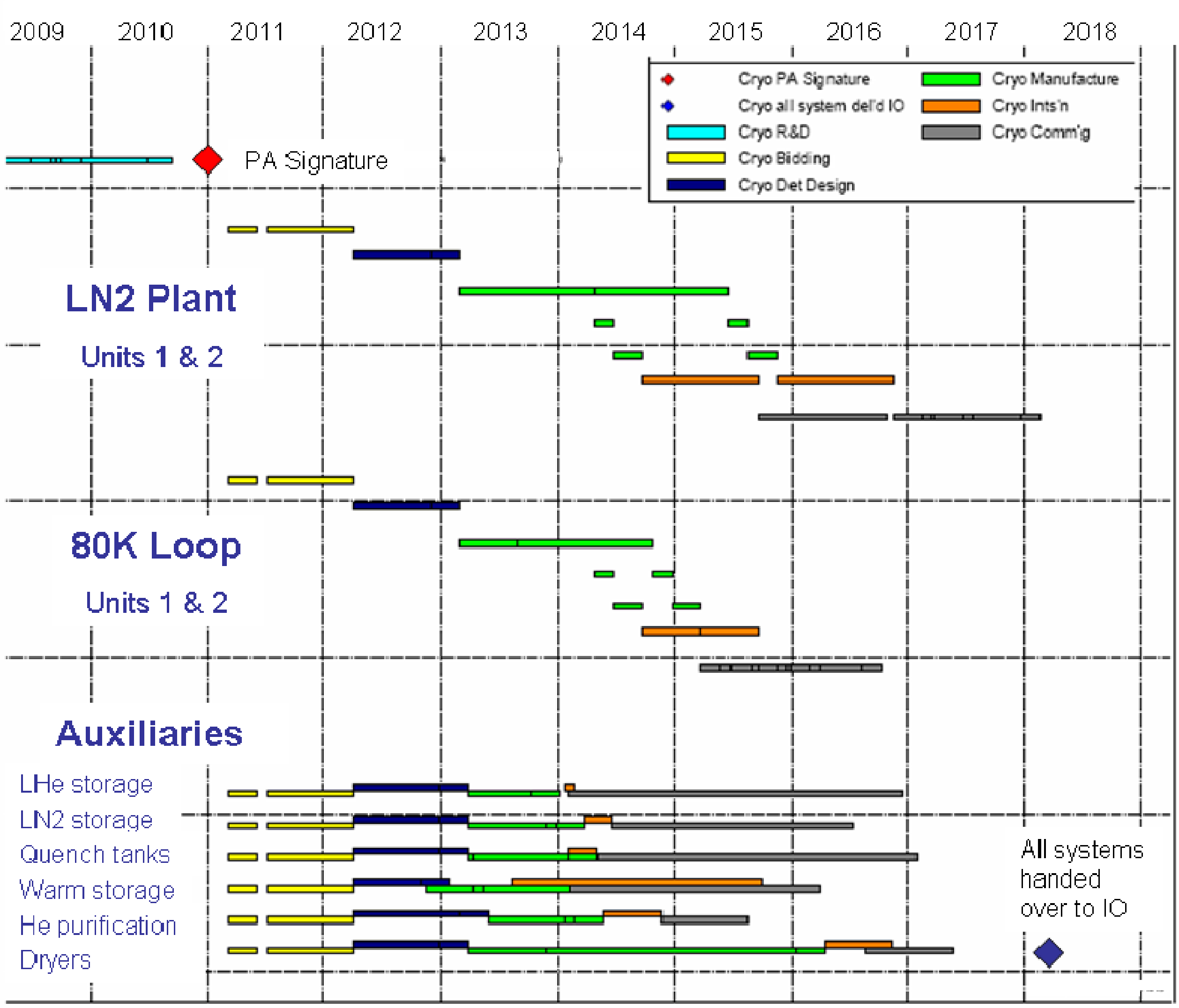
WBS	EU obligation	Design type	Other DA involved/remarks
WBS 3.4.1	LN_2 plant (2 x 650 kW) including compressor station, cold boxes, cabling, cubicles and local control system	Functional specification	Some internal pipework and cryolines will be supplied by India-DA
WBS 3.4.1	80 K loop (2 x 450 kW) including compressor station, cold boxes, cabling, cubicles and local control system.	Functional specification	Some internal pipework and cryolines will be supplied by India-DA
WBS 3.4.1	Auxiliaries : - LN_2 and LHe dewars - Gaseous He storage vessels - Quench tanks - Heaters - He purification unit and dryers including cabling, cubicles and local control system	Functional specification	Some internal pipework and cryolines will be supplied by India-DA

MAIN MILESTONES

Discussions are ongoing with the ITER IO to agree on the level of float required for the delivery of the auxiliary systems.

WBS	Milestone	DA responsible	Expected date
	Cryoplant common milestones		
WBS 3.4.1	Overall cryosystem conceptual design review	IO	Dec 2009
WBS 3.4.1	LN_2 plant, 80K loop and aux. conceptual design review	IO	Sep 2010
WBS 3.4.1	PA for LN_2 plant, 80K loop and aux.	IO	Dec 2010
WBS 3.4.1	All systems handed over to IO	EU	Feb 2018
	LN2 plant milestones		
WBS 3.4.1	Contract signed for LN2 plant	EU	Mar 2012
WBS 3.4.1	LN_2 plant detail design approved by IO	EU	Feb 2013
WBS 3.4.1	1st LN_2 plant delivered to IO site	EU	Sep 2014
WBS 3.4.1	1st LN_2 plant commissioned	EU	Oct 2016
WBS 3.4.1	2nd LN_2 plant commissioned	EU	Dec 2017
	80K loop milestones		

WBS 3.4.1	Contract signed for 80K loop	EU	Mar 2012
WBS 3.4.1	80K loop detail design approved by IO	EU	Feb 2013
WBS 3.4.1	1st 80K loop delivered to IO site	EU	Sep 2014
WBS 3.4.1	1st 80K loop commissioned	EU	Dec 2016
WBS 3.4.1	2nd 80K loop commissioned	EU	Apr 2017
	Auxilliaries milestones		
WBS 3.4.1	First contract signed for Auxiliaries	EU	Mar 2012
WBS 3.4.1	First storage tank delivered	EU	Oct 2013
WBS 3.4.1	All auxiliaries handed over to IO	EU	May 2017



DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

Up to 2007 most of R&D and preliminary design activities for the ITER cryoplant have been concentrated on:

- Preliminary design of cryodistribution components: Auxiliary Cold Boxes and cryolines;
- Numerical flow-dynamic simulations to study heat loads impact on the cryogenic system for different plasma scenarios;
- Operational modes study;
- Analysis and validation of the dynamical behaviour of the cryoplants and ability to cope with ITER dynamic heat loads;
- Definition of the Project Development Plan for the entire cryogenic system.

The outcome of the industrial studies carried out during 2007 on the cryoplant system and layout has allowed to:

- Validate the cryoplant conceptual design and layout;
- Validate the preliminary design and technological choices of the different cryoplant sub-systems;
- Validate the cryoplant procurement, fabrication, installation and commissioning schedule;
- Update the ITER cryoplant cost estimates;
- Identify technical issues and possible improvements of the cryoplant system;
- Have a better understanding of the product and cost breakdown structure for the cryoplant system for the procurement sharing between IO and EU PT.

Within 2009 and 2010, it is mandatory to:

- Validate the heat loads for the whole cryogenic system, margins and overcapacity;
- Validate functional and process requirements from different users;
- Validate all operational and transient modes;
- Validate the variable heat loads mitigation strategy;
- Perform a safety and RAMI analysis for the cryogenic system;
- Perform a global design review of the cryogenic system;
- Optimize the cryoplant system according to updated input design parameters and functional requirements

There has been little progress in the above mentioned areas in 2008. Most of the procurement risks of the cryoplant are connected with the subsystems to be supplied by ITER IO. In consequence the IO design effort is concentrating on evaluating options for the Helium cryoplant and the cryodistribution components which are not part of the EU procurement.

The Heat Loads Working Group launched in June 2009 needs to establish the final heat loads requirements of the cryogen users as this is one of the main design parameters. These numbers are urgently needed to define the functional specifications of the various subsystems.

The technical risks for the EU in-kind components are relatively limited since similar systems are being used regularly in industrial applications or other research facilities. The F4E position for the 50% / 50% splitting of the cryoplant package (PP34.P1) agreed between F4E and IO was driven by the objective to reduce the technical risk.

The main issues are:

- LN_2 plant: The optimized layout and integration of the LN_2 plant with the 80K loop depends on the final heat loads and functional requirements. The present uncertainties are still high and could significantly affect the final design of the LN_2 plant. However, there should be no significant technological risk since proven industrial technologies are available.
- 80K Loop: Choice of the most appropriate 80K loop compressor technology. Development of compressor technology with the required working range could offer the possibility to use compressors with higher energy efficiency and lower contamination rates of the helium circuit. Related risks in procuring compressors are fairly minor and should not delay the signature of procurement contracts for the compressors in early 2012 as standard compressor solutions (screw compressors) can be directly implemented.
- Auxiliary Systems: Well defined functional and technical requirements need to be defined for most of the following systems:
    - Warm and liquid storage systems for He and N_2;
    - Electrical heaters;
    - Helium recovery and purification system;
    - Quench tanks.

The drafting of the functional specifications for these contracts/systems will start in 2010 after the overall system conceptual design review which should provide the required design baseline.

MANUFACTURING READINESS

During 2007 two industrial support contracts were launched in order to review the cryoplant systems design and layout. Their outcome shows that no technology developments are needed in terms of the manufacturing readiness of the proposed design.

R&D AND QUALIFICATION ACTIVITIES

Since the technical risks are limited, only few activities are foreseen beside the work to be done by experts. As mentioned above, there will be a very limited amount of R&D activities on the 80K loop compressor technology. The detailed and build to print design activity will be done mainly as part of the procurement contracts of the various subsystems.

PROCUREMENT STRATEGY

Three main procurement strategies are envisaged:

- One unique turn-key contract which could significantly increase the price while reducing interfaces and contract management requirements. It will imply a strong dependency on one unique contractor;

- Several different contracts one for each of the sub-systems to procure: cost could be better controlled although interface, system integration and contract management requirements will increase;

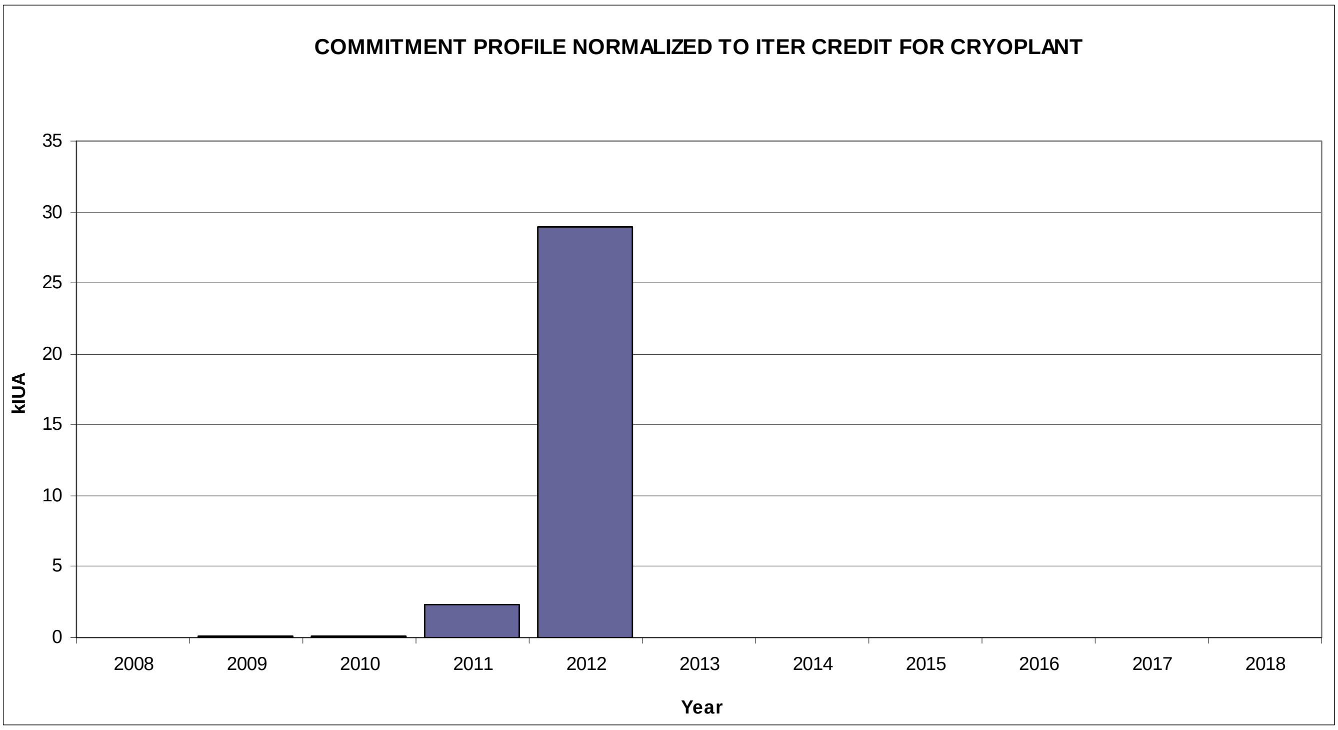
- Use of a cryogenic engineering support company: an engineering support contract would be used for functional specification preparation, support and follow up during procurement up to installation and on-site commissioning. Direct procurement contracts would be issued for few cryoplant sub-systems. It is likely that only the two main European cryogenic suppliers could fulfil this engineering task.

Common costs generated by all major cryoplant systems like control systems, installation, and commissioning should also be taken into account when preparing the procurements. These cost and issues have to be coordinated and integrated in a common approach by the main cryoplant system suppliers (e.g. within the Cryoplant Integrated Product Team (IPT)).

A business intelligence program has been launched within F4E to complete a market survey, benchmark suppliers and stimulate the market. The main outcomes will be to help establish our procurement strategy, reduce the costs of the procurement by maximising competition and obtain feedback from industry on our proposed schedule and technical options.

Presently the best strategy seems to be a middle way between the two extreme cases (i) one single contract or ii) very many contracts. With the implementation of one contract for the two LN_2 plants, one contract for the two 80 K loops and a few contracts for the auxiliary systems (liquid nitrogen tanks, liquid He tanks, purification systems, etc.). This strategy should enable the system to be defined to a suitable level to reduce commercial risks to an acceptable level while keeping interfaces to a manageable level. In addition to the main procurement contracts, it is advisable to place a follow-up contract for engineering support to check key technical points and interfaces if needed. However, the implementation of this strategy depends strongly to what level the functional specification can be defined by ITER IO.

NORMALIZED COMMITMENT PROFILE – CRYOPLANT



POWER SUPPLIES	**WBS 4.1 & 4.3** **31 kIUA**

SHORT DESCRIPTION

In the frame of the ITER in-kind contribution, Europe will provide:

- The detailed design and the assembly of the Steady State Electrical Network (SSEN) and of the Pulsed Power Electrical Network (PPEN);
- The procurement of the Emergency Power Supply, 100% of SSEN cables and 25% of the SSEN equipment.

The electrical plant procurements to be provided by EU are listed here below:

PBS	EU obligation	Design type	Other DA involved/remarks
Pulsed Power Electrical Network (which supplies the magnets converters and the additional heating and current drive systems)			
PBS 41	High Voltage and Medium Voltage distribution	Build to print, and Functional specifications for materials	CN provides 100% of materials CN, KO and RF are involved in other parts of the PPEN (Converters, Reactive Power Compensation & Harmonic Filter System, Switching Network & Discharge circuit)
Steady State Electrical Power Network (which supplies the auxiliaries systems in the ITER site buildings including the safety relevant load , being the Cooling Water System and the Cryoplant its major clients)			
PBS 43	High Voltage, Medium Voltage and Low Voltage distribution. Emergency Power Supply	Built to print, and Functional specifications for materials	US is involved in the procurement of materials (75%) Emergency Power Supply and cables are EU contribution

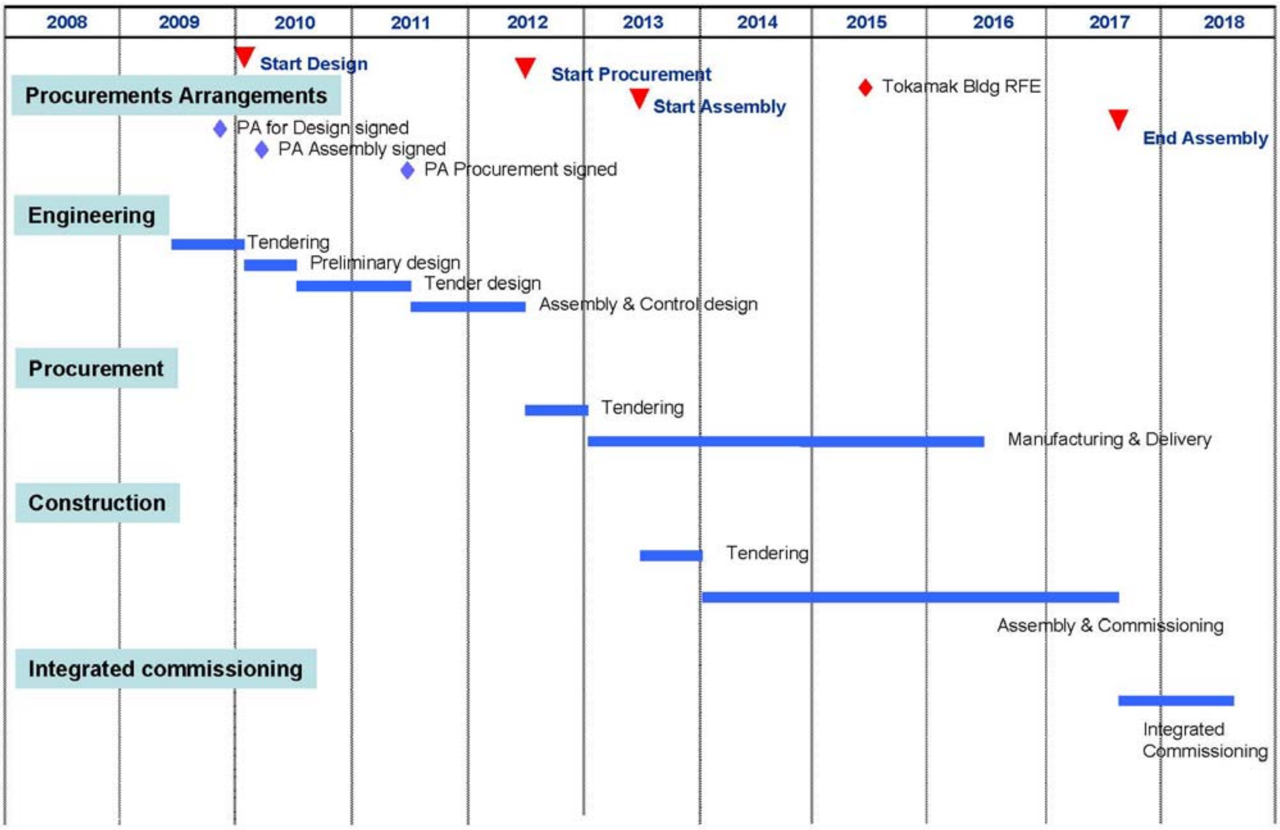
PROCUREMENT ARRANGEMENTS PLANNING & STATUS

PA Title	**PA signature**	**Credit (kIUA)**
Detailed design of the SSEN and PPEN	October 2009	7.0
Assembly of the SSEN and PPEN and SSEN cables	April 2010	13.3
Material procurement for SSEN	June 2011	5
Material procurement for SSEN Emergency Power Supply	June 2011	5.7

MAIN MILESTONES

Considering that the RFE (ready for equipment) of the Tokamak complex and Assembly Hall must take place in June 2015 (Modified Scenario 1), the main milestones are shown below. It must be noted that the ITER electrical plant is not in the critical path per se, but because its design and construction is linked to the ones of the site and buildings as they share the same procurement strategy and implementing contracts.

PBS	Milestone	DA responsible	Expected date
Architectural and Engineering services			
41,43	Preliminary design complete	EU	June 2010
41,43	Tender design complete	EU	June 2011
41,43	Assembly design complete	EU	July 2012
Procurement			
43	Last procurement	EU	May 2016
Construction			
41,43	Final acceptance of the works	EU	August 2017



DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

The IO will provide the functional specifications of the electrical distribution system intended as a complete set of documents, analyses, drawings and models in which the requirements, interfaces, preferred basic configuration and sizing of the equipment is documented. A first set of documents "Initial Functional Requirements" has been developed and used for tendering the F4E assistance contracts (Architect Engineer, Legal Inspection contracts). These documents will be updated by IO into "Final Functional Requirements" by the end of 2009 to allow the Architect Engineer to start the design on a frozen conceptual design basis.

The PA for Electrical Design services signature will take place in October 2009. Anyhow F4E has evaluated the status of the current functional requirements and has found some important issues that need to be finalized by IO by the end of 2009. These include the following:

- Uncertainties regarding the application of safety standards.
- Uncertainties in the requirements (failure scenario, operation sequences, application of standards) concerning the Emergency Power Supply
- Uncertainties in Low Voltage loads definition inside Tokamak complex.

The lifting of these conditions will be a prerequisite to the signature of the PA for Assembly of the electrical plant.

MANUFACTURING READINESS

In general the assembly of ITER electrical plant don't require development of new/special technologies or R&D in support. The exceptions are the low Voltage equipment to be qualified for working under high magnetic field and the seismic qualified diesel generators and auxiliaries.

R&D AND QUALIFICATION ACTIVITIES

Low Voltage equipment to be qualified for working under high magnetic field as described in 4.2

PROCUREMENT STRATEGY

Based on an analysis of the market and technical environment and the risk assessment, the following strategy is defined:

<u>Short-Term</u>

- To launch Architect Engineer, Legal Inspection, and Support to the Owner contracts tendering in summer 2009 in order to have contract signed beginning of 2010. All these three contracts have an initial duration of 6 years, but include 5 optional years that can be exercised in case of delay in design or construction. Therefore the total maximal length of the 3 assistance contracts can be up to 11 years.

- To review the draft functional specifications provided by IO through the PA services with the help of an expert's panel in order to assist IO to improve and to fill out the functional specification. The final functional specifications have to be ready before the end of 2009 and will be the baseline (frozen technical configuration) to launch the detailed studies.

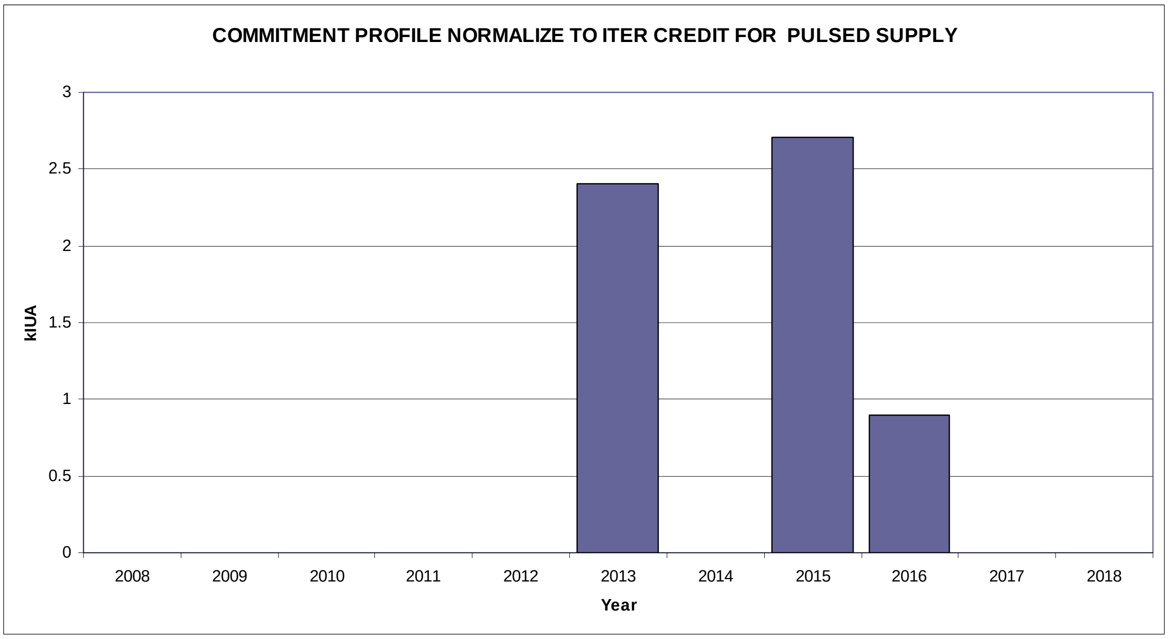
<u>Mid-Term</u>

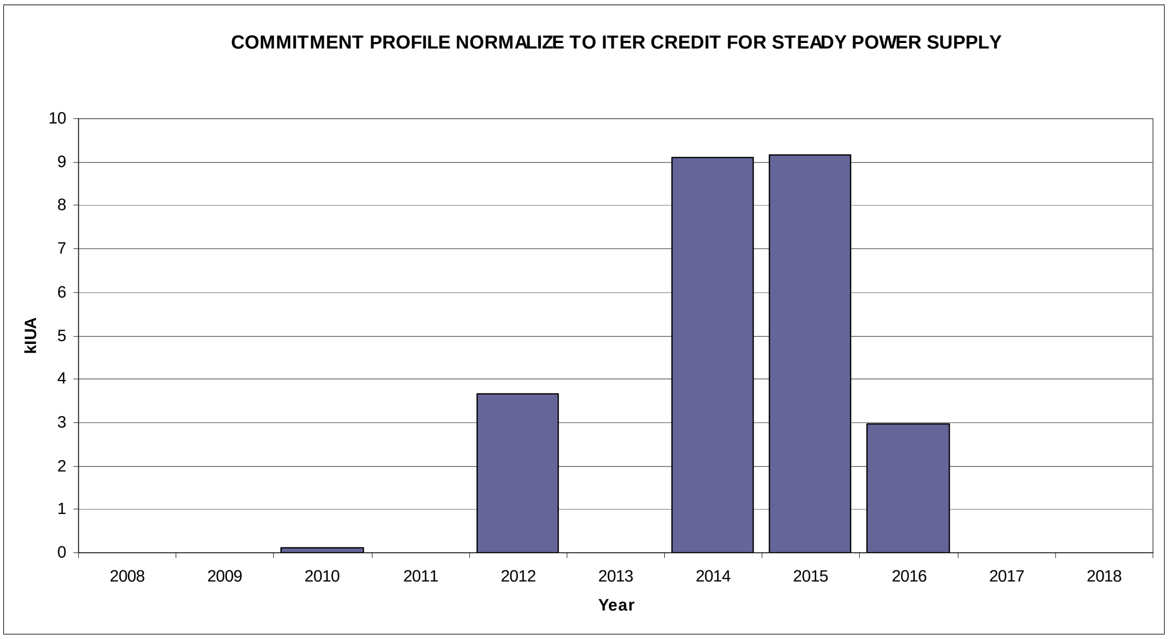
- To carry out detailed studies with Architect Engineer 2010, 2011 and 2012.

- To launch a Call for Tender for the first contracts for civil construction on 1st semester 2011 to be able to start construction on 2nd semester 2011.
- To launch Call for Tender(s) for procurement of **SSEN + PPEN electrical** equipment following Architect Engineer Procurement schedule.
- To launch Call for Tender(s) for assembly of **SSEN + PPEN electrical plant** following Architect Engineer Assembly schedule.

Allotment strategy for the construction of the ITER buildings and electrical plant (see Site & Buildings strategy)

NORMALIZED COMMITMENTS PROFILE PULSED AND STEADY-STATE POWER SUPPLIES





INSTRUMENTATION AND CONTROL (CODAC)	WBS 4.5

SHORT DESCRIPTION

ITER WBS 4.5 is about the infrastructure of command and control of the whole ITER Tokamak. The central part, where the co-ordinating functions among all the systems is performed, is to be designed and built by ITER organisation from Fund. The instrumentation and local control of each ITER subsystem is, in general, included in the related Procurement Arrangement. In most cases the procurement will be based on a functional description.

In general, EU has to provide Instrumentation & Control (I&C) for each of its agreed PA, following both the functional requirements agreed at the time of PA signature and the non functional requirements imposed by ITER CODAC team. The non functional requirements aim at ITER wide standardization and long term cost savings, and to achieve this will impose both a restriction on the choice of components, a specific format of project documentation, and an integrated style of project management (via IPT).

The exact definition of boundaries between IO CODAC and DAs I&C procurements is not complete. In past assessments of ITER project deliverables and costs, many I&C elements were forgotten. This has left a grey area where there is not yet an agreed distinction of responsibilities. The following table presents the result of an initial evaluation of the specific I&C obligation. The information contained can only be considered to be preliminary.

WBS	EU obligation	I&C Design type	Other DA involved/remarks
WBS 4.5	Implementation of **Building I&C**	FS	
WBS 4.5	Implementation of **SSEPN PPEPN I&C**	FS	EU will take a leading design and integration role of components from other countries (CN).
WBS 4.5	Implementation of **Vessel I&C**	FS	
WBS 4.5	Implementation of **Magnets I&C**	None?	IO will probably do the whole magnet instrumentation and CODAC interfacing. EU needs only to install the provided instrumentation within the coils.
WBS 4.5	Implementation of **Cryo plant I&C**	FS	This system is composed of parts from IN, CN, KO and IO.

PROCUREMENT ARRANGEMENTS PLANNING & STATUS

There are no PAs related specifically to I&C or CODAC. On the other hand an aspect of I&C is contained in many PA. The relevant information is therefore contained in the sections related to these PAs.

MAIN MILESTONES

I&C delivery milestones are strongly related to each related plant system milestones. In general I&C

implementation needs to be ready either for when factory tests are performed or for when site acceptance tests are executed. A preliminary design also needs to be ready before manufacturing process begins.

These philosophies cannot be applied directly to each plant system but case by case a correct strategy must be evaluated. At the present status of maturity, the I&C(CODAC) project plan does not contain any milestone but refers to each relevant plant systems project plan.

DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

It is too early to establish the design readiness of I&C for EU Plant Systems. In order to establish it one needs to analyse the functional requirements on which the design needs to be based.

In general I&C should contain only a minimum of components that require special R&D and it should be based on proven off the shelf technologies.

MANUFACTURING READINESS

An assessment is not available at this stage.

R&D AND QUALIFICATION ACTIVITIES

Once the scope of procurements for I&C(CODAC) is clarified and the division of roles within the organisation is firmed up, it is envisaged that a certain amount of R&D might be required to solve some special instrumentation or control requirements.

Problems might arise when trying to interface equipment used in a certain industry segment to CODAC equipment. Technically difficult solution might be needed also for application in the diagnostic instrumentation area. Non standard equipment or solutions might also be generally needed because of the difficult magnetic and radiation environment.

PROCUREMENT STRATEGY

N/A

ION CYCLOTRON H&CD ANTENNA	**WBS 5.1** **4.458 kIUA**

SHORT DESCRIPTION

The function of the ITER ICRF heating system is to couple a power of 20MW to the plasma, for pulse lengths up to 1000s, at frequencies from 40MHz to 55MHz. The ICRF antenna is divided in 4 modules, each composed of 6 straps which are connected in triplets to 2 feed transmission lines. The straps are protected, on the plasma side, by a series of Faraday screen bars. The rear section of each transmission line is designed to be removable. This is done to allow RF windows and key diagnostics to be replaceable from the rear of the port plug, in the case of damage, without the need to remove the entire port plug. A large part of the interior of the port plug is occupied by the shielding material which is required to limit the activation dose at the rear of the port plug. The design includes RF diagnostics, to provide the means of matching the antenna system, and to feed into the arc protection systems. All the 4 modules are identical except for the plasma facing side, including Faraday screen bars and current straps, which has to fit the plasma edge profile. All this components will be water cooled with water at high temperature and high pressure (30bar/100°C in operation and 44bar/240°C for baking).

The ICH include : 51.1 IC Antenna (EU), 51.2 IC Main Transmission Line (US), 51.3 IC RF power sources (IN).

In the frame of the ITER in-kind contribution, Europe will provide the ICH antenna port plug The antenna design has changed considerably from 2001. The major change from the 2007 design review is that the matching system, which was before internal to the port plug and hence part of the EU procurement, is now external to the port plug and to be procured by US. F4E has agreed on the design change as well as on the proposal that the US will procure the matching system, but this change of responsibilities is not formalised. The design of the components internal to the port plug has also changed (DCR-071-Accepted).

The spare antenna was in the PP but was originally not costed. The cost has been agreed with IO. The spare antenna is an ADI. The installation of the spare antenna in the machine with the first antenna is subject of DCR-090 (completed).

The acceptance test facility is to be shared with diagnostic and EC. The IO requirements are not yet finalised

The tooling is described as being responsibility of the DA (including determination of need of special tooling, design, fabrication). The IO now includes here remote handling tools that could be required to install and remove in situ the removable Vacuum transmission Line (new design, DCR-071)

The IC antenna components to be provided by EU are listed here below.

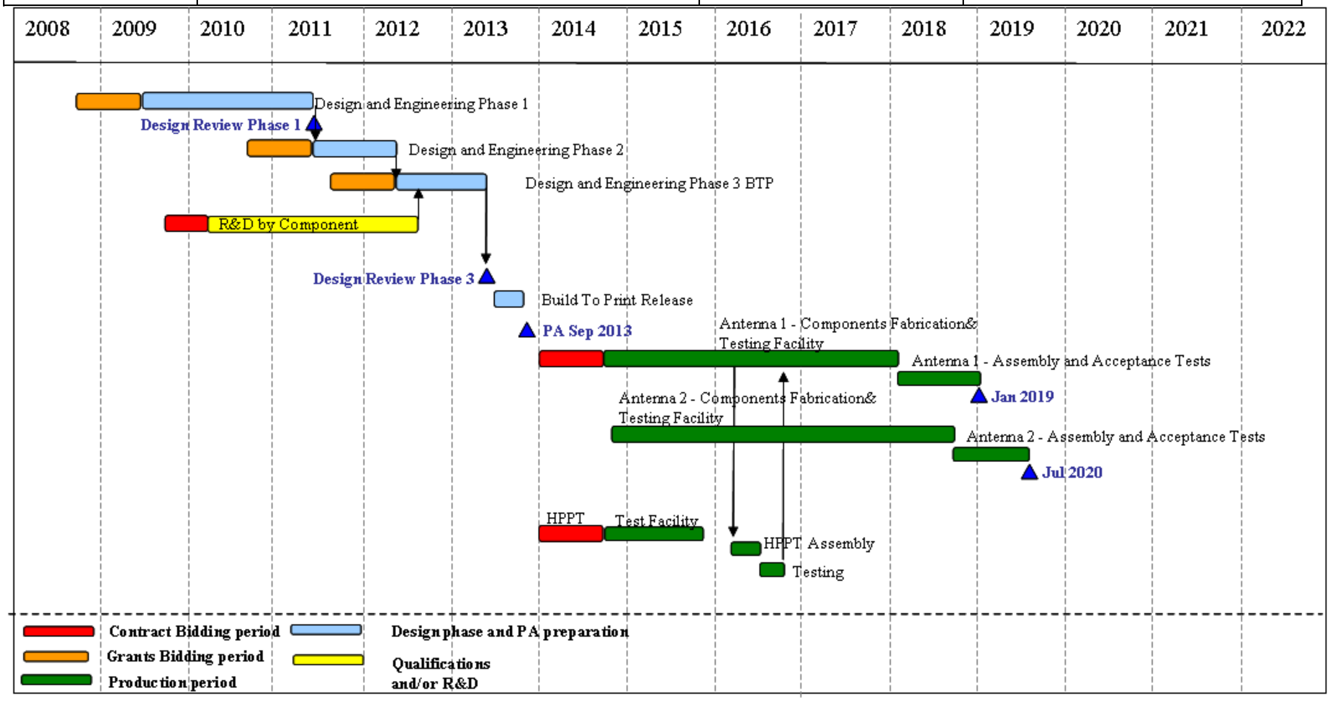
WBS	**EU obligation**	**Design type**	**Other DA involved/remarks**
WBS 5.1	One IC H&CD Launcher.	Build to print	The matching system to be supplied by the US
WBS 5.1	One spare IC H&CD Launcher	Build to print	The matching system to be supplied by the US
WBS 5.1	One IC H&CD Launcher Test Stand	Build to print	
WBS 5.1	IC H&CD Launcher tooling	Build to print	

PROCUREMENT ARRANGEMENTS PLANNING & STATUS

PA Title	PA signature	Credit (kIUA)
ICH Antenna	September 2013	4.458

MAIN MILESTONES

WBS	Milestone	DA responsible	Expected date
WBS 5.1	R&D Windows and FS Bars	EU/IO	Mar 2010
WBS 5.1	Start design phase I (detailed design)	EU/IO	Jan 2010
WBS 5.1	Start design phase II and III (built to print and final design)	EU/IO	Jan 2010
WBS 5.1	Design review end of phase III	EU/IO	June 2013
WBS 5.1	PA Agreement	EU/IO	September 2013
WBS 5.1	Start construction of HPPT high voltage test facility	EU	April 2014
WBS 5.1	End HPPT tests	EU	July 2016
WBS 5.1	Start integrated assembly antenna	EU	January 2018
WBS 5.1	Antenna delivered to ITER site	EU	January 2019



DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

The design of the IC system is still at a conceptual stage and three years of detailed design and R&D work will be required for a "built to print" design to be ready. There has been no funded work since 2007 and hence little progress in the design after the work for the 2007 ITER design review that was completed in December 2007. The design activity is now planned to start at the beginning of 2010.

MANUFACTURING READINESS

The design is fully specified by ITER and the performance responsibility lies with ITER. F4E will contract the fabrication with the design (2D drawings) as it is provided by IO. The supplier chosen (through an open call) by F4E can request changes to the design, if necessary, during the development of the fabrication drawings or during fabrication, but those changes have to be analysed and approved by IO.

The Supplier is responsible for the manufacture and factory testing of the antenna parts in accordance with the Technical Specifications and all related quality requirements. The antenna can be divided in different major sub-packages. All the components will be tested under high vacuum at high temperature with water circuits pressurized before final assembly.

An HPP test, to demonstrate full power full pulse length operation of one antenna module (1/4th of the antenna,) is foreseen during the manufacture phase as part of risk minimisation strategy. The detailed requirements for the test and testing facility are still to be specified. On cost and time schedule considerations, the EU facilities to be considered are the ones that require the minimum extension of pre-existing services, such as for backing and RF sources, and are likely to be CEA or JET.

It will be also necessary to construct an additional facility dedicated to testing of EU equatorial (and upper) port plugs for acceptance test before delivery to IO. The test will mainly consist in vacuum testing the port plug antenna when at high temperature (operational at 150°C and baking at 250°C) and with hydraulic circuit pressurised at high pressure (helium gas at 30 bar).

R&D AND QUALIFICATION ACTIVITIES

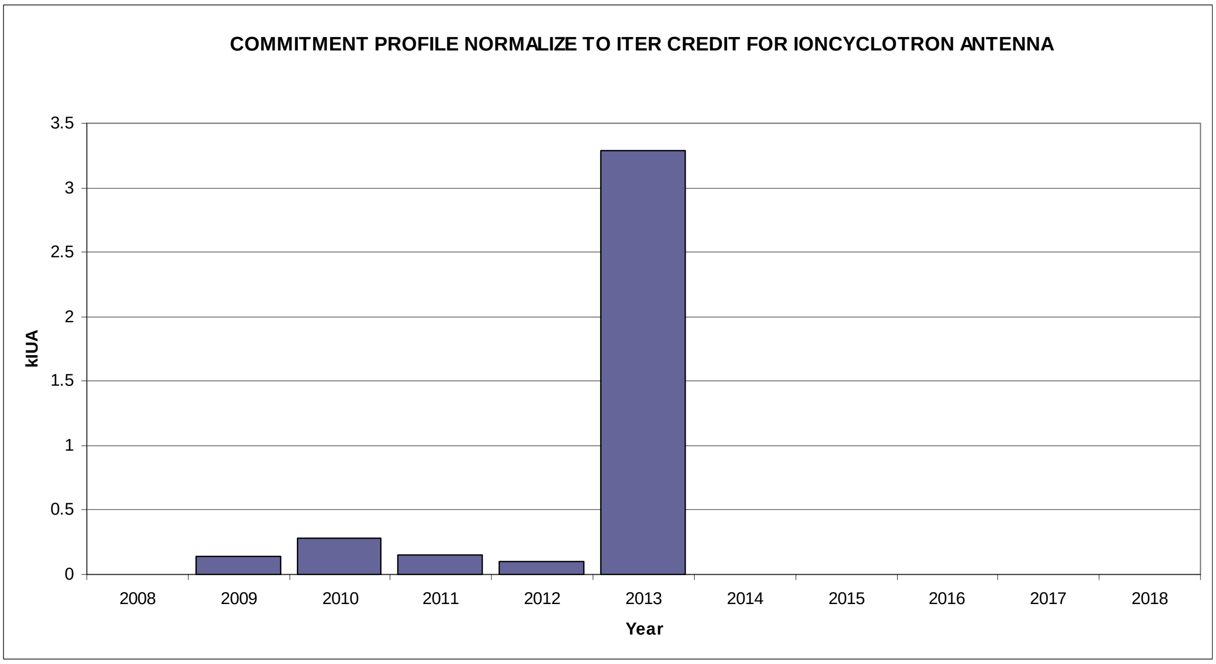
The design work is dividend in three phases corresponding roughly to detailed design phase and built to print design including incorporation of R&D results for the validation of the design.

R&D on the most critical antenna components (RF windows, Faraday shield), on antenna diagnostic and on the RF grounding system design is foreseen. The R&D is aimed at validating the design and fabrication techniques used for the production of the built to print drawings. The built to print design is planned to be ready in the middle of 2013.

PROCUREMENT STRATEGY

The final procurement arrangements for the ICRH system are planned to be signed in Sept. 2013. The HPP test, allowing testing 1/4th of the antenna at the ITER High RF Voltage, is scheduled for mid 2016 during the manufactured phase. This will allow to final check the antenna design and assembly before fabricating the rest (3/4th) of the first antenna and launching the second antenna.

A way to manage contractually this staged procurement, in a way that is cost effective and technically efficient, will have to be devised. The final procurement phase is planned to start at the end of 2016. The delivery of the first antenna to ITER is planned for January 2019 and the second one for July 2020.


COMMITMENT PROFILE NORMALIZE TO ITER CREDIT FOR IONCYCLOTRON ANTENNA
kIUA
3.5
3
2.5
2
1.5
1
0.5
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Year

ELECTRON CYCLOTRON H&CD UPPER LAUNCHER	WBS 5.2.1.2 7.832 kIUA

SHORT DESCRIPTION

The function of the ITER EC system is to provide heating and current drive to the ITER plasma. The total installed power is ~24MW and transmitted power to the plasma ~20MW, for pulse lengths up to 1000s, at 170GHz frequency. The EC power is shared between the equatorial and upper launcher systems by high power, in-line, real-time switches. These switches allow the routing of 1 to 20MW EC power to either system in steps of 1MW.

The Upper Launcher system has the main function of providing real-time control of MHD modes, and consists of 4 launchers, each housing 8, 2MW-compatible EC beam lines. In each launcher, 2 groups of 4 beam lines are directed by a system of quasi-optical mirrors, to 2 independent steering mechanisms. The launcher optics is designed to maximize focusing; The steering mechanism and mirrors are protected, on the plasma side, by a purpose-designed Blanket shield module. At the back of the launcher, outside the closure plate (ie outside the vessel vacuum) each transmission line is equipped with a Tritium-compatible isolation valve and a diamond window, part of the first tritium barrier of the system (with the closure plate and annexed feedthroughs).

The windows and valves are replaceable in-situ from the rear of the port plug, without the need to remove the entire port plug. A good part of the interior of the port plug is occupied by the shielding material which is required to limit the activation dose at the rear of the port plug as well as to shield the neighbouring vacuum vessel welds and TF coils from neutron flux. The design includes EC diagnostics for monitoring of the internal systems and for arc detection, for protection and control. The port plug structure carries its own cooling, and it is compatible with ITER cooling requirements, for normal operations and baking.

WBS 52 includes : the EC equatorial Launcher (52.1.1, JA); the EC Upper Port Launcher (52.1.2, EU); the Transmission lines (52.2.1, US); Gyrotrons (52.3.1, EU); Gyrotrons (52.3.2, JA); Gyrotrons (52.3.3, RF); Gyrotrons (52.3.4, IN); Power Supplies (52.4.1, EU); Power Supplies (52.4.2, IN); EC Plant Controller (52.5, tbd); Cooling Circuit (52.6, tbd) and Auxiliary Systems (fund, tbd). This document deals only with the Electron Cyclotron Upper Launcher WBS 5.2.1.2.

In the frame of the ITER in-kind contribution, Europe will provide the 4 Electron Cyclotron Upper Launcher port plugs (WBS 5.2.1.2). The launcher design has been progressing steadily since 2004, and the present concept was accepted by IO in a Conceptual Design Review (CDR) in October 2005. This CDR established the basis for the launcher concept (front steering of the mm-waves, bolted BSM, etc),

Since then, several PRCs have been put forward for the EC system, with some being of relevance for the EC Upper Launcher, although none impacting on the fundamental of the design. The main PCRs are: PCR-116 (EC 2MW Compatibility (28C4KF), accepted) PCR 117 (EC Internal Interface Requirements (28C4NZ), accepted), and PCR 144 (Port-Plug Sealing Interface (27ZKP5), completed). The present design of the Upper Launcher incorporates the requirements arising from these PCRs.

The EU sharing in the EC Upper launcher PP 5.2.1B is 100%. The value of the PP is 8.9kIUA, if which 88% (7.832 kIUA or 11,980 k€, 2009 value) are foreseen for the procurement and 12% for installation (in FUND, 1.068 kIUA or 1634 k€).

An acceptance test facility is to still to be defined, but it will be shared with diagnostic and IC.

Clarification in the Procurement Packages will be required at the level of Procurement Agreement regarding tooling (described as being responsibility of the DA), including determination of need of special tooling, spares and local controllers.

The EL launcher components to be provided by EU are listed here below.

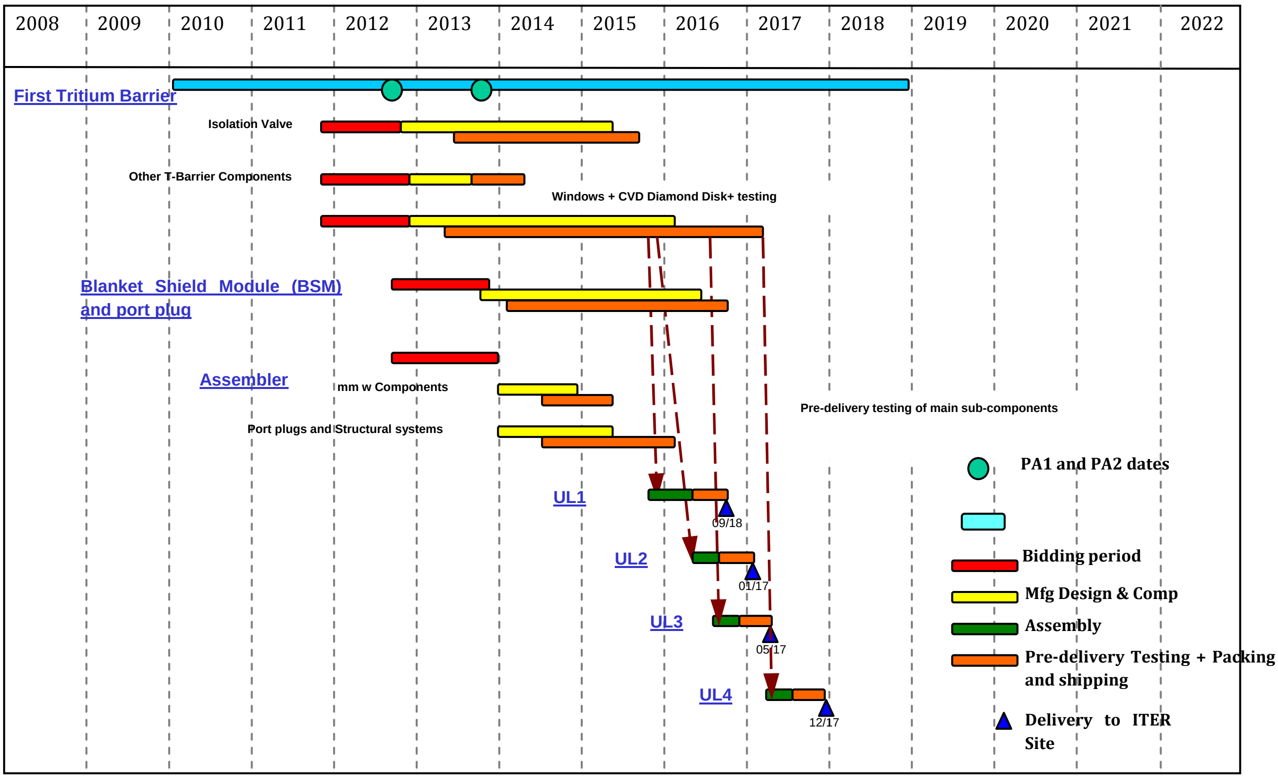
WBS	EU obligation	Design type	Other DA involved/remarks
WBS 5.2.1.2	Four EC H&CD Launchers	Build to print	Possible exchange of credits with US for TL between the closure plate & diamond windows.

PROCUREMENT ARRANGEMENTS PLANNING & STATUS

PA Title	PA signature	Credit (kIUA)
EC Upper Launcher – First Tritium Barrier	September 2012	~31% of the PP credit (2.428 kIUA)
EC Upper Launcher – rest of the launcher + assembly	October 2013	~59% of the PP credit (5.404 kIUA)
	Total	**7.832 kIUA**

MAIN MILESTONES

WBS	Milestone	DA responsible	Expected date
WBS 5.2.1.2	EC launcher Conceptual design review approved	EU/IO	November 2005
WBS 5.2.1.2	Preliminary Design Review	EU/IO	November 2009
WBS 5.2.1.2	Start of final design phase I & prototyping	EU/IO	December 2009
WBS 5.2.1.2	Start of final design (part II)	EU/IO	2011
WBS 5.2.1.2	Final Design review (T-barrier)	EU/IO	January 2012
WBS 5.2.1.2	PA Agreement T-barrier	EU/IO	September 2012
WBS 5.2.1.2	Final Design review (launcher)	EU/IO	February 2013
WBS 5.2.1.2	PA Agreement Launcher	EU/IO	October 2013
WBS 5.2.1.2	Main T-barrier contracts	EU	July 2013
WBS 5.2.1.2	Main launcher contracts	EU	July 2014
WBS 5.2.1.2	Start integrated assembly	EU	September 2016
WBS 5.2.1.2	First launcher delivered to ITER site	EU	September 2017
WBS 5.2.1.2	Forth launcher delivered to ITER site	EU	December 2018



DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

The design of the EC Upper Launcher is at the "preliminary design" level and it is estimated that two (first T barrier) and three years (launcher and integration) of detailed design and R&D work are required for a "built to print" design to be ready.

MANUFACTURING READINESS

The design is fully specified by ITER and the performance responsibility lies with ITER. F4E will contract the fabrication with the design (2D drawings) as provided by IO. The supplier chosen (open call) by F4E can request changes to the design, if necessary, during the development of the fabrication drawings or during fabrication, but those changes have to be analyzed and approved by IO.

The Supplier is responsible for the manufacture, assembly and factory testing of the launcher in accordance with the Technical Specifications and all related quality requirements. The supply of the launchers will most likely be divided in different major sub-packages. All the components will be tested under high vacuum at high temperature with water circuits pressurized before final assembly, in addition to any specific test required for specific components (example: diamond windows will be optically tested at various stages of the manufacture).

Relevant to the manufacturing and testing of the EC Upper Launchers is the fact that it is likely that a facility dedicated to testing of EU equatorial and upper port plugs will be required. This facility is to carry out the final integrated acceptance tests before delivery to IO. The test will mainly consist in vacuum testing the port plugs when at high temperature (operational at 150°C and baking at 250°C) and with hydraulic circuit pressurized at high pressure (helium gas at 30 bar), + specific tests of the steering mechanism, instrumentation, basic control.

No high power test is foreseen. The details of the integration of the EC Upper Launcher manufacturing with the EU port plug testing facility are under discussion.

R&D AND QUALIFICATION ACTIVITIES

R&D and prototype work on critical components has been ongoing for the EC Upper Launcher for a number of years. Notably, prototypes of the diamond windows have been procured and aspect such as optical qualification, validation of thermo-hydraulic models for the window cooling, brazing, T-permeation and RH have been studied and developed. Initial high power mm-wave testing has also been carried out in 2007-2008. Prototypes of the steering mechanism (and its components), isolation valve, BSM structure and other structural sample elements have also been procured and studied in the same period.

Nonetheless, R&D on the main launcher components (diamond windows, isolation valve, significant section of the structure, BSM and FW panels, steering mechanism, specific diagnostics, and other minor mm-wave components), will be carried out as before the PA. The R&D is aimed at validating the final design and fabrication techniques used for the production of the built to print drawings. The built to print design is planned to be ready in the middle of mid 2012 for the T-barrier components and mid-2013 for the rest of the launcher.

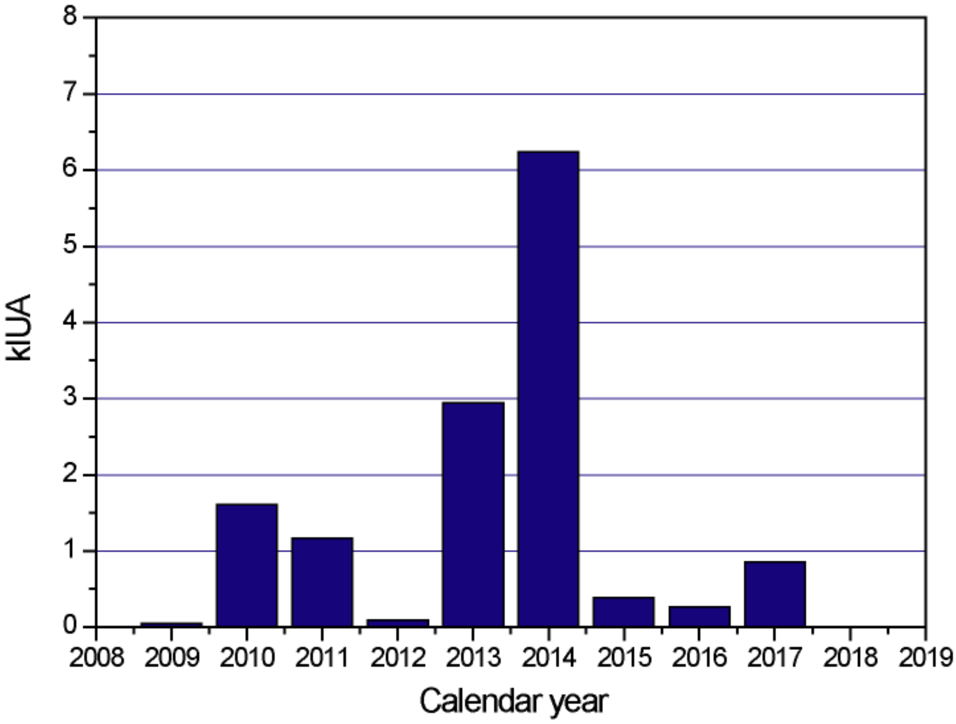
PROCUREMENT STRATEGY

The procurement of the EC Upper launcher is formally divided in two parts: the first related to the PA for the T-barrier components to be signed in Sept 2012, and the second one for the rest of the launcher components, assembly and pre-delivery test, to be signed in Oct 2013.

This division in two PAs has been decided to allow more time for the production qualification of components that are part of the first T barrier, as well as to spread in time the tender procedures and contract awards.

The procurement is envisaged to be constituted by a number of specific contracts for specialized components (example: the diamond windows, the BSM, diagnostics, etc..) and of a contract with an “Assembler” that will be in charge of procuring via sub-contractors more conventional components (example: the port plug structure and the internal shields), as well as to receive and integrate all the launcher parts, and to organize and carry out the pre-delivery testing. The procurement of the launcher will require a continued involvement of the designers as well as the expected work with industry and inspectors.

NORMALIZED COMMITMENT PROFILE – EC H&CD Upper Launcher



Commitment profile for the whole WBS for the time 2008-2018 considering for each year the total commitments for the WBS, divided for the total budget of the WBS for 2008-2018 and normalized to the PP credit + pre-PA and non-procurement credit expected from IO for the WBS

ELECTRON CYCLOTRON RF SOURCES AND POWER SUPPLIES	5.2P3 & 5.2P4 22.9 kIUA

SHORT DESCRIPTION

The Electron Cyclotron (EC) Heating and Current Drive (H&CD) Power Sources (5.2P3) are composed of gyrotron tubes, their superconducting magnets, RF Conditioning Units, and associated auxiliaries. The gyrotron specifications for ITER go beyond the present capabilities of the gyrotrons installed in existing facilities. In order to meet these specifications, an R&D programme is needed for the development of the high power (>1MW), Continuous-Wave (CW) operation, 170GHz gyrotron for ITER.

The EC H&CD power supply (PS) system (5.2P4) feeds the gyrotrons with electrical power. The EC H&CD PS system is mainly composed of the Main high voltage (HV) PS providing the voltage and beam current between the cathode and collector of the gyrotron tube and the body PS which applies a controllable voltage between the acceleration electrode and the collector. Depending on the design of the gyrotron an additional PS could be required for the gyrotron Anode. The system includes fast protection circuits which isolate in a very short time (<10 μs) the body and cathode voltage in the case of tube, line or load breakdown.

SHORT DESCRIPTION OF EU CONTRIBUTION/OBLIGATION

Following the ITER sharing agreement of 2004, the EU is responsible for the procurement of 8MW of 170GHz Power sources for the EC H&CD system (1/3rd of the 24MW total installed capacity). This corresponds to 30.7 % of the PP value, about 10.1 kIUA. The other two Parties each supplying 8MW gyrotrons are JA and RF. The EC Power Sources for the start-up system at 127 GHz, corresponding to 7.9% of the PP value, were within the IN contribution but have now been dropped and India is now procuring two additional H&CD (170 GHz) gyrotrons.

As for the 5.2P4 package, EU was responsible for 100% of the Power Supplies for the EC H&CD system, but not the start-up gyrotrons which are being procured by the IN DA. Thus the EU was providing. 92% of the total EC Power Supplies, for which the ITER credit is 12.8 kIUA. This is now being revised and, though not formalized yet, India may be supplying 1/3rd of the EC Power Supply system.

More in detail the components parts of the specific European scope of supply are described hereafter.

WBS	EU obligation	Design type	Other DA involved/remarks
WBS 5.2P3	**Electron Cyclotron Heating and Current Drive Power Sources** - The 8MW gyrotrons and superconducting magnets will be installed, assembled and tested on ITER site. In addition, auxiliaries, including power supplies for the superconducting magnet, collector sweeping system, electronics, protection systems, and supporting structures are included in the scope. EU obligations include: Manufacturing Drawings, manufacturing and factory testing of components, delivery and testing.	Functional Specifications (FS)	31 % Europe. Japan, Russia are responsible of 31% each, India of the remaining part
WBS 5.2P4	**Electron Cyclotron Heating and Current Drive Power Supplies** – Main PS feeding the cathodes of the H&CD gyrotrons with voltage and current, and body PS	Functional Specifications	EU was responsible for 92% of the procurement

	which, in combination with the Main, provides the total gyrotron beam voltage. Additional anode PS is required for the Japanese gyrotrons. The system includes the fast protection circuits which isolates in a very short time (<10 µs) the body and cathode voltage in the case of tube, line or load breakdown, auxiliaries (cooling, electronics, interlock, etc.). EU obligations include: Manufacturing Drawings, manufacturing and factory testing of components, delivery and testing.	(FS)	package, India of the remaining part. The new contribution following the present negotiations is: 2/3rd EU, 1/3rd IN.

PROCUREMENT ARRANGEMENTS PLANNING&STATUS

PA Title	**PA signature**	**Credit (kIUA)**
EU H&CD Power Sources	August 2011	10.1
EU H&CD Power Supplies	December 2011	12.8

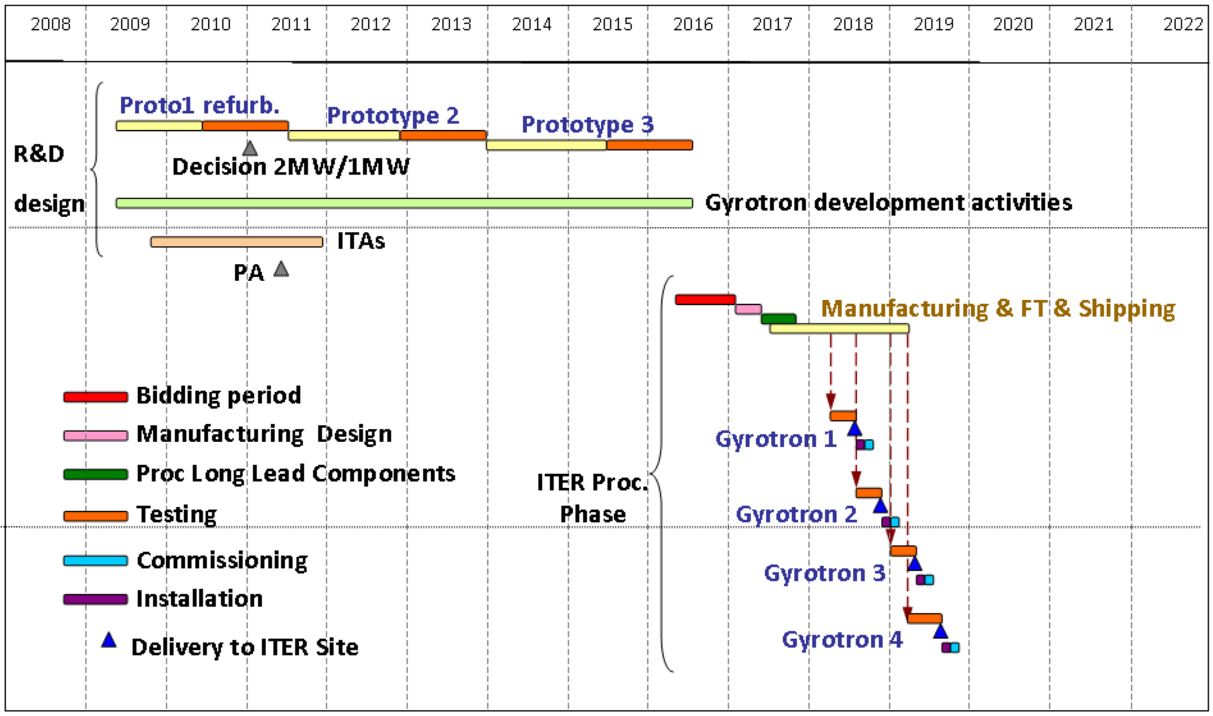
In this table, the Credit indicated corresponds to the Common Understandings on Procurement Allocations, N-12 ROM Att.5.1 (2005). It is noted that some PCRs on-going at this date in IO may produce modifications of the above credits.

MAIN MILESTONES

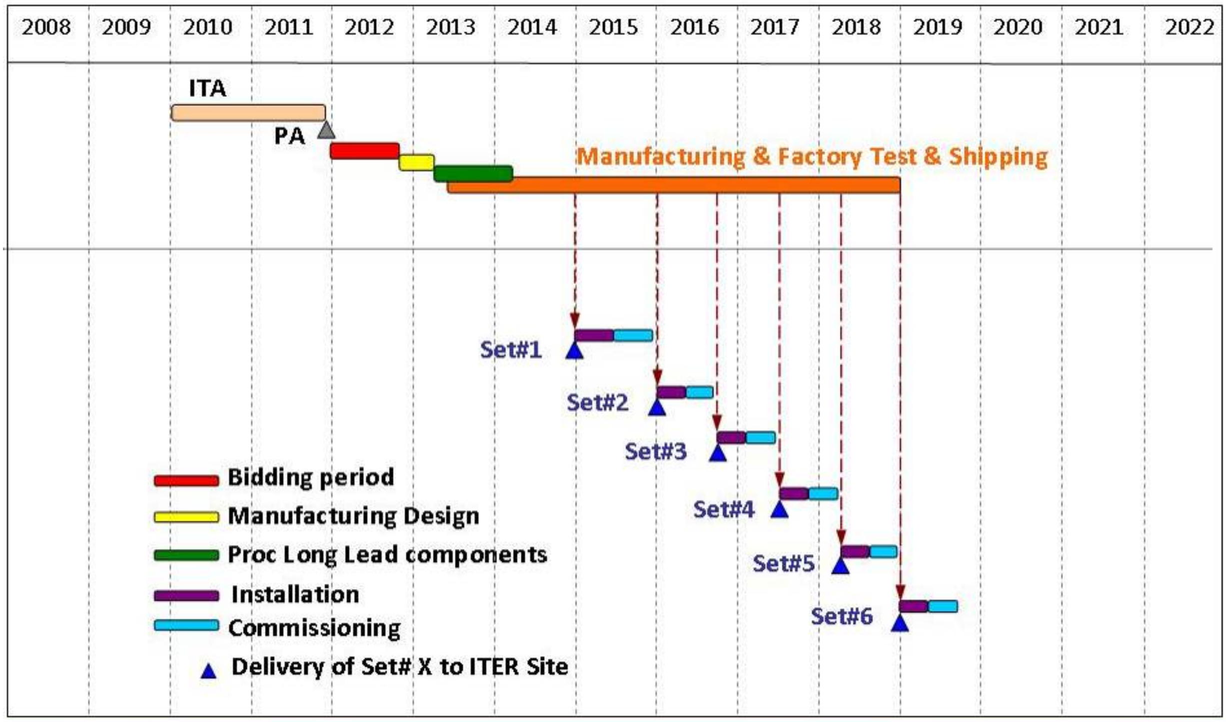
WBS	**Milestone**	**DA responsible**	**Expected date**
WBS 5.2P3	PA for EU 5.2P3 RF Power Sources Received from IO	IO	Aug 2011
WBS 5.2P3	RF Bldg (B15) Required available for Installation of the Gyrotrons	IO	Dec 2014
WBS 5.2P3	Decision to Continue on the Coaxial Cavity Gyrotron Progr	EU	Jan 2011
WBS 5.2P3	Tests with the 3rd gyrotron prototype completed	EU	Apr 2016
WBS 5.2P3	Main Contract for gyrotrons and SCM magnet signed	EU	Jan 2017
WBS 5.2P3	1st Set (2MW) of Gyrotrons (Tube and SCM) Delivered to ITER	EU	Aug 2018
WBS 5.2P3	4th Set (2MW) of Gyrotrons (Tube and SCM) Delivered to ITER	EU	Aug 2019
WBS 5.2P4	PA for EU 5.2P4 RF Power Supplies Received from IO	IO	Dec 2011
WBS 5.2P4	RF Bldg (B15) Required available for Installation of the Gyrotrons	IO	Dec 2014
WBS 5.2P4	Main Contract for Main and Body PS Signed	EU	Nov 2012
WBS 5.2P4	1st Set of EC HVPS Delivered to ITER	EU	Dec 2014

WBS 5.2P4	Last Set of EC HVPS Delivered to ITER	EU	Dec 2018

The main milestones for the EC H&CD Power Sources are summarised in the figure below.



The main milestones for the EC H&CD Power Supplies are summarised in the figure below.



DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

Under EFDA, the development in Europe of the coaxial cavity gyrotron capable of delivering 2 MW, i.e. the double of the ITER specification (1 MW), was initiated in view of (i) the recommendation by ITER to develop higher power sources, and (ii) the promising results obtained in 2004 with the short pulse coaxial gyrotron under an EFDA funded R&D task at FZK, Karlsruhe (2.2MW of output power at 165GHz was generated for a few ms). More recently (August 2009) the FKZ pre-prototype has reached 2.2MW at the ITER frequency (170 GHz).

The development programme of the European gyrotron, now being implemented by Fusion for Energy, foresees the design, manufacturing and testing of three prototypes. So far, the development, launched under EFDA and continued by F4E, has been carried out within a EU collaborative framework: the design of the internal components of the gyrotron (optical components, electron gun, etc) whereas the technical design (cooling, vacuum, supporting components, etc), integration and fabrication is carried out industrial partners, Only one European company is known to have expertise in the production of high power gyrotrons. It is likely that the collaborative framework established under EFDA will continue for the remaining R&D.

A dedicated EC test facility has been established with contributions from EFDA/Commission, for the full power, full pulse length testing the 2MW tube in CW, as well as of the launcher antenna. The test facility includes all infrastructures and services (cooling, vacuum, He re-liquefying and CODAQ systems) and spherical 2MW calorimetric loads. A fully solid-state, CW, high voltage power supply system has been designed and manufactured for the test facility, including the Main and Body PS. A gyrotron superconducting magnet was designed and manufactured. All those industrial contracts were performed by European Industries.

The first industrial gyrotron prototype was designed, manufactured, and delivered at the EC Test Facility. The first tests with the industrial gyrotron were done in 2008. As a main result, the gyrotron operated stably in the desired TE34,19 mode, thus the basic radio frequency design of the tube was proved. An output power of about 1.4 MW (the goal was 2 MW) was measured for short pulses, ca. 2ms (the goal was 1s). The maximum pulse length in the desired mode was 60ms at a reduced power (ca. 0.5MW). The level of output power and the excitation mode sequence observed in the experiments were in good agreement with the multi-mode simulations.

The gyrotron tube is presently being refurbished with an improved electron gun, beam tunnel and mode converter system, which have been first validated with the pre-prototype gyrotron at FZK. The pre-prototype coaxial cavity gyrotron was conceived as a modular, short pulse coaxial cavity gyrotron, with good diagnostics, and it is essentially uncooled allowing an easy replacement of components. The investigations and experiments with this gyrotron at FZK are very useful to identify unexpected problems sufficiently in advance. Very promising experimental results have been recently obtained with the new internal configuration implemented into the pre-prototype tube: 2.2MW of RF power at the right operating mode – right ITER frequency - has been measured in a reproducible way with an efficiency of 30%. Moreover, the quality of the RF beam at the gyrotron window is very high, ~97% of Gaussian mode content which is higher than ITER specifications, and a very good agreement between simulations and measurements has been found.

On the basis of the new experiments on the refurbished 1st gyrotron tube and parallel investigations, a decision point between the 2MW coaxial cavity gyrotron and a more conventional 1MW cylindrical cavity gyrotron is placed along the track of the project plan as risk management strategy. The design of this 1MW cylindrical cavity gyrotron is presently progressing as a fallback solution in time for ITER.

In general, the development programme benefits from the experience acquired during the recent development of high power, long pulse gyrotrons in Europe. For the EC HV Power Supplies, no specific R&D is required since the technology which is foreseen for the final specifications is available within the European industry.

MANUFACTURING READINESS

Tests with the refurbished 1st prototype, aiming at 2MW - 1 second, are planned in 2010. The development phase will be completed with the design, manufacturing and testing of the 2nd and 3rd industrial gyrotron prototype, aiming at 2MW/1min and 2MW/1hour (~CW), respectively. After the development phase, the amount of work for additional design or for the establishment of manufacturing techniques is expected to be very small due to the previous development of prototypes. The technology which is foreseen for the final specifications of the EC HV Power Supplies is available within the European industry and some good industrial competition is expected.

R&D AND QUALIFICATION ACTIVITIES

- Development of the EU gyrotron: theoretical investigations on interactions and parasitic oscillations, modelling of phenomena at the electron gun, beam tunnel, cavity and launcher system, optimisation of the design of internal components for the coaxial cavity gyrotron, design of a cylindrical cavity gyrotron as a back-up solution;
- Experiments with the FZK pre-prototype coaxial cavity gyrotron;
- Design, manufacturing and tests with the 1st, 2nd and 3rd industrial gyrotron prototypes (see the details below);
- Opening and inspections of the industrial prototypes after testing;
- Specific experiments with the European gyrotron prototype and HV power supplies on power modulation;
- Specific experiments with the European gyrotron prototype on reliability;
- Design, manufacturing and testing of a He-free superconducting magnet for the European gyrotron;
- Design of a Matching Optics Unit for the European gyrotrons.

PROCUREMENT STRATEGY

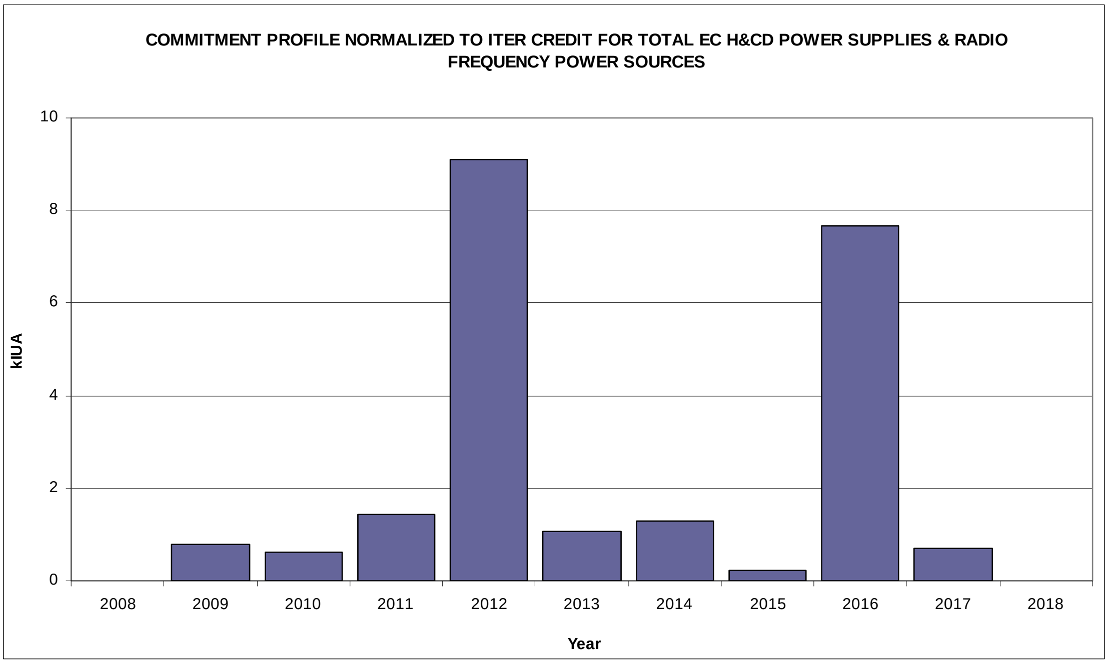
Under the present EU collaborative framework, the design of the internal components of the gyrotron (optical components, electron gun, etc) is carried out by the EU Associates whereas the technical design (cooling, vacuum, supporting components, etc) and integration is carried out by the industrial partner, Only one industrial company in Europe is known to possess the required manufacturing procedures and techniques. A similar strategy is expected to be followed for the remaining R&D.

As for the superconducting magnets, ITER is now proceeding towards formally selecting the so-called “cryogen-free” cooling system for these magnets, which avoids the use of cryogenic lines, has considerably lower operating cost and offers simplicity of design and corresponding reliability. This technology is not established in Europe for gyrotron applications while it is available in other ITER Parties (e.g. Japan). So far in Europe the gyrotron magnets are cooled using a more traditional technique consisting in the immersion of the superconducting coils into a liquid helium bath. The procurement strategy for the magnets in Europe is an open point and should be established.

The detailed procurement strategy for the production gyrotrons has not been established yet. The procurement of the gyrotron tubes and magnets will require either one or two industrial contracts depending on the previous considerations about the “cryogen-free” magnets. The procurement contract could in this case follow an open tender procedure.

An open tender is foreseen for the Power Supplies, for which no adverse or limiting market conditions are expected.

NORMALIZED COMMITMENT PROFILE – EC H&CD POWER SUPPLIES AND RF POWER SOURCES



NEUTRAL BEAM SYSTEM	WBS 53 37.22 kIUA

SHORT DESCRIPTION

The ITER NB H&CD System consists of two injectors that are used to heat the plasma and to drive the plasma current. The possibility to have an additional third H&CD NB injector is retained as an option. The construction and installation of the third injector could take place several years after the first two.

The EU is responsible for in-kind contribution pertaining to six Neutral Beam Procurement Packages in the 2001 Baseline:

53.P1: NB Assembly

53.P2: NB Beam Source and High Voltage Bushing

53.P3: NB Beam Line Components

53.P4: NB Confinement and Shielding

53.P5: NB Active Correction and Compensating Coils

53.P6: NB Power Supplies

A full scale Neutral Beam Test Facility (NBTF) will be included soon as a seventh Procurement Package, containing many of the components in the packages above plus additional ones s specific to the test facility. This is expected to be formally added to the baseline as.

53.Px: NB Test Facility (package not yet in the ITER baseline)

The nature and technical features of the procurements are extremely wide, ranging from very complex mechanical assemblies (e.g. the beam source) to high heat flux components (e.g. the beam line components); from large, water cooled coils to high technology specific components (e.g. the shutter and absolute valve); from extensive plants systems (cooling, vacuum, cryogenic systems) to full control, protection and data acquisition systems; from advanced power supplies systems to the interface with procurements coming from other DAs; from assembly and integration to site commissioning and acceptance. The NBTF is, in itself, a major and complex project.

The bulk of the NB Heating and Current drive system is shared between the EU and JA DAs.The agreement on the six 2001 Proc. Pack. between the two DAs is (percentages refer to the credit values as presently agreed between the two DAs):

	EUDA	JADA
53.P1: NB Assembly	100%	-
53.P2: NB Beam Source and High Voltage Bushing	41%	59%
53.P3: NB Beam Line Components	100%	-
53.P4: NB Confinement and Shielding	76%	24%
53.P5: NB Active Correction and Compensating Coils	100%	-
53.P6: NB Power Supplies	31%	69%

Europe is supporting the IO in the activities leading at the preparation of the technical specifications at the required level of detail. This support include by far most of the design and R&D activities and the establishment of the Neutral Beam Test Facility (PRIMA) which is expected to be covered by a new Procurement Package as described above. In terms of current density, acceleration voltage and pulse length, the ITER NB system represents a large extrapolation from existing devices. Therefore a full scale test facility has been deemed as a necessary step towards the construction of the ITER injector. The strategy is organized in the establishment of two test beds at Padova – Italy: a full scale ion source test facility (SPIDER), to optimize the ion source performance and a full scale 1 MV NB test facility (MITICA) for the development of the full injector. The actual sharing for this new package has not yet been decided though Europe will be certainly responsible for a large part of it. The detailed components parts of the specific European scope of supply are described hereafter:

WBS	**EU obligation**	**Design type**	**Other DA involved/remarks**
	HNB System		
WBS 53.1	**Assembly** - The NB H&CD System will be assembled and tested within the NB cell within the ITER Tokamak Complex. EU has to provide the personnel, equipment, toolings and the consumables required to perform the general assembly on-site, at Cadarache, of all the components of the NB H&CD System (HNB1 & HNB2).	Detailed Technical Specification	100 % Europe. India is however responsible for the assembly of the Diagnostic Neutral Beam. Some synergy possible.
WBS 53.2	**Beam Sources and High Voltage Bushings** – two beam sources, each of them composed of one ion source and one accelerator and two HV bushings connecting the beam source to the SF6 insulated transmission line. EU obligations include: Manufacturing Drawings, manufacturing and factory testing of components, delivery and testing.	Build-to- Print specifications	EU is responsible for the two ion sources and one accelerator (41 % of total credit value). JA is responsible for the second accelerator and the two HV Bushings.
WBS 53.3	**Beam line components –** two sets of beam line components: Neutraliser, Residual Ion Dump (RID) and Calorimeter. EU obligations include: Manufacturing Drawings, manufacturing and factory testing of components, delivery and testing.	Build-to- Print specifications	100 % Europe.
WBS 53.4	**Confinement and Shielding -** The confinement and passive magnetic shielding for the Neutral Beam Heating and Current Drive (NB H&CD) are provided by the Pressure Vessels (PVs) and the Passive Magnetic Shield (PMS). Included in the original package, other components are: the Fast Shutter providing low conductance between the tokamak and the NB vessels, the Drift Duct providing flexible connection between the NB line and the tokamak, and the Duct Box surrounding the fast shutter and the drift duct. EU obligations include: Final design, Manufacturing Drawings, manufacturing and factory testing of components, delivery and	Detailed Technical Specification	EU responsible for the 76% in credit value. JA is responsible for the supply of one passive magnetic shielding for one of the HNB injectors. Some of the technical specification is being reclassified, in agreement with IO, to B-t-P (e.g. vessels). Presently, due to ITER IO design changes, the Duct

	testing.		Box has been removed and the Absolute Valve added providing no conductance (vacuum tight barrier) between the tokamak and the NB vessel. More recently the VVPSS (Vacuum Vessel Pressure Suppression System) box has been proposed by ITER IO to be included inside this Package. These new components have not yet been assigned to any DA.
WBS 53.5	**Active Correction and Compensating Coils (ACCC) -** The Active Correction / Compensation Coils (ACCC) of the Neutral Beam Heating & Current Drive (NB H&CD) system, together with the passive magnetic shield, form the Magnetic Field Reduction system that shields the injector volume from the tokamak magnetic field. EU obligations include: Final design, Manufacturing Drawings, manufacturing and factory testing of components, delivery and testing.	Detailed Technical Specification	100% Europe. (IN DA is responsible for the procurement of the ACCC for the DNB)
WBS 53.6	**Heating NB Power Supplies -** The NB PS can be subdivided in acceleration power supplies (providing -1 MV acceleration voltage), ion source power supplies and Ground Referenced power supplies. The main functions of the NB H&CD power supply units are to supply, with the specified voltage regulation and control: - The ion source, standing at – 1 MV DC to ground, where the negative ions are produced, - The acceleration stages, from - 1 MV to ground, - the other loads (the Residual Ion Dump and the Active Compensating and Correcting Coils) standing at ground potential EU obligations include: Detailed and Final design, Manufacturing Drawings, manufacturing and factory testing of components, delivery, installation and site testing and commissioning up to acceptance.	Functional Specifications	The ITER agreement provides for the sharing of the NB PS between Europe and Japan. The Japanese scope of supply covers in general the equipment with 1MV insulation level. Europe will instead supply the conversion systems, both for the acceleration power supplies and for the ion source power supply at low voltage inside the HV deck and the ground related PS. In addition, Europe will provide the air insulated High Voltage deck where the ion source PS are located and the connection between the HV deck and the SF6 insulated transmission line, part of the Japanese

			procurement.
NB Test Facility (*new procurement package not yet in the baseline*)			
WBS 53.x	**Neutral Beam Test Facility (PRIMA) –** The test facility is composed of two test beds: a full scale ion source test facility (SPIDER), and a full scale 1MV NB test facility (MITICA). MITICA will essentially include a full injector, excluding some front end components and the magnetic shielding. The correction and compensating coils are also replaced by coils simulating the ITER residual field. In addition, PRIMA will be provided with all the specific infrastructures for the NBTF (cryogenic plant, cooling plant, SF6 plant, Vacuum and gas inlet, CODAC, diagnostics, etc.). Since the Test facility approval process is still on-going, European obligations are still not fully defined.	Mixture of B-t-P, DTS and FS	The sharing between ITER Parties of this new package has not yet been decided. However, Europe will be in charge of a large part of it.

PROCUREMENT ARRANGEMENTS PLANNING & STATUS

PA Title	**PA signature**	**EU Credit (kIUA)**
Assembly	June 2014	3,8
Beam sources and high voltage bushings	02/01/2017	3.9
Beam line components	01/09/2015	3.9
Confinement and Shielding	June 2013	8,16
ACC Coils	November 2013	6,1
Neutral Beam Power Supplies and Related Systems (EU5.3P6)	10 July 2009	19.52
Neutral beam test facility	01/06/2010*	tbd**

* estimated. Depending upon NBTF approval process.

** The credit allocated for the NB test Facility is 60 kIUA. Additional 8.8 kIUA from the IO R&D Fund have already been agreed by the IC. The actual sharing amongst DAs not yet defined.

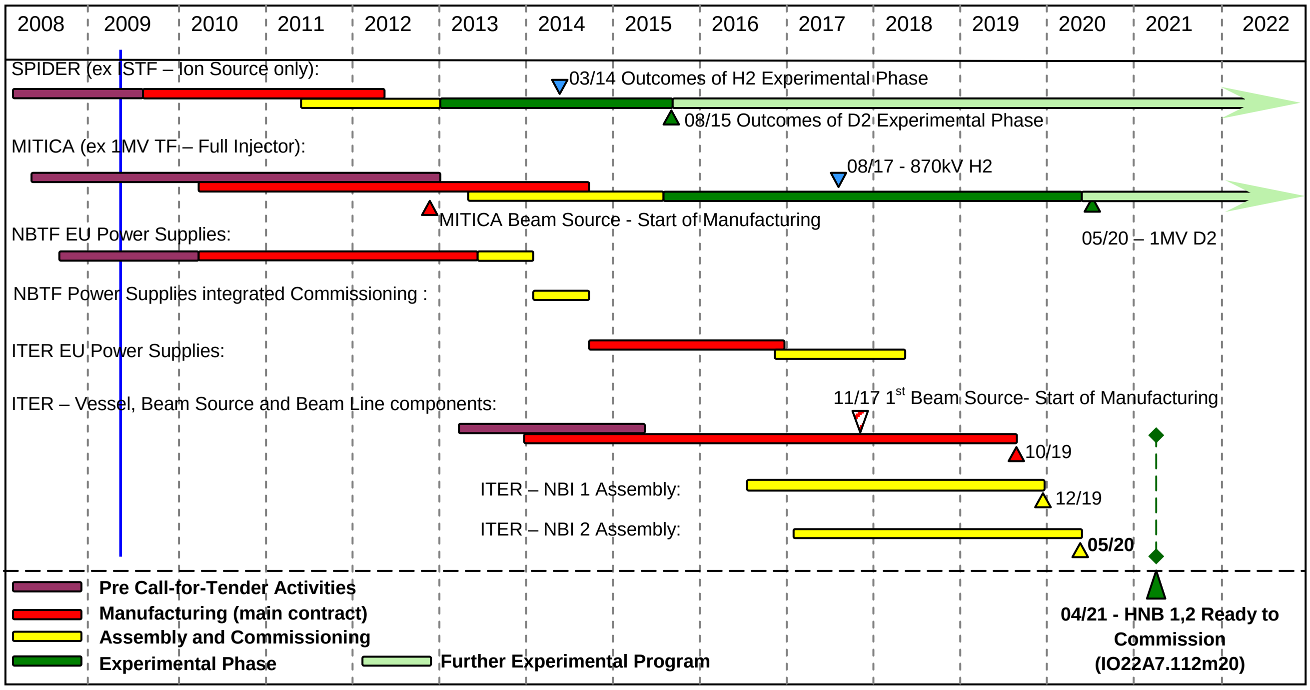
MAIN MILESTONES

WBS	Milestone	DA responsible	Expected date
	HNB system		
WBS 53.1	PA signed for Assembly	EU	June 2014
WBS 53.1	Contracts placed Assembly	EU	January 2015
WBS 53.1	Assembly for HNB 1 completed	EU	September 2019
WBS 53.1	Assembly for HNB 2 completed	EU	May 2020
53.2	Signature of the PA for Ion source NBI-1-2 and accelerator NBI-1	EU	January 2017
53.2	Ion source NBI 1 available	EU	March 2019
53.2	Ion source NBI 2 available	EU	October 2019
53.3	Signature of the PA for BLCs NBI-1-2	EU	September 2015
53.3	Calorimeter NBI 1 available	EU	July 2018
53.3	Calorimeter NBI 2 available	EU	January 2019
53.3	RID NBI 1 available	EU	October 2018
53.3	RID NBI 2 available	EU	April 2019
53.3	Neutraliser NBI 1 available	EU	October 2018
53.3	Neutraliser NBI 2 available	EU	June 2019
WBS 53.4	PA for Confinement & Shielding	EU	June 2013
WBS 53.5	PA for ACC Coils	EU	November 2013
WBS 53.4	Components delivered to IO for Confinement & Shielding	EU	From July 2015 to Oct. 2016 (see section 8)
WBS 53.5	Components delivered to IO for ACC Coils	EU	July 2018
53.6 NBPS	Start of procurement for HNB1	EU	October 2014
53.6 NBPS	EU Supply for HNB1 accepted, ready for integration.	EU	January 2018 (PS only) April 2018 (incl. NBPS and overall NB Control)
53.6 NBPS	EU Supply accepted for HNB2, ready for integration.	EU	July 2018 October 2018 (incl. NBPS and overall NB Control
	NB Test Facility*		
53.X	Signature of the PA for the NBTF, European Parts	IO/EU	June 2010
53.X	PRIMA buildings available	Host	June 2011

53.X	Start of SPIDER operation	EU	January 2013
53.X	Results of the SPIDER experiments in H2	EU	March 2014
53.X	Results of the SPIDER experiments in D2	EU	August 2015
53.X	Start of MITICA operation	EU	August 2015
53.X	Results of the MITICA experiments in H2	EU	August 2017
53.X	Results of the MITICA experiments in D2	EU	May 2020
* The NB Test Facility has not yet been approved by IO and the activities are therefore subjected to a certain degree of uncertainty. A final integrated schedule, taking into account procurements from other DAs, has not yet been finalized by IO. In addition, the actual procurement sharing amongst DAs has not been defined. Some assumptions have been made in the above table.			
Common activities			
53.X	ELISE start of operations	EU	June 2011
53.X	ELISE final report on achievement of the target parameters	EU	June 2013

* Some type of framework arrangement may be put in place if a suitable form is found within the F4E Implementing Rules.

The main milestones are summarized in the simplified project schedule below



DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

53.1 Assembly

In general, the actual scope of the supply is at present not well defined since it depends heavily on the final design of the components and the arrangements of the NB Cell (presently under substantial revision, DCR 49). F4E is not yet in a position to start the preparation of the specification.

53.2 Beam Source

The actual design of the Beam Sources for the ITER injectors will benefit and will be finalised on the basis of the testing at the NBTF test facility. See corresponding section for the present state.

53.3 Beam Line Components

The actual design of the Beam Line Components for the ITER injectors will benefit and will be finalised on the basis of the testing at the NBTF test facility. See corresponding section for the present state.

53.4 Confinement and Shielding

The overall design of these components is still at a conceptual stage and approximately three years of detailed design and R&D work will be required for a "built to print" design to be ready.

Some aspects of the remote handling have been taken into consideration. An EFDA task, with a final report has been issued in January 2008 (EFDA Task TW6-TVR-NBRH – ITER NBI REMOTE HANDLING STUDY).

It is planned to use the next three years to finish the design of these components up to the built to print drawing and to co-ordinate this activity with the design work carried out, under responsibility of F4E Remote Handling group, to take in charge all the Remote Handling aspects for the NBI.

53.5 Active Correction and Compensation Coils

For each coil, there are values (electrical + dimension) and design requirement defined in the 2001 PP. They have all to be re-calculated. As well, for each coil, the design of the supporting structure has to be made. This is planned to be made during the next three years using a contract presently being initiated.

Some aspects of the remote handling have been taken into consideration. It is clear that all the top coils will have to be removed to obtain access to the NBI vessel top lid.

An EFDA task produced the final report issued in January 2008 (EFDA Task TW6-TVR-NBRH – ITER NBI REMOTE HANDLING STUDY).

It is planned to use the next three years to finish the design of these components up to the built to print drawing for the structure (to co-ordinate this activity with the design work carried out, under responsibility of F4E Remote Handling group, to take in charge all the Remote Handling aspects for the NBI.

53.6 Power Supplies

The HNB PS will be procured on the basis of functional specifications and the detailed design is produced by the Industrial Suppliers during the initial phase of the contracts. Requirements and conceptual design are well defined and included in the PA documentation.

Some issues may arise from the interfacing between EU and JA scopes of supply whose final details can only be fully defined during the execution of the supply contracts. Those interfaces have anyway been the subject of special care during the preparation of the PA specifications which were written in co-operation between the EU and JA teams with the participation of IO. It is nevertheless absolutely necessary that this co-operation is maintained throughout the full execution of the procurement.

The part which has less defined specifications is the one related to the NB system control. This is almost unavoidable since the detailed features of the NB system itself, the number of signals and control functions have not been defined at this stage.

53.x NB Test Facility

The core components of the NBTF test facility will be in practice the first prototypes of the ones for the ITER injectors. This holds in particular for the Beam Sources, for the Beam Line components and to a great extent for the vessels which are in the EU scope of procurement and the HV bushing, to be procured by JADA. In addition, the full power supply system, identical to the ITER ones, will also be installed and operated for the first time. Additional components and sub-systems (e.g. cooling and cryo systems), specific for the test facility will be procured. Finally, systems like CODAQ and diagnostic will be made as similar as possible to the ITER ones but, due to the specific application and environments, will present their own specificities.

The final procurement sharing amongst DAs has not yet been fully defined. In the following, some assumptions on the basis of the best present understandings are made.

The design, at the level necessary for the launching of the Call for Tenders in the EU scope of supply, is well progressed for all the key components. In particular, at this date:

- Power Supplies, based on FS. PA Signed. Ion Source Power Supplies specs completed and CfT launched. The specifications for all our PS parts are progressing to schedule.
- Beam Source, based on B-t-P. Specs being finalised for the first application on the SPIDER test bed.
- Beam Line Components, based on B-t-P. Some critical aspects of the 2001 design have been revised and different design proposed, e.g. for the calorimeter. Specs not ready yet.
- SPIDER vessel, based on DD/B-t-P. Specs being completed.
- MITICA vessel, based on DD/B-t-P. Specs not ready yet
- PRIMA Cooling System, FS. Being finalised
- PRIMA Cryosystem, FS. Being finalised

The buildings are procured directly with resources and under responsibility of the Host. Their specifications are ready.

MANUFACTURING READINESS

53.1 Assembly

While feasibility is not expected to be an issue, the actual scope and extent of the package is only tentatively known. See Sections above.

53.2 Beam Source

The manufacturing of the Beam Sources for the ITER injectors will benefit from the expertise gained on the basis of the procurements for the NBTF test facility. See corresponding section for the present state.

53.3 Beam Line Components

The manufacturing of the Beam Line Components for the ITER injectors will benefit from the expertise gained on the basis of the procurements for the NBTF test facility. See corresponding section for the present state.

53.4 Confinement and Shielding

R&D is required only for the Absolute Valve, which has not yet been assigned to any DA being a new components not present in 2001, and it is quite well defined. It concerns the Metallic Seat and Seal of the absolute valve that has to prove working within the ITER dimension (it requires a valve four times bigger that present existing metallic valves)

53.5 Active Correction and Compensation Coils

It is expected that the scope of procurement does not need any major R&D. The procurement will therefore be carried out by the Industrial Suppliers who will be responsible for any dedicated development, if so required.

In particular, the manufacture of such coils (conventional water cooled conductor made out with Oxygen Free High Conductivity (OFHC) copper) is expected to be well within the EU industrial know-how. The main industrial difficulty will be probably related to the large dimensions.

53.6 Power Supplies

The EU part of NB PS system is composed of a wide range of electrical equipment, mainly power converters of different sizes, which is generally within the capability of the European industry. A specific design will of course be required both at system and at components level (not off-shelf components).

The pieces of equipment which are outside industrial practice and may pose some technical/industrial risks are the: *High Voltage Deck 1 and HVD1-TL Bushing*

In fact, the HV Deck 1, housing the ion source power supplies, is a large metallic enclosure insulated for 1 MV from ground with long (ca 6 m) insulators able to withstand the seismic loads.

The HVD1-TL bushing connects the HV Deck 1 to the Transmission line in SF_6 provided by JA DA. Being rated at 1 MV DC, it is also quite outside the industrial practice and its design is somehow complicated by the large number of different conductors which must be accommodated in it. Interfacing and connection with the Japanese transmission line will also require special care and good co-ordination.

While preliminary contacts with industry are re-assuring concerning the feasibility, it is necessary that adequate contractual arrangements are found to allow the prototyping and testing before the starting of the actual production.

53.x NB Test Facility

The manufacture of the NB components for the NBTF is not expected to present issues which go beyond the present industrial capability. The main aspects to which some specific care should be paid are reported hereafter.

- Beam Source - Most of the manufacturing aspects related to the ion source are validated (IPP-Garching test facilities, JET PINI). They are also going to be further investigated with the establishment of the half-size RF ion source (ELISE). The manufacturing capacity for almost all the parts is established, although some particular processes e.g. extrapolation to bigger size of consolidated procedures, electro-deposition, and coating may present some critical aspects. The early involvement of industry, via the Engineering Support Contracts, is starting.

- Beam Line Components – As for the Beam Source, most of the manufacturing aspects of the beam line components benefits from the experience form other NB experiments. Some aspects are however still to be validated. Early involvement of industry, via the Engineering Support Contracts, is planned.

- Power Supplies – see section here above.

R&D AND QUALIFICATION ACTIVITIES

NOTE: Since the core components, and the ones requiring more development, of the NB system are to be specified by IO on the basis of build-to-print specifications, the ultimate responsibility for the activities necessary to achieve a full performing NB system lies with IO. Europe has taken, over the last years, a leading position in supporting IO in those activities and, the present section, outline some of the on-going or proposed actions, some of that not yet finalised with IO. However, the final decisions on the design features and on most of the activities necessary are to be taken by IO.

53.1 – General Assembly

No R&D nor Qualification Process is foreseen

53.2 Beam Source

Three RF ion source test facilities are operating at the present moment at the Max-Planck-Institut für Plasmaphysik (IPP) in Garching-Germany, namely:

- BATMAN: H^-,D^-, short pulses
- MANITU: H^-,D^-, long pulses
- RADI: H^-,D^-, large extraction area (1/2 of ITER source size) but no extraction

The procurement of another large extraction area test facility, ELISE, similar to RADI but capable of extraction up to 60kV, is on-going. The operations should start in the second half of 2011, while MANITU and RADI will be shut down approximately one year before, as ELISE will make use of their hardware.

Two contracts are going to be signed in the area of the ion source R&D, one contract to support experiments on BATMAN, MANITU and RADI and one service contract to support the development and exploitation of ELISE. The main R&D activity on the beam source will obviously take place at the NB Test Facility (see below).

53.3 Beam Line Components

No large scale R&D is foreseen in addition to the activities described under the NB Test Facility section.

53.4 – Confinement & Shielding.

This concerns the following components:

- the Pressure Beam Vessel → No R&D nor Qualification Process is foreseen
- the Passive Magnetic Shield → No R&D nor Qualification Process is foreseen
- the Drift Duct → No R&D nor Qualification Process is foreseen
- the Fast Shutter → Some R&D or Qualification not yet clearly identified may be requested for this component. If needed it will be defined during the design phase (01/01/2010 to 31/12/2011)

new and not yet formally agreed with ITER IO:

- the Absolute Valve → R&D is required for the Absolute Valve and it is well defined (TS are already written). It concerns the Metallic Seat and Seal of the absolute valve that has to prove working within the ITER dimension (it requires a valve four times bigger than present existing metallic valves and has the additional complexity of two seals with pumped inter-space to meet the functional requirements). IO will place directly a contract with industry for this R&D (IO has launched a call for tender in August 2009). The technical follow-up of this R&D is carried on under the F4E coordination (contract for NBI Component outside the scope of the NB Tests Facility)

- the VVPSS and associated ducting → No R&D nor Qualification Process is foreseen

- the BLV exit scrapper → No R&D nor Qualification Process is foreseen

53.5 ACC Coils

No R&D nor Qualification Process is foreseen

5.3.6 and 5.3x - HNB Power Supplies (including the ones for the NB Test Facility)

The procurement of the Power Supplies for the Neutral Beam is broadly standard and generally within the capability of European industry, with the exception of the HV Bushing. connecting the air-insulated HV Deck 1 (at -1 MV from ground) to the SF6-insulated Transmission Line procured by Japan.

A prior market survey and informal consultation with technical experts and with the industry have shown that the bushing is outside standard industrial practice. In addition the design is complicated by the large number of conductors that it must accommodate. There is therefore a significant level of technical risk for this procurement, with no guarantee that any Supplier would be willing to procure it on the basis of functional specifications only. To decrease the technical risk and ensure delivery to IO an activity of R&D is envisaged, to develop a prototype bushing. This may be done either prior to procurement or else by introducing a prototyping phase in the procurement contract.

53.x The Neutral Beam Test Facility

In terms of current density, acceleration voltage and pulse length, the heating neutral beam system of ITER represents a big extrapolation from the existing devices. Therefore the establishment of a full scale test facility is a necessary step towards the construction of the ITER injector as it mitigates almost all the risks associated with the Heating Neutral Beam System. The strategy is organized around the establishment of the Neutral Beam Test Facility (PRIMA): a full scale ion source test facility (SPIDER), to optimize the ion source performance and a full scale, full power 1 MV test facility (MITICA) to act as support for the development of NBs and the procurement of the two ITER HNB injectors.

The NB Test Facility will be therefore the essential tool for the main R&D on the NB system and the mitigation of all the most critical risks. Some of the specific issues requiring experimental investigation on a full scale test facility are:

- achievement of the specified negative ion current density with minimum Cs consumption;
- spatial uniformity of the negative ion flux to the aperture array in the plasma grid of the ion source - within 10% or better;
- high voltage holding for both the beam source and the power supply system;
- study of the effect of residual magnetic field on the beam trajectory;
- studies of phenomena associated with high accelerated currents (optics, space charge, beamlet - beamlet interaction, etc.);
- test of beam line components at full power, including power deposition from any co accelerated electrons and X-rays;
- beam neutralisation studies and measurements at full power;
- proof of correct operation of the electrostatic residual ion dump;
- integrated tests of the power supplies (essential to ensure reliability during operation);
- verification of overall reliability of the NB system.

<u>R&D on HV vacuum tests for SPIDER and MITICA components.</u> The design of the high voltage components of both SPIDER and MITICA would benefit from an accompanying R&D programme to verify its correctness with respect to the expected performance in terms of the reliability of the voltage holding.

This includes the optimization of the electrode shape in multi electrode – multi potential HV systems in vacuum (e.g. the MAMuG accelerator or the HV Bushing), based on a probabilistic formulation of the HV breakdown mechanism described by the clump theory.

All the activities foreseen in this field shall be coordinated with the R&D activity performed in the other two 1MV facilities, at CEA-Cadarache and at JAERI, Naka, in the framework of a F4E/ITER coordinated program.

Prototypes and tests for design and manufacturing qualification of components for the beam source. The "door-size" extraction area of the NB ion source requires the realization of some prototypes to verify the use of known technology for the realization of larger and more complicated geometry, such as a thick molybdenum coating to cope with the high energy backstreaming ions foreseen in MITICA. Some specific R&D is also required to finalize the thermo-hydraulic and electrical design of the grids. In particular some detail qualification of the cooling pipe joints on the grids and the electrical flexible connections is required to consolidate the manufacturing technology.

PROCUREMENT STRATEGY

On the basis of an analysis of the market environment and the risks associated to the procurement of the different components, the following procurement strategy is being considered.

53.1 Assembly

It is expected that the General Assembly will be managed by one major contract with one specialised EU company. Due to the different fields involved (mechanical, electrical, water cooling, transportation, safety) a subsequent number of subcontracted companies will be necessary.

In general, the best way to implement all site assembly should be revised with ITER since those activities are very much interlinked and dependant upon the overall ITER assembly and construction programme. **It may therefore be more convenient that IO itself take charge of site assembly, as for many other ITER components.** This would be of course a fundamental change of the scope of procurement and responsibilities but could simplify the overall management possibly producing also reduction of risks and globally cost savings.

53.2 Beam Source

Expected Open Tender. To be finalised also taking into account of the experience gained for the NBTF procurements. Some pre-tender studies within the framework of the Engineering Support Contract is planned,

53.3 Beam Line Components

Expected Open Tender. To be finalised also taking into account of the experience gained for the NBTF procurements. Some pre-tender studies within the framework of the Engineering Support Contract is planned,

53.4 Confinement and Shielding

Call for Tender will be launched only on fully defined design and clear 2D Built-To-Print drawings.

The procurement may be naturally sub-divided in 7 groups, homogeneous under the technological viewpoint:

- the Pressure Beam Vessel + the Pressure Source Vessel;
- the Passive Magnetic Shield;
- the Fast Shutter;
- the Drift Duct;
- the Absolute Valve (DA responsible not yet defined);
- the VVPSS and associated ducting (DA responsible not yet defined);

- the BLV exit scraper.

On the other hand, the seven groups are not fully independent and the sub-division in contracts will imply the creation of interfaces in addition to the ones already present with the Japanese scope of procurement and with the ITER site. The possibility of some combining will therefore be investigated.

With the exception of the Absolute Valve, no specific R&D is expected to be necessary. Some pre-tender studies within the framework of the Engineering Support Contract is planned. Procurement will be made on the basis of Open Tenders.

ACCC

The manufacture of all the coils will be procured with one contract. This will concern a total of 12 coils (HNB 1 and 2). Some pre-tender studies within the framework of the Engineering Support Contract is planned,

Calls for Tender will be launched only on fully defined design and clear 2D Built-To-Print drawings. All the coils will be procured with one single contract and the procurement will be made on the basis of Open Tenders.

Power Supplies

The HNB PS is the subject of a Procurement Arrangement between IO and EU, signed in July 2009. The PA currently covers two Power Supplies Units, the first one for Padua, and the second one for ITER Site, with provision for an optional third Unit covering for the second ITER injector PS).

After official approval of the NB Test Facility, it will be decided, jointly with IO, whether to:

- amend the existing NBPS PA to include all the Power Supplies needed for the Test Facility, with corresponding additional credits;
- include all the Power Supplies of the Test Facility in the NBTF PA and amend the NBPS PA accordingly, to indicate that both Units are for ITER Site.
- Include in the NBTF PA the Power Supplies of the Test Facility that are not covered by activating the option of the PA and amend the HNBPS PA to activate the option.

On the basis of an analysis of the market environment and the risks associated to the procurement of the different components, the following procurement work packages have been defined:

Procurement 1. Ion Source and Extraction Power Supplies (ISEPS) – up to 4 Units;

Procurement 2. Acceleration Grid Power Supplies + Ground Referenced Power Supplies + NBPS Control and DAQ (NB AGPS + GRPS + NBPS Control & DAQ) – up to three Units; strategy for this procurement is under review, may be further split by separating the NBPS Control and data Acquisition from (AGPS+GRPS).

Procurement 3. High Voltage Deck 1 (HVD1) and HVD1-TL Bushing; (NB HVD1 + Bushing) – up to 3 Units;

Procurement 4. NB System Control and DAQ; (NB Control & DAQ System) – up to 3 Units.

53.x NBTF

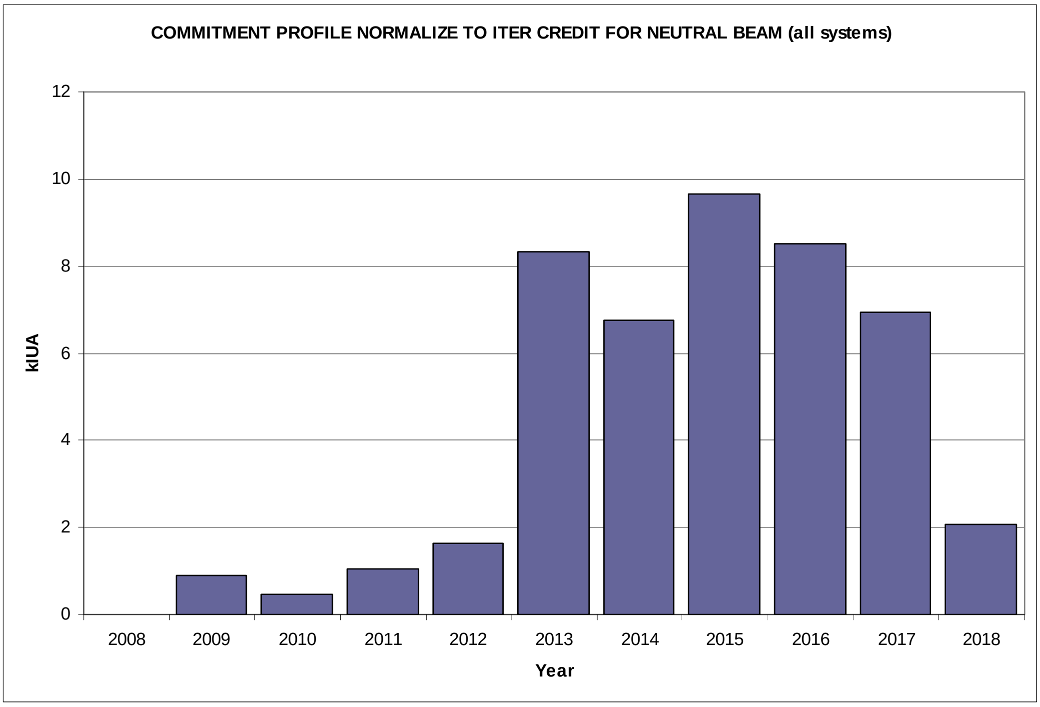
The procurement allocations of the components for the NBTF are currently under negotiations amongst the Parties and the IO and a final picture has not yet been established. In this section, the assumptions made are generally the ones at the basis of the EU strategy for the NB development. This includes the scheme of contributions, the estimated required resources, and the time schedule for the NBTF. Presently the following procurements that should fall in the EU scope have been identified. All this could be revised in the light of the progress of the negotiations.

- SPIDER beam source and vacuum vessel – open call for tender;
- SPIDER control and DAQ – under discussion. Due to the nature of the supply and to the difficulty to defined accurate specifications a-priori, way to share the procurement of the host will be investigated. To be reminded that, also for ITER, CODAQ will be provided via FUND (not in-kind) and the IO will be directly responsible;
- SPIDER diagnostics - under discussion. Due to the nature of the supply and to the difficulty to defined accurate specifications a-priori, way to share the procurement of the host will be investigated;
- PRIMA vacuum and gas injection – not defined yet;
- MITICA vessel – open call for tender
- MITICA diagnostics - under discussion. Due to the nature of the supply and to the difficulty to defined accurate specifications a-priori, way to share the procurement of the host will be investigated;
- MITICA Beam Source – open call for tender;
- MITICA beam line components - open call for tender;
- MITICA RMFCs – open call for tender;
- SPIDER Power Supplies, with the exception of the 100 kV one (to India) – open call for tender;
- The MITICA Power supplies, EU parts according to the EU DA/JA DA sharing for the ITER baseline. – open call for tender, in general. The procurement of the HVD and bushing may follow some specific procedure due to the need to integrate the construction and testing of a bushing prototype. See also corresponding section above,

In addition some other contracts are foreseen to be placed with the system integrator of the NBTF which should be the responsible for activities such as the assembling or the "balance of plant" and, probably, some parts of the control, protection and data acquisition system.

The SPIDER calorimeter has been assumed to be procured by INDA.

NORMALIZED COMMITMENT PROFILE – TOTAL NBI SYSTEM (excluding NBTF)



DIAGNOSTICS	WBS 5.5 35.487 kIUA

SHORT DESCRIPTION

ITER WBS 5.5 includes elements for 50 separate diagnostic systems and 6 groups of engineering components, common to several of the diagnostics systems (such as port plugs and cabling).

The 56 WBS elements are grouped into eight main categories: Magnetics Diagnostics (WBS 5.5.A); Neutron Diagnostics (WBS 5.5.B); Optical Diagnostics (WBS 5.5.C); Bolometric Diagnostics (WBS 5.5.D); Spectroscopic & NPA Diagnostics (WBS 5.5.E); Microwave Diagnostics (WBS 5.5.F); Plasma Facing and Operational Diagnostics (WBS 5.5.G); and Diagnostic Engineering (WBS 5.5.N). These categories formed the basis of the 2001 Diagnostic Procurement Packages.

In 2004, following a request from the ITER Team Leader and the recommendations of an all-Party working group on Diagnostics, these WBS elements were redistributed between 34 new Procurement Packages, primarily to associate responsibility for provision of the generic engineering components, and associated design integration, with the main port-based diagnostic systems. During negotiations in 2007, these new packages were allocated to the Parties and to FUND as consistently as possible with the distribution of Credit for Diagnostics agreed in the ITER Treaty.

In the frame of the ITER in-kind contributions, EU will provide eight of the 2004 Procurement Packages and, in addition, one Package (for the low field side Collective Thomson Scattering diagnostic) agreed by ITER Council in 2009 by acceptance of Design Change Request 125/126. These nine Packages incorporate components from 22 WBS 5.5 elements, representing 25.73% of the total Credit for Diagnostics.

Unfortunately, the ITER WBS was never amended to reflect the redistribution between the 2001 and 2004 Procurement Packages, which means that no one-to-one correspondence exists between the EU obligations and ITER WBS elements. Therefore, in the table below, reference is made to both the 2004 Procurement Package identifier and the WBS element. One further complication for Diagnostics is that the design type within each Procurement Package (and, indeed, within each WBS element) is mixed between Functional Specification (FS) and Detailed Design (DD).

WBS	EU obligation	Design type	Other DA involved/remarks
WBS 5.5A.01 - A.06 2004 PP22	System-level design of **Magnetics Diagnostic** Production of BTP specifications and fabrication of sensor hardware (pick-up coils; flux loops; Rogowski coils; diamagnetic loops, halo current sensors, steady-state sensors etc) and mounting platforms R&D, design and fabrication of signal processing electronics; interface to CODAC; and control and analysis software	FS DD FS	
WBS 5.5B.01 2004 PP11	System-level design of **Radial Neutron Camera** R&D, design and fabrication of collimated flight tubes and neutron shielding; neutron detectors; calibration hardware; signal processing electronics; interface to CODAC; and analysis and control software	FS FS	

WBS 5.5B.07 2004 PP11	System-level design of **Gamma-ray Spectrometer**	FS	This diagnostic is only to be ‘enabled’ - i.e. design interfaces identified and provisions made for future installation.
WBS 5.5B.11 2004 PP11	System-level design of **High-Resolution Neutron Spectrometer** R&D, design and fabrication of plug to ‘close’ collimator LOS	FS FS	This diagnostic is only to be ‘enabled’ - i.e. design interfaces identified and provisions made for future installation.
WBS 5.5C.01 2004 PP14	System-level design of **LIDAR Core-plasma Thomson Scattering Diagnostic** Production of BTP specifications and fabrication of in-vessel (port-plug based) components (optical system comprising mirrors; mirror mounts; shutters; laser beam dump etc.) R&D, design and fabrication of ex-vessel optical system; laser(s) (>1J and <1ns pulses in near-IR, <10ms rep. rate); filter-based spectrometers; sub-ns, gated detectors in the near-IR; signal processing electronics; interface to CODAC; and analysis and control software	FS DD FS	
WBS 5.5C.07 2004 PP34	System-level design of **LFS Collective Thomson Scattering Diagnostic** R&D, design and fabrication of in-vessel (port-plug based) waveguides; mm-wave mirrors; and horn arrays	FS FS	LFS CTS in-vessel components are to be integrated into Equatorial Port Plug 12, to be supplied by CN-DA
WBS 5.5D.01 2004 PP21	System-level design of **Bolometer Diagnostic** R&D, design and fabrication of bolometer sensors, camera heads, mounting platforms, signal processing electronics; interface to CODAC; and analysis and control software	FS FS	Some bolometers are to be integrated in Upper Port Plug 17, to be supplied by US-DA
WBS 5.5E.01 2004 PP02	System-level design of **Core-plasma Charge Exchange Recombination Spectroscopy Diagnostic** R&D, design and fabrication of optical system (comprising mirrors; mirror mounts; shutters etc); optical fibres; CCD camera based detectors; spectrometers; signal processing electronics; interface to CODAC; analysis and control software	FS FS	

WBS 5.5E.14 2004 PP11	System-level design of **Hydrogen-phase Hard X-ray Monitor** R&D, design and fabrication of hard X-ray detector; signal processing electronics; interface to CODAC; and analysis and control software	FS FS	
WBS 5.5F.03 2004 PP01	System-level design of **Plasma Position Reflectometer** Production of BTP specifications and fabrication of in-vessel mm-wave transmission lines (horn antennas, waveguides, supports etc.) R&D, design and fabrication of ex-vessel transmission lines, signal processing electronics; interface to CODAC; and analysis and control software	FS DD FS	
WBS 5.5G.01 2004 PP11	System-level design of **Mid-plane Visible/IR Wide-angle Viewing System** Production of BTP specifications and fabrication of in-vessel (port-plug based) components (dual-wavelength optical system comprising mirrors; mirror mounts; shutters etc) R&D, design and fabrication of ex-vessel dual-wavelength optical system; visible/IR beam splitters; visible CCD cameras; 3-5 μm IR camera; signal processing electronics; interface to CODAC; and analysis and control software	FS DD FS	Some Vis/IR WAVS components are to be integrated in Equatorial Port Plug 12, to be supplied by CN-DA, and Equatorial Port Plugs 03 and 09, to be supplied by US-DA
WBS 5.5G.03 2004 PP21	Production of BTP specifications and fabrication of **Pressure Gauges** hardware and mounting platforms R&D, design and fabrication of signal processing electronics; interface to CODAC; and control and analysis software	DD FS	
WBS 5.5G.11 2004 PP26	System-level design of **Inner Target and Blanket Thermocouples** R&D, design and fabrication of thermocouples, mounts, signal processing electronics; interface to CODAC; and control and analysis software	FS FS	
WBS 5.5N.01 2004 PP30	R&D, design and fabrication of **In-vessel Services** including cables; conduits; vacuum feedthroughs; and connectors (plugs, sockets and marshalling boxes)	FS	

WBS 5.5N.03 - N.06 2004 PPs 01; 02; 11; 14; 21; 22; and 26	**Design integration** of diagnostic systems into the following ports: • Upper Port 14 • Upper Port 03 • Upper Port 01 • Equatorial Port 10 • Equatorial Port 01	FS	Incl. integration of components provided to IO from: US-DA IN-DA JA-DA JA-DA JA-DA, US-DA and CN-DA
	R&D, design and fabrication of P**ort Plug Structures; Internal Radiation Shielding Modules; and First Vacuum Closures**	FS	
	R&D, design and fabrication of **Port Interspace Structures; Second Vacuum Closures;** and Port-specific Diagnostic Services (cables etc.)	FS	
	R&D, Design and fabrication of **Ex-bioshield Electrical Equipment** (e.g. Diagnostic cubicles and power supplies)	FS	
	Assembly of port plugs and port-plug based diagnostic equipment and **Environmental Testing** of port plugs	FS	

PROCUREMENT ARRANGEMENTS PLANNING & STATUS

Two PAs will be issued for the EU contributions: one covering the 'early delivery' diagnostic systems and components, required for Phase 1 of ITER operations (i.e. for First Plasma); and one for Phase 2 and beyond. The diagnostics required for Phase 1, and thus the distribution of Credit between the two PAs, are however not yet fully defined and are the subject of on-going discussions between F4E and ITER IO. As a minimum, the Phase 1 PA will include the Magnetics Diagnostic, In-vessel Services, Plasma Position Reflectometer and Pressure Gauges.

The current draft of the ITER Project Schedule (IPS) presents preliminary signature dates for the two EU PAs as 15th and 16th December 2010. However, these dates are recognised as unrealistic due to the absence of certain key ITER documentation and resource limitations at both ITER IO and F4E needed to support definition and construct of the PA specifications. Final dates are therefore still under discussion between F4E and ITER IO.

PA Title	**PA signature**	**Credit (kIUA)**
Phase 1 Diagnostics (EU-DA)	15th December 2010[1]	35.487
Phase 2 Diagnostics (EU-DA)	16th December 2010[1]	

[1] Preliminary dates in draft IPS

The first EU procurement of components for the Magnetics Diagnostic is scheduled for October 2011. This represents the ultimate deadline for signature of the Phase 1 PA covering that contribution. An earlier signature date of July 2011 is in fact likely to be agreed with ITER IO for the Phase 1 PA, in order to provide some margin. The Phase 2 PA is less urgent since procurements are scheduled to begin only in 2015. A date of July 2012 has therefore been proposed to ITER IO. Both these dates assume that R&D and design activities forming part of PA-credited contributions can be undertaken in advance of PA signature, probably through the medium of a 'pre-PA arrangement' mutually agreed between F4E and IO.

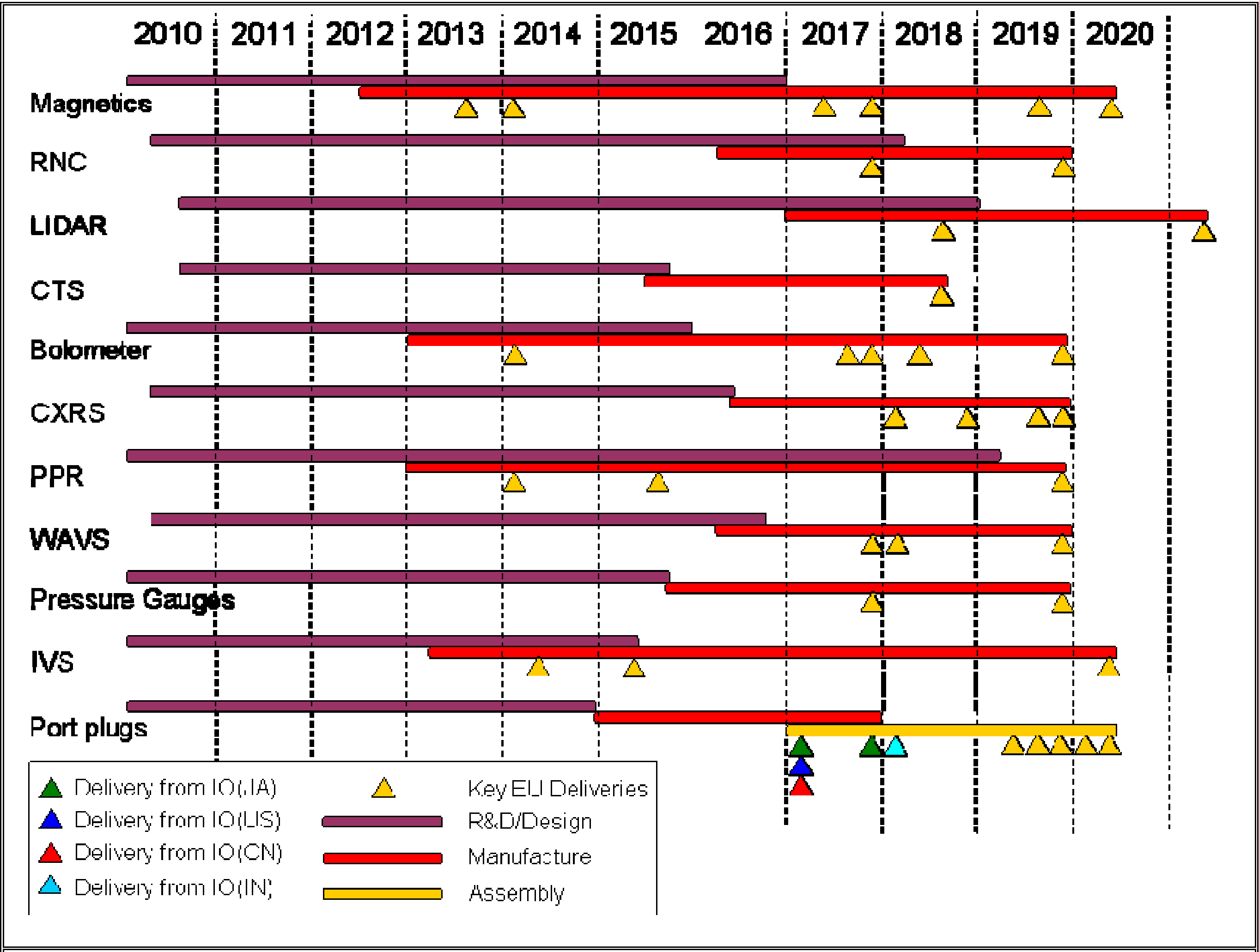
Several components forming part of the EU in-kind contributions are to be procured at the Detailed Design level. Although conceptual designs are generally available, detailed designs for these components do not exist.

MAIN MILESTONES

WBS	Milestone	DA Responsible	Expected date
Magnetics Diagnostic			
WBS 5.5A.01-A06	On-vessel magnetics diagnostics sensors/platforms and external Rogowski coil design complete	EU	May 2012
WBS 5.5A.01-A06	Divertor magnetics diagnostics sensors and blanket halo current sensors design complete	EU	Dec 2016
WBS 5.5A.01-A06	Magnetics electronics design completed	EU	Dec 2016
WBS 5.5A.01-A06	On-vessel magnetics sensors/platforms delivered	EU	Jul 2013
WBS 5.5A.01-A06	External Rogowski coils (plasma current) delivered	EU	Mar 2014
WBS 5.5A.01-A06	External Rogowski coils (TF current) delivered	EU	Jun 2017
WBS 5.5A.01-A06	Magnetics electronics delivered	EU	Dec 2017
WBS 5.5A.01-A06	Blanket halo current sensors delivered	EU	Sep 2019
WBS 5.5A.01-A06	Divertor magnetics sensors delivered	EU	May 2020
Radial Neutron Camera (RNC)			
WBS 5.5B.01	RNC port plug component design complete	EU	Nov 2015
WBS 5.5B.01	RNC ex-vessel component design complete	EU	Mar 2018
WBS 5.5B.01	RNC port plug components delivered	EU	Nov 2017
WBS 5.5B.01	RNC ex-vessel components delivered	EU	Dec 2019
WBS 5.5B.01	RNC electronics delivered	EU	Dec 2019
LIDAR Core-plasma Thomson Scattering Diagnostic			
WBS 5.5C.01	LIDAR port plug component design complete	EU	Aug 2015
WBS 5.5C.01	LIDAR ex-vessel component design complete	EU	Dec 2018
WBS 5.5C.01	LIDAR port plug components delivered	EU	Aug 2018
WBS 5.5C.01	LIDAR ex-vessel components delivered	EU	Jun 2021
WBS 5.5C.01	LIDAR electronics delivered	EU	Jun 2021
LFS Collective Thomson Scattering (CTS)			
WBS 5.5C.07	CTS port plug component design complete	EU	Aug 2015
WBS 5.5C.07	CTS port plug components delivered	EU	Aug 2018
Bolometer Diagnostic			
WBS 5.5D.01	Blanket bolometer platform design complete	EU	Dec 2012
WBS 5.5D.01	Blanket bolometer design complete	EU	Jun 2016
WBS 5.5D.01	Divertor bolometer/platform design complete	EU	Sep 2015

WBS 5.5D.01	Port-plug bolometer/platform design complete	EU	Dec 2015
WBS 5.5D.01	Blanket bolometer platforms delivered	EU	Feb 2014
WBS 5.5D.01	Divertor bolometers/platforms delivered	EU	Sep 2017
WBS 5.5D.01	Port-plug bolometers/platforms delivered	EU	Dec 2017
WBS 5.5D.01	Blanket bolometers/platforms delivered	EU	Jun 2018
WBS 5.5D.01	Bolometer electronics delivered	EU	Dec 2019
Core-plasma Charge Exchange Recombination Spectroscopy Diagnostic (CXRS)			
WBS 5.5E.01	CXRS port plug component design complete	EU	Nov 2014
WBS 5.5E.01	CXRS ex-vessel components design complete	EU	Jun 2016
WBS 5.5E.01	CXRS port plug components delivered	EU	Mar 2018
WBS 5.5E.01	CXRS optical fibres delivered	EU	Dec 2018
WBS 5.5E.01	CXRS spectrometers delivered	EU	Sep 2019
WBS 5.5E.01	CXRS electronics delivered	EU	Dec 2019
Plasma Position Reflectometer (PPR)			
WBS 5.5F.03	PPR in-vessel mm-wave component design complete	EU	Nov 2011
WBS 5.5F.03	PPR port plug mm-wave component design complete	EU	Dec 2013
WBS 5.5F.03	PPR ex-vessel mm-wave component design complete	EU	Mar 2019
WBS 5.5F.03	PPR in-vessel mm-wave components delivered	EU	Feb 2014
WBS 5.5F.03	PPR port plug mm-wave components delivered	EU	Sep 2015
WBS 5.5F.03	PPR ex-vessel mm-wave components delivered	EU	Dec 2019
WBS 5.5F.03	PPR electronics delivered	EU	Dec 2019
Mid-plane Visible/IR Wide-Angle Viewing System (WAVS)			
WBS 5.5G.01	WAVS port plug component design complete	EU	Dec 2014
WBS 5.5G.01	WAVS ex-vessel component design complete	EU	Jun 2016
WBS 5.5G.01	WAVS EPP03 components delivered	EU	Nov 2017
WBS 5.5G.01	WAVS EPP09,10 & 12 components delivered	EU	Mar 2018
WBS 5.5G.01	WAVS ex-vessel components delivered	EU	Dec 2019
WBS 5.5G.01	WAVS electronics delivered	EU	Dec 2019
Pressure Gauges			
WBS 5.5G.03	Pressure gauge/platform design complete	EU	Jan 2015
WBS 5.5G.03	Pressure gauges/platforms delivered	EU	Nov 2017
WBS 5.5G.03	Pressure gauges electronics delivered	EU	Dec 2019

In-Vessel Services (IVS)			
WBS 5.5N.01	IVS on-vessel cables design complete	EU	Feb 2012
WBS 5.5N.01	IVS on-vessel loom/conduit design complete	EU	Dec 2011
WBS 5.5N.01	IVS on-vessel feedthrough/connector design complete	EU	Sep 2013
WBS 5.5N.01	IVS divertor looms & connectors design complete	EU	Jun 2015
WBS 5.5N.01	IVS on-vessel conduits delivered	EU	May 2014
WBS 5.5N.01	IVS on-vessel looms delivered	EU	Jun 2015
WBS 5.5N.01	IVS feedthroughs/connectors delivered	EU	Jun 2015
WBS 5.5N.01	IVS divertor looms & connectors delivered	EU	Jun 2020
Diagnostic Engineering (Port-Plugs)			
WBS 5.5N.03-N.06	UPP 01 design integration complete	EU	Dec 2013
WBS 5.5N.03-N.06	UPP 03 design integration complete	EU	Sep 2014
WBS 5.5N.03-N.06	UPP 14 design integration complete	EU	Sep 2013
WBS 5.5N.03-N.06	EPP 01 design integration complete	EU	Jun 2014
WBS 5.5N.03-N.06	EPP 10 design integration complete	EU	Dec 2014
WBS 5.5N.03-N.06	JA-DA Divertor Impurity Monitor UPP01 components delivered from IO	IO (JA)	Mar 2017
WBS 5.5N.03-N.06	IN-DA Beam Emission Spectroscopy UPP03 components delivered from IO	IO (IN)	Mar 2018
WBS 5.5N.03-N.06	US-DA visible/IR WAVS UPP14 components delivered from IO	IO (US)	Mar 2017
WBS 5.5N.03-N.06	JA-DA Edge Thomson Scattering EPP10 components delivered from IO	IO (JA)	Dec 2017
WBS 5.5N.03-N.06	JA-DA Polarimeter EPP10 components delivered from IO	IO (JA)	Dec 2017
WBS 5.5N.03-N.06	JA-DA Divertor Impurity Monitor EPP01 components delivered from IO	IO (JA)	Mar 2017
WBS 5.5N.03-N.06	US-DA Motional Stark Effect EPP01 components delivered from IO	IO (US)	Mar 2017
WBS 5.5N.03-N.06	CN-DA Neutron Flux Monitor EPP01 components delivered from IO	IO (CN)	Mar 2017
WBS 5.5N.03-N.06	UPP 01 Delivered	EU	Sep 2019
WBS 5.5N.03-N.06	UPP 03 Delivered	EU	Mar 2020
WBS 5.5N.03-N.06	UPP 14 Delivered	EU	Jun 2019
WBS 5.5N.03-N.06	EPP 01 Delivered	EU	Dec 2019
WBS 5.5N.03-N.06	EPP 10 Delivered	EU	Jun 2020



DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

The ITER diagnostic systems forming part of the EU contributions are, as far as possible, based on diagnostic techniques and technologies with a proven track record on existing fusion experiments. Significant development has been, and is still necessary, however, to adapt these for compatibility with the harsh ITER environment and reliability requirements.

Design solutions and conceptual designs, broadly compatible with the ITER measurement requirements, exist for most of the systems forming part of the EU contributions, although in several cases additional system-level design activities are likely to be required before a conceptual design review (necessary for PA signature) can be passed. In a few cases, most notably for the Magnetics Diagnostic inductive sensors and platforms, designs exist which are somewhat more advanced, though not at the Detailed Design level. The bulk of the specific R&D, detailed design, detailed integration and qualification for most of the EU contributions therefore remain to be completed, in addition to production of manufacturing specifications and build to print drawings, before manufacture can begin.

Some of the more significant design activities remaining include:

- Development of high efficiency, very fast, large area detectors in the 850-1200nm range
- Lasers in the near-IR with sub-ns pulse length, energies greater than 1J and high repetition rate
- Mechanical shutter mechanisms able to operate with high rep. rate and 100% availability in high vacuum and high neutron fluences

- Radiation-hard neutron detectors with an adequate balance of sensitivity and dynamic range
- Mechanisms for in-situ calibration of surface emissivity in the IR
- Robust, shaped mirrors to transmit astigmatic beams
- Quality assured sources of radiation-hard cables
- Robust, radiation-hard electrical contacts
- Low reflectivity collimators
- Deposition of robust 12 μm Pt films on 1.5 μm SiN substrates
- Visible light spectrometers with large etendue, high resolution and high efficiency
- mm-wave waveguides and waveguide joints combining adequate strength and good conductivity
- Upper port plug structures with acceptable deflection under expected e-m loads
- Design integration into port plugs of multiple diagnostics, from several Parties

Most of the Diagnostic systems forming part of the EU contributions require perhaps 1-2 years of additional R&D (20-50 PPY) and 3-4 years of design work (40-80 PPY) before development of manufacturing specifications and build to print drawings can begin.

MANUFACTURING READINESS

For most of the EU contributions, the manufacturing readiness is essentially zero since mature designs do not exist, even at the preliminary design level. However, although the design status is clearly immature, significant R&D has already been conducted (especially irradiation testing), including limited R&D prototyping of some components. This R&D has demonstrated, or at least improved confidence, that credible manufacturing paths are available for the most critical components.

ASSESSMENT OF RISK: see Annex II

R&D AND QUALIFICATION ACTIVITIES

Given the immature design status of most diagnostic systems, extensive R&D and qualification activities are required in preparation for hardware procurement. The topics that will be addressed most urgently are:

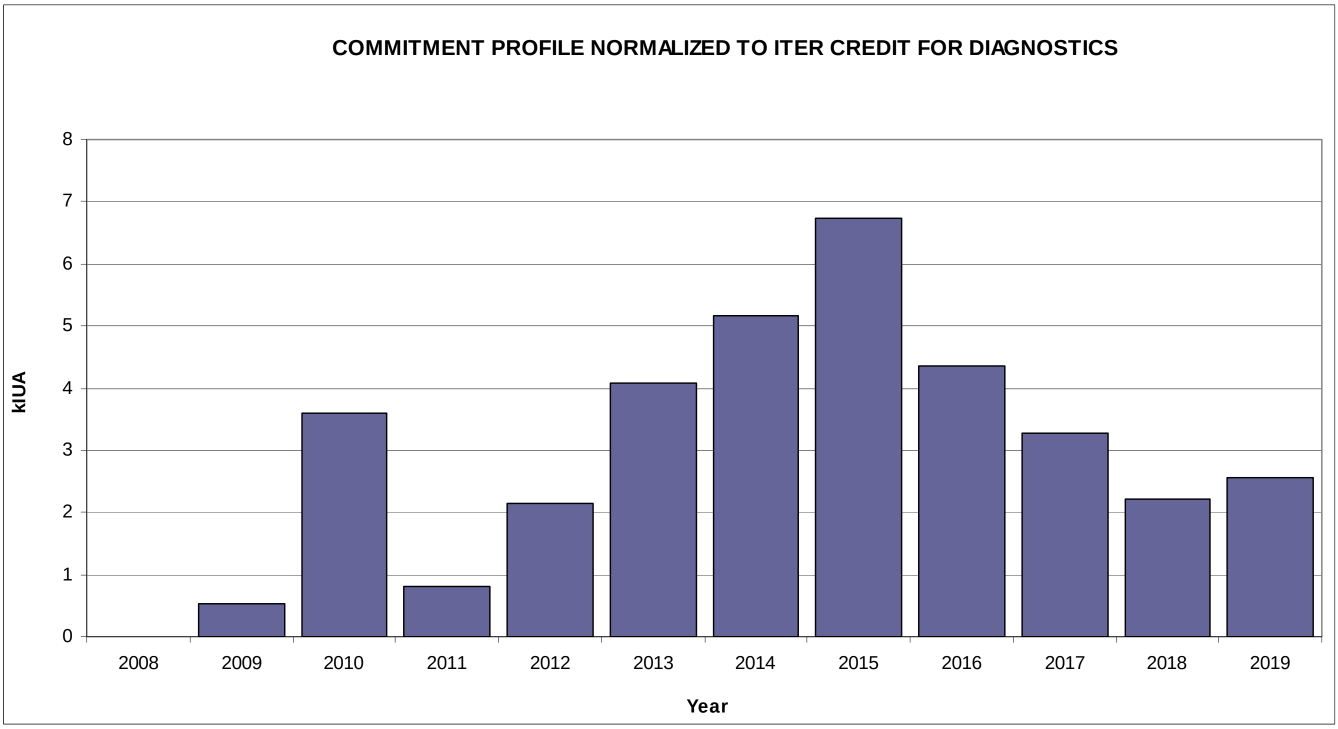
- Design of port-plugs and prototyping of the relevant components;
- R&D on, and qualification of, components to be mounted on the vacuum vessel and TF-coil case at the factory (e.g. magnetics sensors, in-vessel cables, diagnostic mounting platforms and electrical joints);
- R&D on critical components of the port-based systems (e.g. damage-resistant mirrors, shutters and actuators)
- integration of diagnostics into port plugs and definition of interfaces with systems procured by the other ITER parties.

PROCUREMENT STRATEGY

In order to meet the IPS, the diagnostic system design activities must be conducted in parallel with R&D and qualification of components, at least for sub-systems needed for installation in the port plugs and vacuum vessel. The diagnostic systems combine many different technologies and their components are to be installed in many of the ITER sub-systems: TF-coil case; vacuum vessel; divertor; port plugs; and buildings. As a result, different diagnostic components are driven by very different timescales for supply. The fabrication of some components needs to begin by 2013, whilst delivery of some ex-vessel components may not be required until commissioning of the associated systems in 2020.

The wide range of technologies used in the diagnostic systems will require a large number of companies and laboratories to be involved in the design, testing and manufacture of components. Some expertise only exists with the EFDA Associates, particularly that related to system-level design aspects (i.e. design activities related to the functional performance of the system and 'specialist' calculations such as neutronics analyses). Some aspects of the detailed component design are, however, within the capabilities of both industry and EFDA Associates, as are engineering design management (such as that required to integrate several independent diagnostic designs into the port plugs) and diagnostic assembly into port plugs. Production of prototypes and build-to-print drawings; fabrication of most diagnostic components and port structures; and follow-up of contracts (e.g. for quality assessment or test validation) will be conducted through contracts with industry. It is envisaged that diagnostic assembly into port plugs and port plug testing will be conducted at a single integration site, perhaps together with other port-based systems under EU procurement (such as the EC and IC heating systems).

NORMALIZED COMMITMENT PROFILE – DIAGNOSTICS



SITE AND BUILDINGS	WBS 6.1 – 6.5 377.9 kIUA

SHORT DESCRIPTION

In the frame of the ITER in-kind contribution, Europe will provide the detailed design and the construction of the buildings and site infrastructures. The Site and Buildings procurements to be provided by EU are listed here below.

PBS	EU obligation	Design type	Other DA involved/remarks
Site			
PBS 61	Site infrastructures related to the buildings	Build to print, and Functional specifications for materials	No
Reinforced concrete buildings			
PBS 62	All the "nuclear" buildings, including the Fire protection system, the HVAC system, the cranes, lifting and mechanical equipment	Build to print, and Functional specifications for materials	No
Steel framed buildings			
PBS 63	All the non-nuclear buildings, including the Fire protection system, the HVAC system, the cranes, lifting and mechanical equipment	Build to print, and Functional specifications for materials	No
Liquid and gas distribution networks			
PBS 65	Potable water, Fire protection water, Hot water, Compressed Air, Demineralised Water, Breathing Air, Nitrogen, Helium (gas)	Build to print, and Functional specifications for materials	No

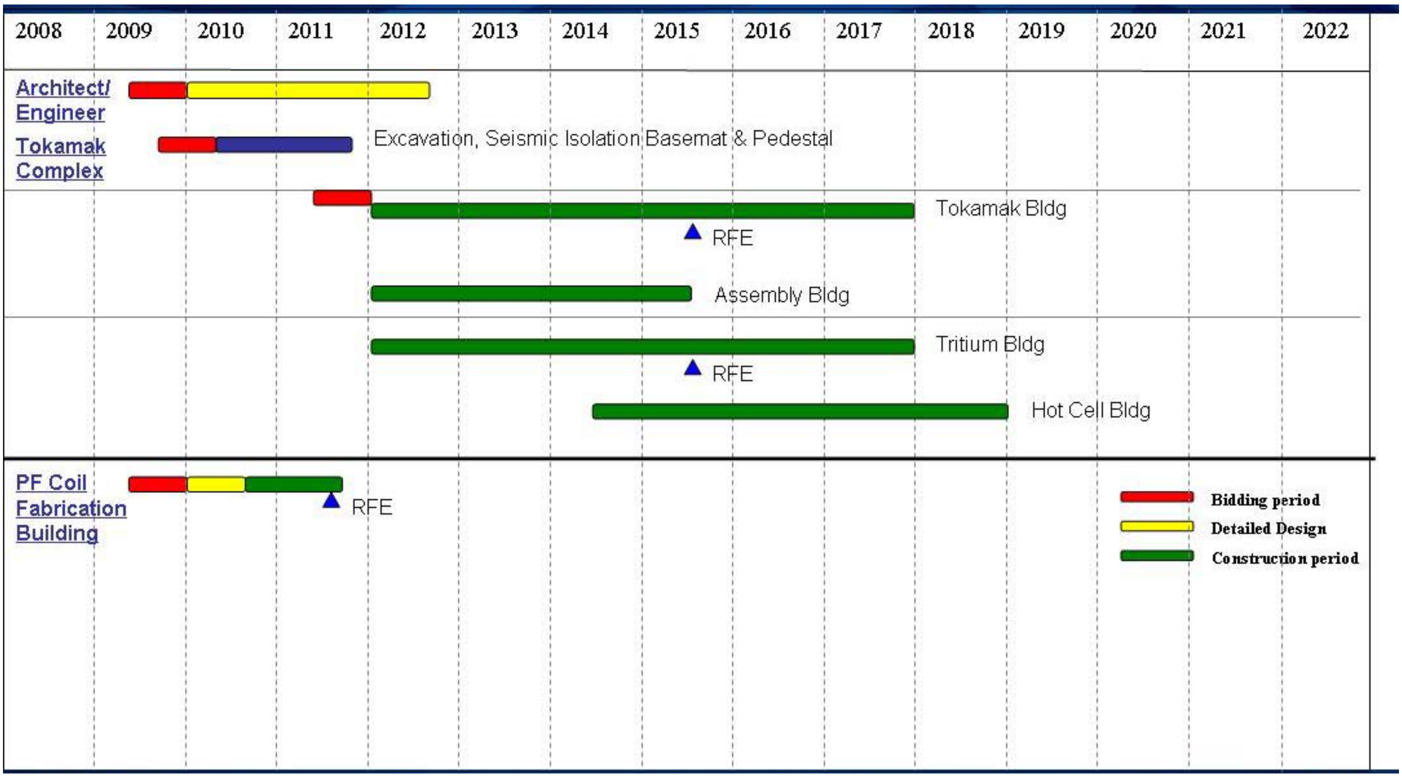
PROCUREMENT ARRANGEMENTS PLANNING & STATUS

PA Title	PA signature	Credit (kIUA)
PF Coil building	November 2008	12.8
Architectural and Engineering services	May 2009	54.7
Excavation and support structure	May 2009	31.0
Antiseismic bearings	May 2009	6.2
Construction (Reinforced Concrete Buildings and Steel Frame Buildings)	January 2010	273.2

MAIN MILESTONES

PBS	Milestone	DA responsible	Expected date
Site			
61	Completion of Platform Levelling	EU	June 2009
PF Coil Building			
63	Start of PF Coils Building Assistance Contract	EU	May 2009
63	End of PF Coils Building Assistance Contract	EU	December 2009
63	Construction design complete	EU	July 2010
63	Ready for Equipment of PF Coils fabrication building	EU	July 2011
63	Final acceptance of the works	EU	December 2011
Excavation and support structure			
62	Final acceptance of the works	EU	September 2011
Architectural and Engineering services			
61,62,63,65	Start of Value Engineering Contract	EU	May 2009
61,62,63,65	End of Value Engineering Contract	EU	February 2010
61,62,63,65	Start of Architect Engineer Contract	EU	January 2010
61,62,63,65	Preliminary design complete	EU	July 2010
61,62,63,65	Tender design complete	EU	July 2011
61,62,63,65	Construction design complete	EU	August 2012
Construction			
61,62,63,65	Start of Tokamak Building Construction	EU	January 2012
61,62,63,65	Start of Hot Cell Building Construction	EU	June 2014
61,62,63,65	Tokamak RFE	EU	June 2015
61,62,63,65	Completion of Tokamak Building Construction	EU	December 2017
61,62,63,65	Completion of Hot Cell Building Construction	EU	December 2018
Anti seismic bearings (*planning based on the assumption that the ASB are installed before the Tokamak*			

complex upper basemat is finished)			
62	Beginning of the qualification process	EU	April 2010
62	Final acceptance	EU	June 2012



DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

IO has the duty to provide the functional specifications of the buildings intended as a complete set of documents, analyses, drawings and models in which the requirements, interfaces, preferred basic configuration and sizing of the buildings is documented. A first set of documents "Initial Functional Requirements" has been developed and used for tendering the F4E support contracts (Architect Engineer, Support to the Owner, and Health and Safety Protection Coordination & Legal Inspection contracts). These documents will be updated by IO into "Final Functional Requirements" by the end of 2009 to allow the Architect Engineer to start the design on a frozen conceptual design basis.

Following the signature of the PA for services in May 2009, F4E has evaluated the status of the current functional requirements and has found some important issues that need to be considered by IO. The result of this assessment was sent to IO with the objective of having IO teams finalize the functional requirements by the end of December 2009. The main issues are the following :

- Missing information or incompleteness of some documents;
- Some equipments need further definition and interface definition;
- Uncertainties in the assumptions considered for designing the radiological shielding have to be clarified;
- Load specifications are incomplete.

The lifting of these conditions will be a prerequisite to the signature of the PA for Construction.

MANUFACTURING READINESS

In general the construction of ITER buildings does not require the development of new/special technologies or R&D in support. The anti-seismic bearings are however a specific case because they have to pass a qualification process.

The actual design and qualification process were developed through a joint qualification program with the RJH reactor currently ongoing elsewhere on the Cadarache site with one supplier. Other suppliers are available in the EU. Our aim is to have the broadest competition possible throughout the EU, but the technical and financial feasibility of having an additional qualification process which would result in the installation of the bearings after commencement of the Tokamak Complex Construction, has to be assessed. This assessment is scheduled for October 2009.

ASSESSMENT OF RISK: see Annex II

R&D AND QUALIFICATION ACTIVITIES

Only the anti-seismic bearings are to be considered, as described in 4.2

PROCUREMENT STRATEGY

Based on an analysis of the market and technical environment and the risk assessment, the following strategy is defined:

Short-Term

- To launch the Architect Engineer, Health & Safety Protection Coordination & Legal Inspection, and Support to the Owner contracts tendering before mid October 2009 in order to have contracts signed in the beginning of 2010. All of these three contracts have an initial duration of six years, but include five optional years that can be exercised in case of delay in design or construction. Therefore the total maximal length of the three assistance contracts can be up to 11 years;
- To sign the PF Coils Design & Build contract in the beginning of 2010 in order to start the construction mid of 2010;
- To sign excavation and support structure contract beginning of 2010;
- To review the draft functional specifications provided by IO through the PA services with the help of an expert's panel in order to assist IO to improve and to fill out the functional specification. The final functional specifications have to be ready in December 2009 for the signature of the PA construction and will be the baseline (frozen technical configuration) to launch the detailed studies.

Mid-Term

- To carry out detailed studies with Architect Engineer from 2010 to 2012 (29 months);
- To launch a Call for Tender for the first contracts for civil construction on 1st semester 2011 to be able to start construction on 1st semester 2012;
- Allotment strategy for the construction of the ITER buildings;
- A global strategy has been drawn-up. Each contract should be directly followed-up by F4E staff with the assistance of the Support to the Owner that for that reason 12 main contracts will be launched. A brain storming meeting has been organized in September 2009 covering:
    - An analysis of all the constraints
    - An analysis of all opportunities to split the construction of the 32 separate service buildings

and structures into Civil Engineering, HVAC, electrical service, finishing & cranes contracts or different package nuclear, non-nuclear, steel frame

- o An assessment of the pros and cons of the different options and associated risks.

The analysis has taken into account the different main constraints such as the constructability constraints, the schedule constraints and the search for maximum competition. Following the meeting, the following principles will be taken into account:

- Rank contracts by class and not by building (Civil engineering, HVAC and electrical services, cranes and bridges, finishing);
- For the Civil Engineering, make a maximum of three construction packages to limit interfaces and to attract international competition (the amount of each contract should be higher than 100 MEUR). Each package must be clearly distinct geographically or in terms of schedule;
- Taking into account the constructability constraints, schedule constraints, the need for competition and the fact that the two most technically specific buildings (and therefore the two that need the more time to design) are the Tokamak complex and the Hot Cell Facility, the meeting narrowed down to two possible allotment strategies.

Strategy 1 which intends to split the civil engineering works in the following lots:

- lot 1: CE1 (Tokamak Complex and adjacent buildings)

- lot 2: CE2 (Hot Cell facility and adjacent buildings)

- lot 3: CE3 (All other buildings)

Strategy 2 which intends to split the civil engineering works in the following lots:

- lot 1': CE1 merged with CE2

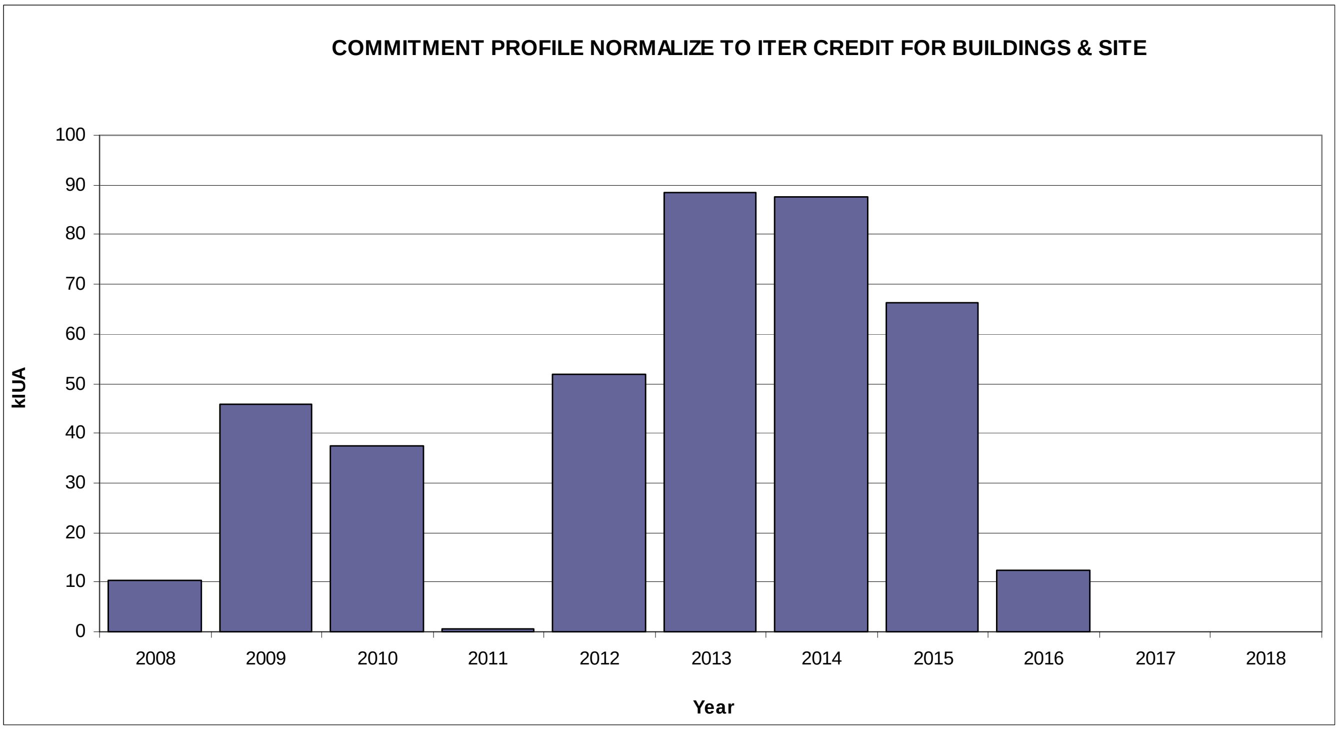
- lot 2': CE3.

In the current schedule, the Hot Cell facility construction has to start only after the Tokamak complex construction is well ahead. Therefore, strategy 1 seems to be the less risky in terms of schedule and costs:

The CE1 construction could be almost finished when the CE2 starts. This approach allows the design of the Hot Cell facility to be finished before the construction call for tender.

Once the contract signed, the Architect Engineer's expertise will be used to finalize the definition of the construction packages.

NORMALIZED COMMITMENT PROFILE – SITE & BUILDINGS



RADIOLOGICAL AND ENVIRONMENTAL MONITORS	**WBS 6.4** **4.18 kIUA**

SHORT DESCRIPTION

The following functions are provided by the Radiological Monitoring and Protection and Environmental Monitoring System (RPS):

- Radiological monitoring for protection of personnel and equipment (RM&PS) from ionizing radiation, including tritium hazards. The function is accomplished by a combination of fixed and movable radiation/contamination monitors working in conjunction with dosimetry and bioassay systems. Fixed instruments include those tritium monitors that are necessary to detect trigger changes in the HVAC but do not include those that are concerned with process or glove box atmosphere monitoring.

- Radiological monitoring to provide information suitable for maintaining compliance with environmental regulations. The function is accomplished by a combination of fixed and movable environmental monitors working in conjunction with a plant and site sampling and inspection program.

- Monitoring and measurement of airborne and surface contamination by Beryllium. Be detection is not part of radiological monitoring. However, air streams in ducts may need to be sampled for Be particulates using identical techniques as for radioactive particulates.

Many of these instruments will provide data to be transmitted to CODAC for on-line monitoring and in addition provide local alarms which will also be relayed to a central facility by a hard-wired system. Some fixed instruments will be required to continue operating during power outages and will require Uninterruptible Power Supply (UPS).

Many of these instruments are provided for radiological safety and will be required to comply with the requirements laid down in the Basic Safety Standards (BSS) and derived national documents.

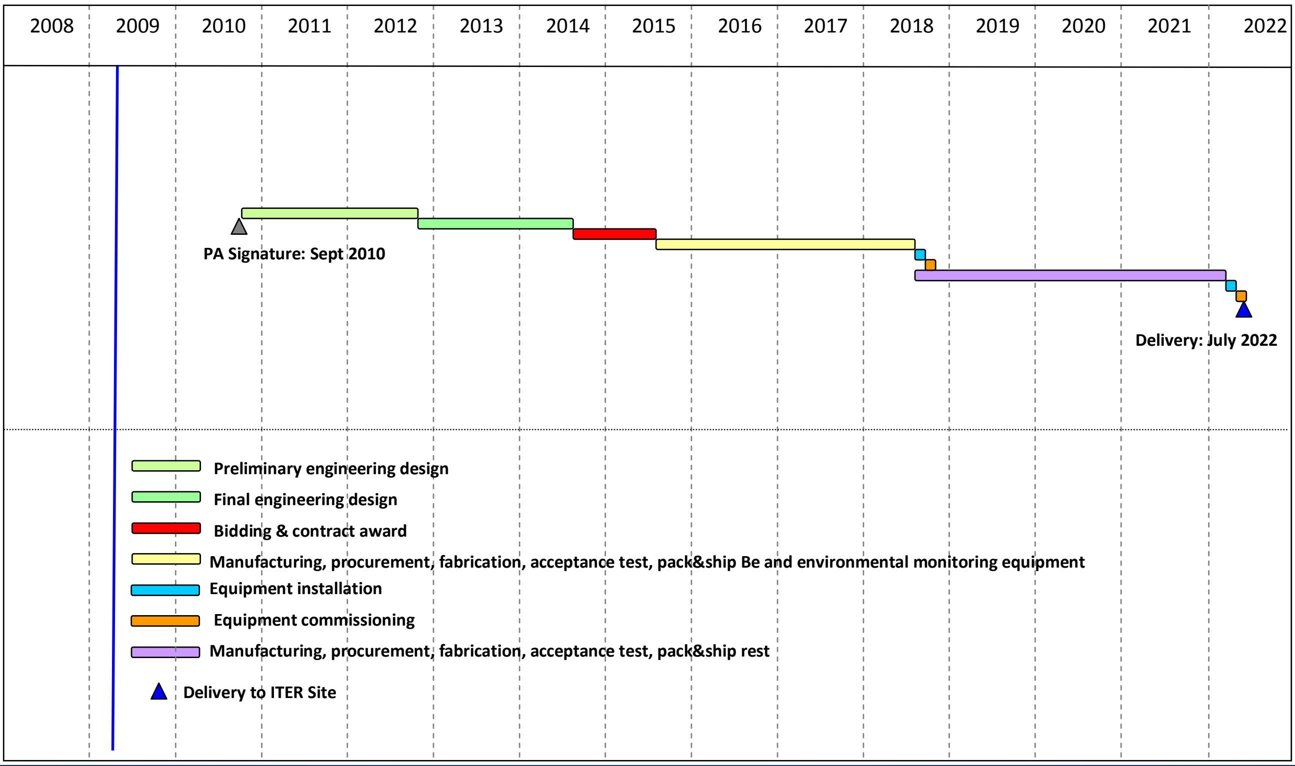
PROCUREMENT ARRANGEMENTS PLANNING & STATUS

PA Title	**PA Signature**	**Credit (kIUA)**
Radiological & Environmental Monitoring System	September 2010	4.18

MAIN MILESTONES

WBS	**Milestone**	**DA Responsible**	**Expected Date**
WBS 64	Conceptual Design Approved	IO	Jun 2010
WBS 64	PA 6.4P1.EU.01 for RPS	EU/IO	Sep 2010
WBS 64	Prel. Engineering Design Approved	EU	Nov 2012
WBS 64	Final Engineering Design Approved	EU	Jan 2015

WBS 64	Delivery Be and Env. Monitoring Equip	EU	Aug 2018
WBS 64	Delivery Nuclear phase Env. Monitoring Equip	EU	Mar 2022



DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

The level of design for the Tokamak Complex and the Tritium Building is adequate to define functional specifications and to provide reasonable cost estimation. This work originally credited to F4E by ITER-IO at a level of 0.2 PPY inside the task agreement TA-CAD/Eng-EU will now be implemented directly by ITER-IO through their engineering support contracts and not by F4E.

The design level of the Hot Cell Building is not yet adequate to define functional specifications and to provide reasonable cost estimation. Therefore a task to define functional specifications including cost estimates would be envisaged to be implemented by F4E during 2010. In general the design does not require development of new/special technologies or R&D in support.

MANUFACTURING READINESS

All the equipment is mature technology and in general the design does not require development of new/special technologies or R&D in support. The instrumentation listed at §7 is commercially available. Some evolution in the proprietary designs may occur in the intervening period before procurement but the preference will be for instrumentation that has a proven track record.

R&D AND QUALIFICATION ACTIVITIES

All the equipment is mature technology and in general the design does not require development of new/special technologies or R&D in support.

PROCUREMENT STRATEGY

The supply, as defined in the 2000 ITER-FEAT Procurement Package 64.P1, 2001 DDD 6.4, being identical to those listed in 2007 Project Integration Document (ITER_D_2234RH), consists of a comprehensive array of monitors and instruments, the installation, testing and commissioning. The list of instruments, monitors, samplers together with quantity and parameter values is comprehensive and given in the following table.

Description **Radiological Protections**	**Quantity**	**Radiation Type**	**Parameters Values**
Whole body detector	2	gamma	Per standards
Area gamma monitor	130	Gamma	0.5 μSv/hr-10 mSv/h
Tritium in air monitor	100	Total T	0.1 to 10000 DAC
Tritium in air duct monitor	15	Total T	0.1 to 10000 DAC
Pumping/manifold system for T in air monitor	10		Per standards
HT/HTO discriminating sampler	10	HT/HTO	Per standards
HTO bubbler	20	HTO	Per standards
Liquid scintillation counter	4	HTO in water	> 4Bq/L H_2O
Area neutron monitor	10	Neutron	0.5 μSv/hr-10 mSv/h
Portal monitor	10	Beta/gamma	Per standards
Frisker	30	Beta/gamma	Per standards
Portable radiation monitor	50	Beta/gamma	0.5 μSv/hr-1 mSv/h
Portable T in air monitor	50	HTO, T_2	0.1 to 10000 DAC
Portable neutron monitor	5	Neutron	0.5 μSv/hr-1 mSv/h
Radioactive particulate monitor	25	Beta/gamma	10 kBq/m^3-100MBq/m^3
High-range gamma monitor	10	Gamma	Up to 1 Sv/hr
T in air HVAC trigger monitor	12	Total T	10 to 10000 DAC
Surface smear counter	50	Beta/gamma	> 1Bq/cm^2
Personal electronic visitors dosimeters	300	Gamma	1 μSv-10 mSv
Personal dosimeter	1500	Beta/gamma	1 μSv-10 mSv
Personal dosimeter	50	Neutron	1 μSv-10 mSv
Air activation products monitor	5	Beta/gamma	10 kBq/m^3-100MBq/m^3
Aqueous T sampler	25	HTO	>1kBq/L
Aqueous activation products sampler	10	Beta/gamma	TBD
Portable aqueous sampler	10	Beta/gamma	TBD
Portable aqueous sampler	10	HTO	>10 kBq/L

Airborne Be monitor	25	Be particulate	TBD

There are a number of items mentioned in this where it is not clear if this was intended to be included in the PP. For example sampling systems and alarm handling. There is also no provision for periodic calibration that will be required for those instruments defined under the BSS as radiological protection. For radiation monitors, sources could be used (outside of this PP) but for tritium monitor, either a special injection rig would be needed or facilities plus spares to allow removal for calibration. The supply shall also cover the following:

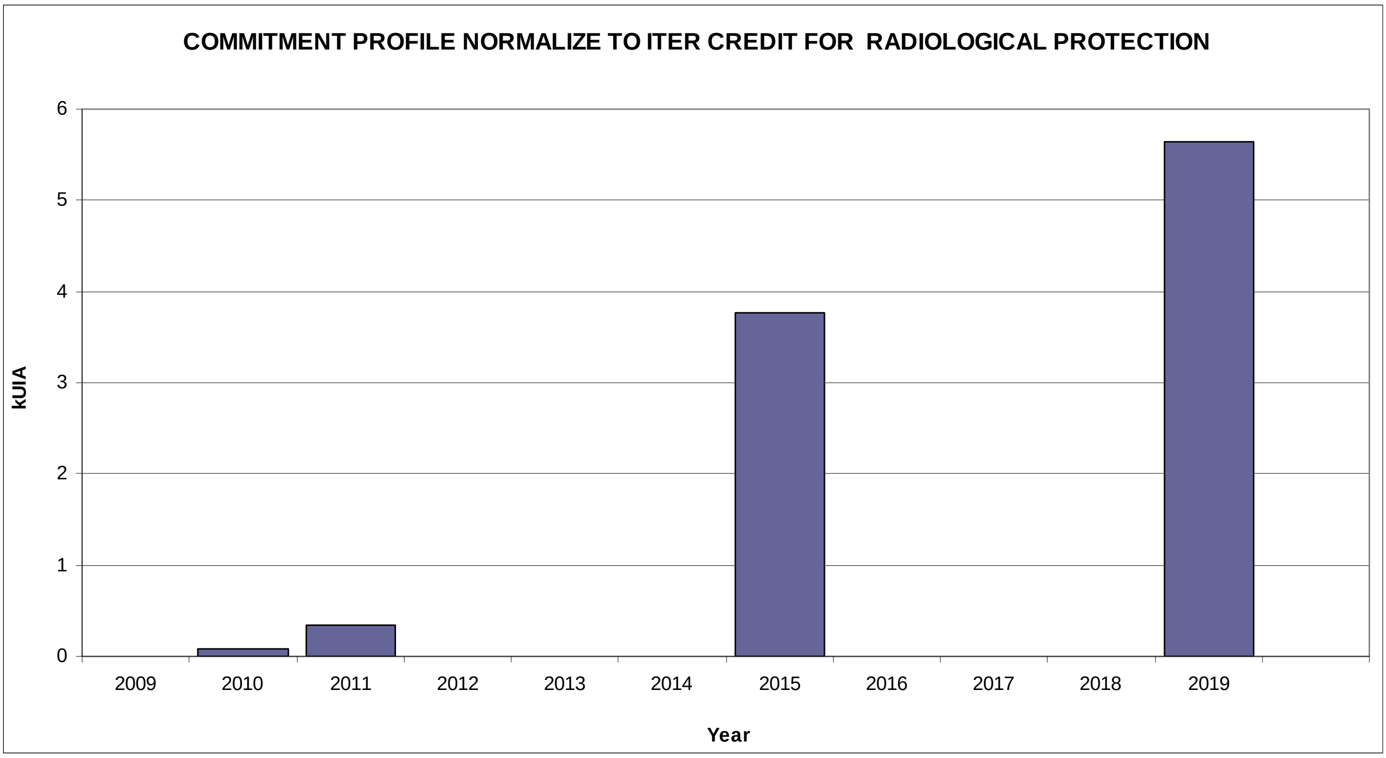
- Shipment;
- Installation;
- Provision of software for the instruments and for the integrated systems;
- Testing of all equipment;
- Preparation of test and maintenance manuals;
- As-built drawing, documentation including QA;
- At least two years of warranty.

A re-evaluation of the above scope for compliance with the current ITER building configuration (particularly changes to the Hot Cell and tritium plant) has not been carried out but, apart form the HVAC changes mentioned below, significant increases in scope are unlikely.

The instruments are to be designed and manufactured under a detailed QA programme. The current requirements are ISO 9001 for design and ISO 9002 for manufacture.

This is not foreseen to be a significant issue for proprietary equipment procurement as part of the package. However ITER QA and Tritium Manual requirements may constrain aspects of the sampling systems.

NORMALIZED COMMITMENT PROFILE – RADIOLOGICAL PROTECTION



RADWASTE TYPE A AND CONVENTIONAL WASTE	WBS 66.1-2 7.6 kIUA

SHORT DESCRIPTION

Components for Receiving, sorting, processing, conditioning and dispatch of Type A radwaste and conventional waste. The two systems consist of:

A sorting table, drum filling, compaction, characterisation and dispatch of **SOLID** low level waste; Processing **OILY** radwaste and Transport, de-watering, resin treatment, cementation, characterisation and dispatch of **LIQUID** low level radwaste.

The conventional waste system deals with chemical and (non-activated) beryllium waste. So far no work has been carried out on this system by IO.

This low level radwaste results from plant operation and maintenance activities. The very low level (TFA) radwaste system may use the same equipment as the solid low level waste or be located in a separate building but is not included in the European PA-66, and not included in this PP.

Europe will make an in-kind contribution of 100% of the components for the Type A radwaste (agreement 6.3) and conventional waste. The systems to be provided by EU are listed below in more detail:

WBS	EU obligation	Design Type	Other DA involved/remarks
66-1	Detailed design of solid and liquid radwaste system and components to IO specification, procurement, and/or manufacture of specified equipment, installation and commissioning.	Functional Specifications	This equipment is to comply with IO safety requirements and may need additional inspection and testing to meet nuclear standards.
66-2	Detailed design of conventional chemical waste treatment system to IO specification, procurement, and/or manufacture of specified equipment, installation and commissioning. Note: the conventional waste system may be required before the radwaste system (and for installation and initial operation). Beryllium dust will be sampled from mid-2018 onwards, so the conventional waste system needs to be available prior to this. This implies that IO specification needs to be completed in 2012. Currently no design work has been carried out and the location of the conventional waste system has not been established.	Functional Specifications	This equipment is to comply with IO safety requirements.

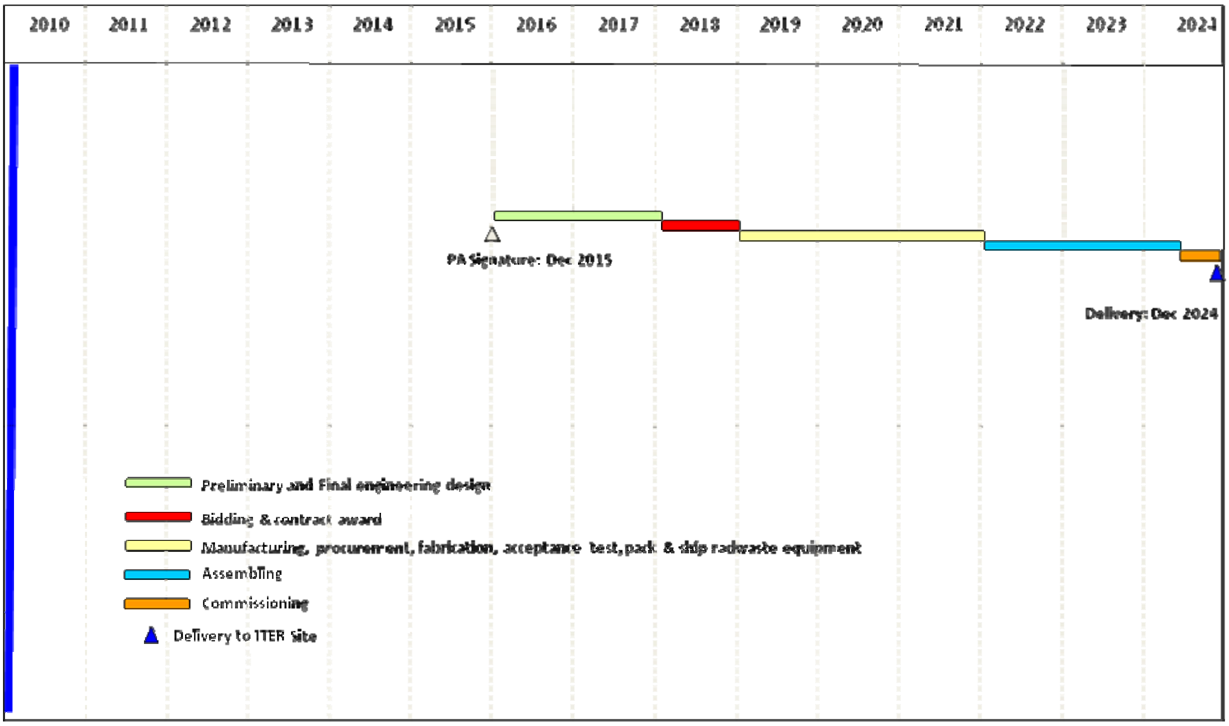
PROCUREMENT ARRANGEMENTS PLANNING & STATUS

PA Title	Subject	PA signature	Credit (kIUA)
PA66	Acceptance of Type A waste design proposal	Dec 2015	-

	(including costs) carried out by IO		
PA66	Detailed design of type A waste structures, systems and components (SSCs), tendering, fabrication, installation and commissioning.	2015 - 2024	6
PA66	Conventional Waste	TBD	1.6

MAIN MILESTONES

WBS	Milestone	DA responsible	Expected date
WBS 6.3 A1	PA signature for Type A radwaste	F4E/IO	Dec 2015
WBS 6.3.A1	Design review of solid and liquid radwaste system and components	F4E	Nov 2017
WBS 6.3.A1	Final Delivery of specified equipment,.	F4E	Jun 2021
WBS 6.3.A1	System Reception after commissioning and tests	F4E	Oct 2024
WBS 6.3 A2	Conventional Waste	IO	TBD



The graph above does not include the conventional waste.

DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

The number and type of ITER Type A waste systems and components are currently being assessed by ITER IO. This work is continuing and is anticipated to be complete in October 2009.

Work on conventional waste has not yet started.

MANUFACTURING READINESS

Most equipment is available commercially, and must be engineered into suitable systems. However, at the moment the process information required to specify the design is not available, and work is continuing to develop the design detail required.

One part of the design may not be commercially available. This is the tritium characterisation system, and the current situation is described below.

In order to dispose of the waste to a suitable waste stream this must be characterised in terms of its radioisotopes (as well as chemical composition). It is already apparent that the relatively high tritium contamination levels will in many cases exceed the disposal limit currently used for fission waste. A measurement system for purely tritiated waste is available: a characterisation system for a mixture of tritium and other isotopes is not currently commercially available. Such a characterisation system is being developed under an R&D task supported by JET. As far as F4E is aware, ITER IO is not participating in this task.

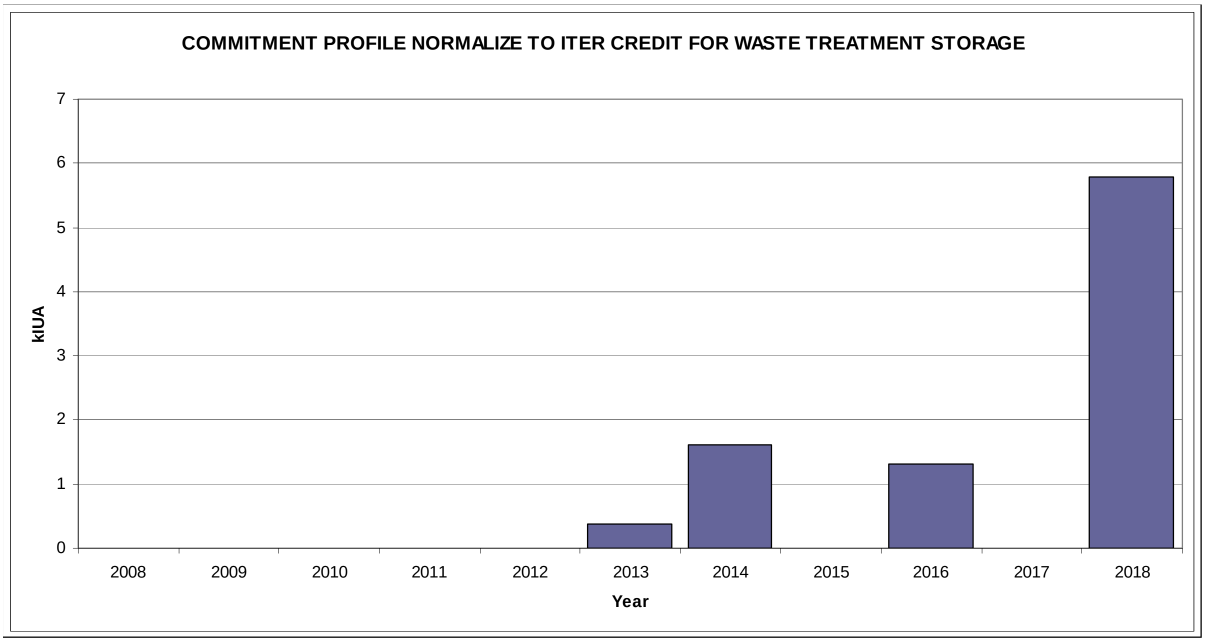
R&D AND QUALIFICATION ACTIVITIES

There are currently no R&D activities to support the procurement activities.

PROCUREMENT STRATEGY

The procurement strategy is to minimise project risk by ensuring that the process design is complete and validated by the ITER Safety team and the Design Integration team before procurement takes place.

NORMALIZED COMMITMENT PROFILE – WASTE TREATMENT STORAGE



MATERIALS DEVELOPMENT

SHORT DESCRIPTION

The mission of Materials Development (MD) within the F4E Plant Systems Division is related to development, characterization and qualification of (structural) materials for breeding blankets (BB) for the next generations, (i) TBM (Test Blanket Modules) in ITER and (ii) DEMO BB. The candidate material for the two EU reference breeding concepts is the RAFM (reduced activation ferritic-martensitic) steel EUROFER. In particular for TBM in ITER a grade called EUROFER-97 is foreseen. Consequently the objectives include:

- To provide the data needed for the final design of ITER-TBM and the subsequent successful licensing process, i.e. physical and mechanical data on EUROFER (base materials as well as various joining processes) in un-irradiated and low-dose irradiated conditions, or more generally, under any fusion relevant conditions (Qualification of EUROFER-97).
- To further develop (with respect to improved activation and optimized mechanical properties), characterise and qualify EUROFER-type steels for design, construction and installation of BBs in a demonstration reactor (DEMO). (See note below).

The EU is currently developing two reference concepts for DEMO, both using EUROFER-97 as structural material. The key date for materials characterization is "Final design ready by Dec. 2016".

Other goals of the MD programme at F4E include R&D programmes on two materials used for alternative blanket concepts, e.g. dual coolant options, that might also be tested in ITER at a later stage or in collaboration with other parties, i.e.

- EUROFER ODS (oxide dispersion strengthened) steels for use at higher temperature,
- SiC-Dual, a SiC/SiC composite for thermal and electrical insulation.

The objective for both programmes is the exploration of the material, improvement of properties and fabrication processes and the successful manufacturing and qualification.

The products of the F4E MD programme are therefore not the supply of components but the supply of:

- A data base collecting all physical and mechanical properties needed for design, construction and licensing of TER-TBM,
- A consistent framework of design rules (high temperature application and joints) needed for the design and licensing of TBM,
- Specifications describing the production of EUROFER-97, EUROFER ODS and SiC-Dual.

Notes:

<u>TBM versus DEMO activities:</u>

In this part only activities with respect to TBM are described. The R&D on EUROFER steels for use in DEMO are detailed in the part concerning activities for DEMO

<u>Relation to EFDA Workprogramme:</u>

The development of ferritic ODS steels and W-alloys, which are candidate materials for gas-cooled divertor options in DEMO, is managed within the EFDA programme for Emerging Technologies.

The F4E MD shall benefit from the REMEV (Radiation Effect Modelling and Experimental Validation) Programme run under EFDA, which aims to increase knowledge on the stability and evolution of microstructure under irradiation (e.g. driving mechanisms, time scales). The benefit shall be through (i) guidelines on improved alloy composition, (ii) established relationship between processing and microstructure, which shall, in particular, result *in an accelerated development.*

Therefore, the REMEV programme is an essential element for DEMO R&D, and it shall also provide data (like on He-effects) that shall be of importance for materials validation programme for TBM..

The F4E Materials Development programme is funded and managed fully by the EU and its results are of benefit for the TBM project and for DEMO. The MD programme has not any direct obligations or connections with ITER other than through the supply of data to the TBM project.

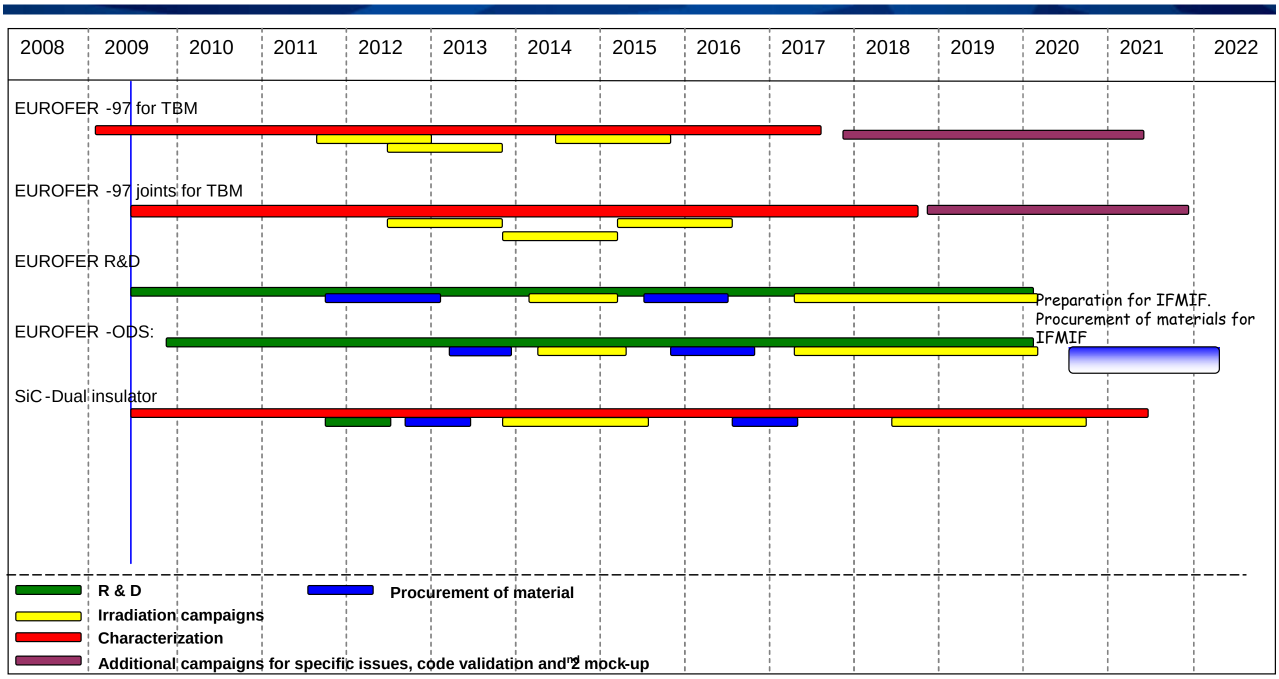
WBS	EU activity	Design type	Other DA involved/remarks
EUROFER-97 qualification & validation for TBM needs			
N/A	Characterization of EUROFER-97 and EUROFER-97 welds	N/A	
N/A	Irradiation campaigns on EUROFER-97 and EUROFER-97 welds	N/A	
N/A	Development of design methodologies for high temperature and for joints	N/A	
EUROFER ODS development and qualification programme for DCLL TBM Options			
N/A	R&D for improved performance and improved fabrication technology	N/A	
N/A	Procurement of small trial heats for studies	N/A	
N/A	Procurement of larger batch of 3rd generation of EUROFER ODS	N/A	
N/A	Procurement of larger batch of 4th generation of EUROFER ODS	N/A	
N/A	Qualification programme & irradiation campaigns & studies	N/A	
SiC-Dual ceramic composites for DCLL TBM Options			
N/A	Qualification of 1st generation material	N/A	
N/A	R&D phase for improvements	N/A	
N/A	Procurement of further plate material (2nd generation)	N/A	
N/A	Procurement of semi-finished products	N/A	
N/A	Qualification programme & irradiation campaigns	N/A	

PROCUREMENT ARRANGEMENTS PLANNING & STATUS

The MD programme has no direct obligations with ITER IO, thus no procurement arrangements are foreseen between ITER IO and F4E on materials development.

MAIN MILESTONES

WBS	Milestone	DA responsible	Expected date
EUROFER-97 qualification & validation for TBM needs			
N/A	Out-of-pile qualification for TBM preliminary design analyses	EU	Dec. 2012
N/A	Joining processes validated at laboratory level	EU	Dec. 2013
N/A	Data base ready acc. to codes and standards to start licensing process	EU	Dec. 2015
N/A	TBM design rules for joints and high temperature	EU	Dec. 2015
N/A	Data base final information on irradiated joints (~1dpa)	EU	Dec. 2017
N/A	Programme in response to issues raised during final licensing process	EU	TBD
EUROFER ODS development and qualification programme for DCLL TBM Options			
N/A	Qualification programme of 3rd generation completed	EU	Dec. 2016
N/A	Qualification programme of 4th generation completed.	EU	Dec. 2020
SiC-Dual composite material for DCLL TBM Options			
N/A	Qualification programme of 2nd generation (plates) completed	EU	Dec. 2015
N/A	Qualification programme of 3rd generation (semi-finished products)	EU	Dec. 2020



Note: For completeness also the DEMO activities are shown as "EUROFER R&D".

DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

N/A

MANUFACTURING READINESS

N/A

READINESS OF TECHNOLOGY AND INFORMATION

Data base and engineering data for EUROFER-97 are available to a large extend covering data on various physical and mechanical properties under various conditions (including irradiation campaigns) and in a temperature window covering the foreseen operational conditions of ITER-TBM.

Data have been assessed and evaluated according to codes and standards set by ITER (SDC) and, in addition, by RCC-MR.

The data base needs to be completed and complemented, in particular with respect to (i) high temperature application (no rules and standards are included in ITER-SDC) and (ii) advanced joining methods applied in fabrication of TBM. As various diffusion bonding processes (HIP) and combined hybrid processes have never before been used in nuclear environment, they are not addressed in codes & standards and design rules need to be newly developed.

<u>Readiness:</u>

EUROFER-97 data base and related engineering information ("design allowable data") and related design methodologies and appropriate rules shall be finalized before December 2016.

R&D and QUALIFICATION ACTIVITIES

Materials Development for Breeding Blankets (TBM part)

EUROFER-97 - Qualification for use in TBM:

Reduced activation ferritic-martensitic (RAFM) Cr steels are developed and qualified with the final goal to be used in DEMO breeding blankets. In a first step, the 9Cr 1.2W, 0.2V 0.14Ta steel EUROFER-97 is the reference specification for ITER TBM. The material needs further characterisation and validation, in particular in low dose irradiation of ~1 dpa. The major activities are the qualification of various joining procedures needed for the TBM box fabrication.

Materials for TBM-DCLL option:

- **EUROFER ODS steels**
  EUROFER ODS steels are being developed as plate material and foreseen to be used in DCLL blankets at the FW. The material aims for higher temperatures and radiation resistance than conventional RAFM steels. The composition is the same as EUROFER-97 with 0.3% [nano-sized] Yttrium-oxide added. The material needs further optimization of the fabrication technology (preferably in collaboration with industry) and subsequently irradiation campaigns at several temperatures as part of a larger characterization programme. A key for the development is to find correlations between the formation of various nano-sized particles (different in chemical composition, size and function) and, both, the properties achieved in terms of improved ductility and improved tolerance against Helium embrittlement, and the production parameters.

- **SiC/SiC ceramic composite.**
  These materials are being developed as thermal and electrical insulators in dual coolant lithium-lead breeder concepts (called SiC-Dual). A first batch of plates was procured with EU industry to demonstrate the feasibility. Next steps are a screening in short term low-dose irradiation campaign and characterisation of physical and mechanical properties and subsequent R&D towards fabrication of plates and semi-finished products.

PROCUREMENT STRATEGY

EUROFER-97:

The material for TBM fabrication is procured within the TBM project.

EUROFER ODS steels:

The only company in the EU that has successfully produced EUROFER ODS steel at industrial level has withdrawn from the ODS steel production in favour of other activities in fusion. Within the next few years it needs not only to improve production parameters (to be tested as R&D in Association) but also to develop a new fabrication strategy to find companies that are able to perform individual production steps and/or to encourage a company to invest in the future. (Fission industry developing ODS material too, is facing the same problem, however, with potentially a larger market).

SiC-Dual composite material:

There are several EU companies in the space and/or aircraft industry that have sufficient knowledge and experience to produce SiC-SiC ceramic composite material and have the potential to achieve the required properties.

Experience from the previous production shows that too demanding requirements imposed cannot be achieved simultaneously. Hence in a first step improved material should be produced with an optimization metric (R&D in collaboration with industry), before in a next steps larger and/or more complex geometries (stove pipe type) shall be produced.

TEST BLANKET MODULE (TBM)	**WBS 5.6**

SHORT DESCRIPTION

The testing of Tritium Breeder Blanket concepts is one of the ITER missions and has been recognized as an essential milestone in the development of a future reactor ensuring tritium self-sufficiency, extraction of high grade heat and electricity production.

Europe is currently developing two reference breeder blankets concepts for DEMO reactor specifications that will be tested in ITER under the form of Test Blanket Modules (TBMs):

- the Helium-Cooled Lithium-Lead (**HCLL**) concept which uses the eutectic Pb-15.7Li as both breeder and neutron multiplier;
- the Helium-Cooled Pebble-Bed (**HCPB**) concept which features lithiated ceramic pebbles (Li_4SiO_4 or Li_2TiO_3) as breeder and beryllium pebbles as neutron multiplier.

It is foreseen to test about four TBMs of each concept over 10 years of ITER operation (from H-H phase up to DT phase 2). Each TBM will be specifically designed and instrumented to optimize the scope of achievable tests with respect to the different ITER phases. The four TBMs to be tested for each concept are:

- EM-TBM: “Electromagnetic”-TBM (will be installed in ITER during the phase 2 Machine Assembly and tested during the H-H phase);
- TN-TBM: “Neutronic and Thermal”-TBM (tested during the plasma D-D phase);
- NT/TM-TBM: “Neutronic-Tritium/Thermo-mechanical”-TBM (D-T phase 1);
- IN-TBM: “Integral”-TBM (D-T phase 2).

The procurement needed for the testing of TBMs Systems in ITER consists of the following main supply items:

- *Hardware for TBMs testing in ITER*: The HCLL and HCPB TBMs, their ancillary systems (TBM-WBS-1.1, 1.3, 1.5) and their support equipment (TBM-WBS-1.6) in ITER.
- *Evaluation/qualification of TBMs prototypical performances prior to ITER*: HCLL TBM prototypical performance evaluation/demonstration (TBM-WBS-1.2), HCPB TBM prototypical evaluation/demonstration (TBM-WBS-1.4)
- *Development/qualification of DEMO-relevant technologies & materials to be used in TBMs*: Materials development & validation (TBM-WBS-1.7), Technologies development & validation (TBM-WBS-1.8), Support test facilities (TBM-WBS-1.13)
- *Predictive tools to be validated through TBMs testing in ITER:* Predictive tools development & validation (TBM-WBS-1.9)
- *TBMs test sequence in ITER and PIE plan*: Tests in ITER and PIE (TBM-WBS-1.10)
- *Project technical data*: Engineering data, Support data, Technical manuals, Prototypes test data, etc. (TBM-WBS-1.12)

The precise description of each work package (scope, deliverables, milestones) is given in the WBS dictionary

The European TBMs project is funded 100% by the EU. The components of the Test Blanket System (TBS) managed and financed by the EU are not in-kind components as all other components in ITER to be installed by the EU. The TBS components are not necessary for the operation of ITER however use the ITER machine as a large test facility to test breeder components (the TBMs) for the first time in a fusion environment.

Although the principle of collaboration with other Parties is open, the EU intends to keep an independent capacity to develop, fabricate and test the European TBM Systems. Collaborations with other Parties are presently mainly limited to non-strategic areas (e.g. characterization and modeling of physical phenomena) within the framework of the IEA Nuclear Technology for Fusion Reactor (NTFR) Agreement. Key technological developments in view of design and fabrication of DEMO Breeder Blankets are kept protected by EU IPR (e.g. fabrication technologies, materials data base, tritium technologies, etc.).

Notes:

The EU contribution includes the procurement of 2 TBM dummy modules (to replace TBMs in case of unavailability or during potential operational phase without TBMs) and of 2 TBM Port Plug Frames. These components shall be procured under a Procurement Arrangement with ITER IO (date still to be defined).

The design development (up to built-to-print) of the two TBM dummy modules and of the TBM Port Plug Frame are not included in the EU contribution.

The EU contribution includes the design, development and procurement of specific equipments for TBM maintenance, including those needed in the Hot Cell facility or the Tokamak Facility (cutting tools, RH tools in Port Cell, etc.). However, equipments used in common with ITER, like Air Transfer System, Handling tools in Hot Cell, etc. are not part of the EU TBM contribution.

The TBM System components/items to be provided by EU are listed here below.

Note: Below are mentioned all workpackages of the EU TBM project (construction + commissioning phase).

Note: In the table below, work packages are also referenced according to the TBM work breakdown structure ("TBM-WBS") of the F4E/TBM Group.

WBS	**EU contribution**	**Type**	**Remarks**
HCLL Test Blanket System (HCLL TBS)			
5.6 (TBM-WBS 1.1.1)	HCLL Test Blanket Modules (HCLL TBM)	Hardware	
5.6 (TBM-WBS 1.1.2)	HCLL Ancillary Systems	Hardware	
5.6 (TBM-WBS 1.1.3)	HCLL TBS Data Acquisition and Control System	Software & hardware	
5.6 (TBM-WBS 1.1.4)	HCLL TBS integration engineering, assembly, checkout	Integration service	
HCPB Test Blanket System (HCPB TBS)			
5.6 (TBM-WBS 1.3.1)	HCPB Test Blanket Modules (HCLL TBM)	Hardware	
5.6 (TBM-WBS 1.3.2)	HCPB Anillary Systems	Hardware	
5.6 (TBM-WBS 1.3.3)	HCPB TBS Data Acquisition and Control System	Software & hardware	
5.6 (TBM-WBS 1.3.4)	HCPB TBS integration engineering, assembly, checkout	Integration service	
HCLL TBM prototypical performance evaluation			

5.6 (TBM-WBS 1.2)	HCLL TBM prototypical performance evaluation	Qualification	
HCPB TBM prototypical performance evaluation			
5.6 (TBM-WBS 1.4)	HCPB TBM prototypical performance evaluation	Qualification	
Port Cell #16 integration engineering			
5.6 (TBM-WBS 1.5)	Port Cell #16 integration engineering	Integration service	
Support equipment			
5.6 (TBM-WBS 1.6.1)	Port Cell dis-/assembly RH system	Hardware	
5.6 (TBM-WBS 1.6.2)	Irradiated TBM transport equipment	Hardware	
5.6 (TBM-WBS 1.6.3)	Hot Cell Facility equipment	Hardware	
5.6 (TBM-WBS 1.6.4)	Dummy TBM modules	Hardware	
5.6 (TBM-WBS 1.6.5)	TBM Port Plug Frames	Hardware	
Materials development/characterization			
5.6 (TBM-WBS 1.7.1)	EUROFER characterization / qualification	Material specifications and qualification	
5.6 (TBM-WBS 1.7.2)	Ceramic breeder pebbles development / characterization	Material specifications and qualification	
5.6 (TBM-WBS 1.7.3)	Be pebbles development / characterization	Material specifications and qualification	
5.6 (TBM-WBS 1.7.4)	PbLi development / characterization	Material specifications and qualification	
TBM technologies development/qualification			
5.6 (TBM-WBS 1.8.1)	EUROFER box fabrication development / qualification	Qualified welding procedure specifications	
5.6 (TBM-WBS 1.8.2)	Be coating development / qualification	Qualified assembly procedure specifications	
5.6 (TBM-WBS 1.8.3)	Anti-corrosion/permeation coating development / qualification	Qualified assembly procedure specifications	
5.6 (TBM-WBS 1.8.4)	Sensors & instrumentation development / qualification	Sensors specifications and qualification	
Predictive tools development & validation			
5.6 (TBM-WBS 1.9.1)	EM predictive tool	Software and	

		diagnostic/tests needs in ITER	
5.6 (TBM-WBS 1.9.2)	Thermal-hydraulics predictive tool	Software and diagnostic/tests needs in ITER	
5.6 (TBM-WBS 1.9.3)	MHD predictive tool	Software and diagnostic/tests needs in ITER	
5.6 (TBM-WBS 1.9.4)	Pebble bed mechanics predictive tool	Software and diagnostic/tests needs in ITER	
5.6 (TBM-WBS 1.9.5)	Neutronic predictive tool	Software and diagnostic/tests needs in ITER	
5.6 (TBM-WBS 1.9.6)	Tritium transfer and cycle predictive tool	Software and diagnostic/tests needs in ITER	
5.6 (TBM-WBS 1.9.7)	Other predictive tools (coupled phenomena / systems)	Software and diagnostic/tests needs in ITER	
TBMs testing in ITER & PIE			
5.6 (TBM-WBS 1.10)	TBMs testing in ITER & PIE	Testing and PIE	Excluding IO manpower for operation of TBMs
System engineering management			
5.6 (TBM-WBS 1.11)	System engineering management	Engineering service	
Project data management			
5.6 (TBM-WBS 1.12)	Project data management	Data collection	
Support test facilities			
5.6 (TBM-WBS 1.13)	Support test facility	(Upgraded) test facilities & test sections	

PROCUREMENT ARRANGEMENTS PLANNING & STATUS

PA Title	PA signature	Credit (kIUA)
HCLL TBM System	TBD (*)	Non credited
HCPB TBM System	TBD (*)	Not credited

TBM dummy modules	TBD	TBD
TBM Port Plug Frames	TBD	TBD

(*) Procurement Arrangement to be defined according to a new PA model, still to be defined between Parties and ITER IO

MAIN MILESTONES

WBS	Milestone	DA responsible	Expected date
HCLL/HCPB TBM Systems			
5.6 (TBM-WBS 1.1, 1.3, 1.5, 1.6, 1.11)	Conceptual design review achieved	EU	Dec-2012
5.6 (TBM-WBS 1.1, 1.3, 1.5, 1.6, 1.11)	Intermediate engineering design review achieved	EU	Dec-2014
5.6 (TBM-WBS 1.1, 1.3, 1.5, 1.6, 1.11)	Final engineering design review achieved	EU	Dec-2016
5.6 (TBM-WBS 1.1, 1.3)	TBMs (EM-TBMs) delivered to ITER site	EU	Feb-2020
5.6 (TBM-WBS 1.1, 1.3, 1.5, 1.6)	Ancillary systems and support equipment delivered to ITER site for assembly	EU	Jun-2019
5.6 (TBM-WBS 1.1, 1.3)	TBMs (EM-TBMs) + Port Plug Frame assembly tested	IO	Mar-2020
5.6 (TBM-WBS 1.1, 1.3, 1.5, 1.6)	Ancillary systems and support equipment assembly achieved	EU	Oct-2020
5.6 (TBM-WBS 1.1, 1.3, 1.5, 1.6, 1.11)	TBM Systems commissioning achieved	IO	Mar-2021
HCLL/HCPB TBM prototypical performances evaluation			
5.6 (TBM-WBS	TBM prototypical mock-ups (PMU) conceptual design achieved	EU	Dec-2012

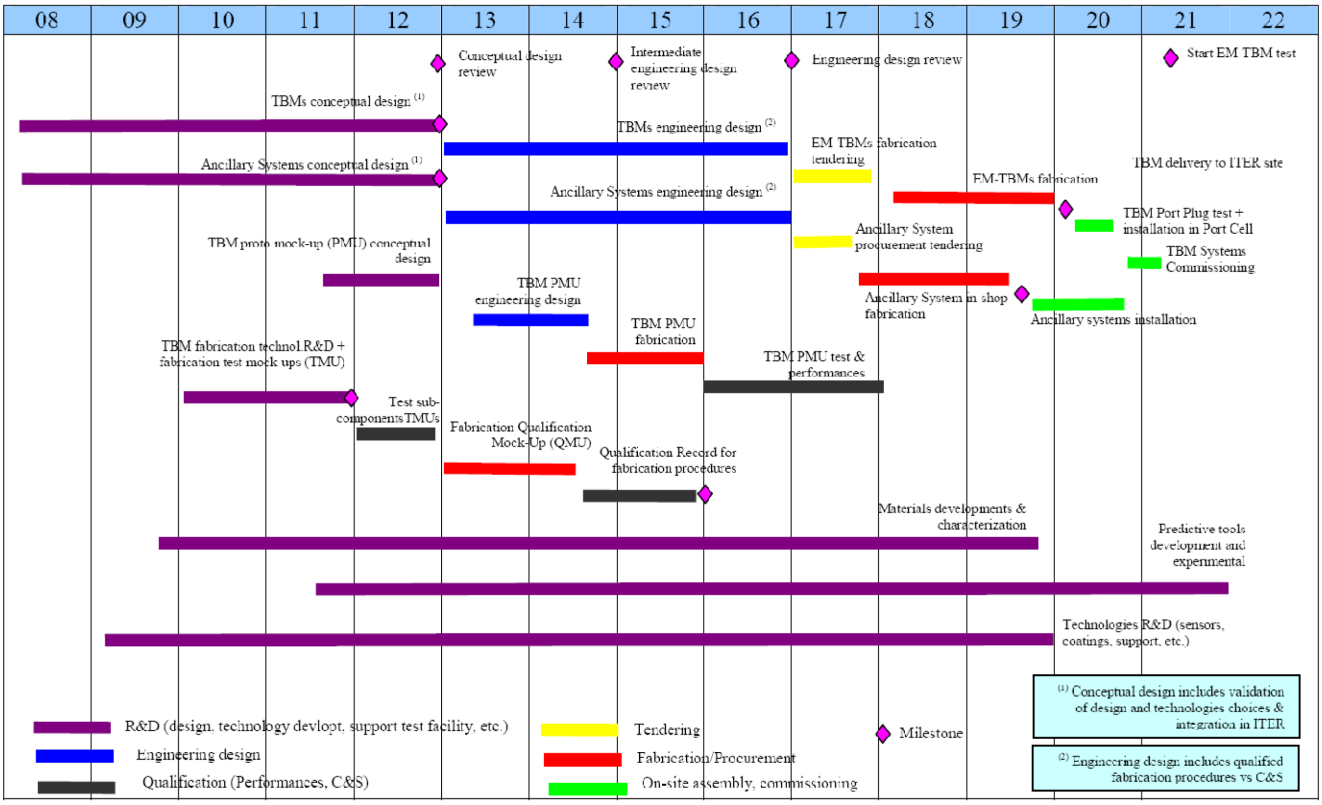
1.2, 14)			
5.6 (TBM-WBS 1.2, 14)	TBM prototypical mock-ups (PMU) engineering design achieved	EU	Jul-2014
5.6 (TBM-WBS 1.2, 14)	TBM prototypical mock-ups (PMU) fabrication achieved	EU	Dec-2015
5.6 (TBM-WBS 1.2, 14)	TBM prototypical mock-ups (PMU) tests achieved	EU	Dec-2017
TBM box fabrication technologies development/qualification			
5.6 (TBM-WBS 1.8.1)	TBM fabrication technologies: Preliminary welding procedure specifications (pWPS) ready	EU	Dec-2011
5.6 (TBM-WBS 1.8.1)	TBM fabrication technologies: TBM sub-components Test Mock-ups (TMU) tested	EU	Dec-2012
5.6 (TBM-WBS 1.8.1)	TBM fabrication technologies: TBM Qualification Mock-UP(s) (QMU) fabricated	EU	Sept-2014
5.6 (TBM-WBS 1.8.1)	TBM fabrication technologies: Qualified welding procedure specifications (qWPS) ready	EU	Dec-2015
TBM technologies, predictive tools, materials development/qualification. Support test facilties			
5.6 (TBM-WBS 1.7, 1.8.2, 1.8.3, 1.8.4, 1.9, 1.13)	Support R&D achieved	EU	Dec-2021

DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

TBMs:

All TBMs to be tested over the first 10 years of ITER operation will share the same design for their box structure (TBMs generic box, WBS-1.1.1.1, 1.3.1.1). Only the designs of the internal breeder zone and the internal diagnostic systems will differ. The conceptual design of the TBMs generic box has been achieved, i.e. the basic technologies have been selected and the expected performances are in accordance with the specifications (DEMO-relevancy, structural integrity criteria in ITER). Moreover the design has already entered in the preliminary engineering phase, i.e. detailed analyses have been carried out with respect to ISDC-IC and RCC-MR and the main operational scenarios have been studied. Also the verification of design operational margins in ITER are under experimental verification, for instance the convective heat transfer coefficient in First Wall channels and the Helium flow balance in the TBM manifold systems.



The integration of diagnostic systems in the TBMs generic box for validation of DEMO design predictive tools is in progress. Considering that space available inside TBMs for diagnostics is limited, F4E has launched in the WP 2008 a systematic and coordinated re-assessment of test objectives and tools validation scheme in all fields in order to define priorities. On this basis, the integration of diagnostic systems will be defined in detail in 2009-10.

The built-to-print design for the first TBMs to be installed in ITER (i.e. HCLL and HCPB EM-TBMs) is expected in 2014.

Ancillary Systems:

The conceptual design of the He Coolant System (HCS) has been achieved and has entered now in the preliminary engineering phase. The space reservation for the integration of HCSs in ITER Tokamak building has been done (~81 m^2 each) and more detailed technical interfaces activities will be carried-out in 2009 (pipe routing, etc.).

The conceptual design of tritium systems (Tritium Extraction Systems, Coolant Purification Systems) is still on-going because several alternative technological solutions are under study. For instance, alternative technologies for tritium extraction from the PbLi will be discriminated in the TRIEX facility (ENEA) which is now ready to operate. Main integration issues like space reservation in ITER Tritium Building have been checked.

The preliminary engineering design of all ancillary systems is expected in 2012. It will be followed by procurement contracts (engineering design, certified-for construction drawings, fabrication, and installation).

TECHNOLOGIES/MANUFACTURING READINESS

TBMs:

- *Box fabrication technologies*: The feasibility of advanced fabrication processes for the TBMs box (diffusion bonding, mixed welding/diffusion bonding, laser/TIG/Hybrid welding) has been demonstrated on small and/or medium scale mock-ups. A near-to-full-size mock-up of the cooling plate – the sub-component requiring the most advanced fabrication technology (mixed welding/HIPing) and for which no alternative technology exists – has even been successfully tested under ITER relevant conditions. It is now mandatory to extend the demonstration to test mock-ups for all types of sub-components and then to qualify the advanced fabrication processes including Post Welding Heat Treatments (PWHT) through the fabrication and characterization of qualification mock-ups designed according to relevancy criteria defined by EN Standards.

- *EUROFER steel*: 3 batches of EUROFER of several tons each have already been produced by Industry in accordance to technical specifications (e.g. impurity control, mechanical properties) for a total of ~21 t. EUROFER material has been extensively characterized in un-irradiated and irradiated conditions (even up to 32 dpa for some limited number of properties) to build a data base. Some properties are still to be completed. Engineering EUROFER handbook has been derived from the data base and is in use for design of TBMs.

Ancillary Systems:

- *Helium Cooling Systems (HCS)*: Two Helium turbo-circulators with suitable materials selection in view of future tritium compatibility are under final procurement stage for integration in HELOKA and Upgraded HeFUS3 test facilities. The technology of these turbo-circulator is relevant to the one needed for the ITER TBM HCSs. The HELOKA Helium test facility presently under construction in FZK will be relevant to the TBMs HCS specifications (except compactness).

- *Tritium Extraction Systems (TES)*: The design of TES is based on standard industrial technologies and specifications. An adaptation of these technologies to the TBMs operational conditions (low tritium concentrations) will be needed.

- *Coolant Purification Systems (CPS)*: The design of the CPS is based on standard industrial technologies and specifications. An adaptation of these technologies to the TBMs operational conditions (very low tritium concentration, moisture content) will be needed.

- *PbLi loop*: The design of the PbLi loop is based on standard industrial technologies and specifications. The construction of the Integrated European Lead Lithium Loop (IELLLO) was completed in 2007 in ENEA with technical specifications close to the ones of the ITER HCLL TBM (except compactness).

R&D and QUALIFICATION ACTIVITIES

For successful development and procurement of the TBM Systems and their testing in ITER, R&D and qualification activities are needed in the following areas:

- Conceptual design development
- Technologies developments
- Predictive tools developments
- Support test facilities
- Support to C&S qualification

More particularly, the following technical areas are concerned:

- TBM Systems design development & performances validation
- Optimization of the TBMs testing sequence and diagnostics integration
- TBMs box fabrication development & support to qualification
- Functional materials developments & qualification (Be/Be alloy, ceramics pebbles, PbLi)

- Sensors & instrumentation development
- Coating technologies developments & qualification (anti-corrosion/permeation)
- TBMs predictive tools developments & experimental validation (MHD, neutronics, thermal-hydraulics, pebble bed thermo-mechanics, tritium cycle, etc.)
- Support test facilities
- TBM Prototypical Mock-ups performances analyses

The top priority of R&D activities to be funded are:

- Development of preliminary fabrication procedure specifications
- Support to qualification of fabrication procedure specifications (C&S)
- Performances analyses of TBMs prototypical mock-ups

PROCUREMENT STRATEGY

On the basis of a preliminary analysis of the market environment and the risks associated to the procurement of the different components, the following procurement work packages have been defined.

TBMs

TBM EUROFER steel box:

The fabrication procedure specifications will be developed first in collaboration between associations having developed the processes and industry (initiation of the industrial transfer). Preliminary fabrication procedure specification will be established on the basis of available nuclear codes and standards.

In a second step, the preliminary fabrication procedure specification will be used for launching a procurement contract for the fabrication of TBM qualification mock-up(s) resulting after systematic examination in qualified fabrication procedure specifications.

In a third step the qualified fabrication procedure specifications will be used for launching the TBM EUROFER steel box procurement.

The procurement contract for the box shall be ensured by an industrial company experienced in fabrication of nuclear vessel/components.

The fabrication of the TBM (EUROFER steel box + functional materials + instrumentation) will have to be ensured by an "integrator" supplier used to perform the realization of nuclear prototypes and coordinate the supply and integration of many sub-elements.

Ancillary Systems and equipments

Ancillary systems and equipments belong, in general, to industrial state-of-the-art of nuclear or specialized industry. A particular case is the helium turbo-circulator for which tritium compatible technologies like magnetic bearings and emergency bearings without lubricant (oils) have to be implemented. Prototypes of turbo-circulators relevant of the TBM systems have already been procured through an EFDA Art 7 contract.

As a consequence, it is foreseen to launch procurement calls for tenders on the basis of the engineering design (built-to-print) developed in previous phases with industry and associations.

PLASMA ENGINEERING

SHORT DESCRIPTION

As major contributor to the ITER project, Europe has a strong interest in following and influencing the preparation to the operation of ITER. Furthermore, it is necessary to examine the impact of design changes on the machine performance and operation. This is a process that occurs at all stages of system and sub-system design, with changes arising as a consequence of optimization, interaction with industry at the procurement phase and non-conformities during construction.

The activities of plasma engineering are to be seen in the framework described above. These activities are in large part, funded by means of competed ITAs which are published by ITER-IO as open calls to all the DAs and assigned on the basis of the DAs replies.

All the Plasma Engineering activities can be categorized as R&D, comprising procurement, mainly of software, that will increase as the commissioning and operation of the machine gets closer.

PROCUREMENT ARRANGEMENTS PLANNING&STATUS

N/A

MAIN MILESTONES

N/A

DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

N/A

MANUFACTURING READINESS

N/A.

R&D and QUALIFICATION ACTIVITIES

N/A

PROCUREMENT STRATEGY

N/A.

SAFETY

SHORT DESCRIPTION

Activities focus on the support of the ITER licensing process, by performing related safety studies and R&D. The F4E Project Plan on Safety (PPS) is taking into account expected requirements form ongoing ITER Design Change Requests (DCRs), it includes R&D activities requested by the French Nuclear Safety Authority (ASN) to substantiate and quantify claims made in the ITER Preliminary Safety Analysis Report (RPsS) and is prepared to provide complementary information requested by ASN.

Typical examples are R&D to provide the justification for the ITER-IO strategy on the in-vessel dust and tritium management, i.e., to develop diagnostic and removal techniques, and to validate computer codes for the analysis of the consequences of explosions involving hydrogen and dust mixtures (graphite-tungsten-Beryllium).

Occupational Radiation exposure analyses will have to be performed to demonstrate that they are ALARA, by taking into account evolving and refined remote handling and maintenance procedures. Nuclear Engineering support will be given to the preparation of all F4E procurement specifications, to ensure that the safety and licensing requirements are adequately integrated.

In anticipation of future official ITER IO requests (via Task Agreements, TAs) the PPS shows the way to implement those necessary safety related activities, which are of strategic importance for the EU:

WBS	EU contribution	Design type	Other DA involved/remarks
Supporting R&D for ITER licensing			
8.1	R&D related to Combined Hydrogen/Dust explosion	N/A	--
8.1	In-vacuum vessel dust measurement and removal techniques	N/A	--
8.1	Transport of corrosion products in water coolant loops	N/A	
8.1	Arc behavior and consequences, including experiments at high currents	N/A	
Implementation of response from Licensing Authorities			
8.1	ALARA demonstration for occupational radiation exposure (ORE)	N/A	--
8.1	Supporting safety analyses for the ITER licensing process	N/A	--
Nuclear engineering support for F4E Procurement Technical Specifications			
8.1	Prepare guideline documents for F4E designers	N/A	--

8.1	Give support in production of F4E procurement technical specifications	N/A	--
Safety of Test Blanket Modules			
8.1	Development and validation of computer codes for safety analysis of Test Blanket Modules	N/A	--
8.1	Safety assessment of EU Test Blanket Modules	N/A	--

PROCUREMENT ARRANGEMENT PLANNING&STATUS

N/A

MAIN MILESTONES

WBS	**Milestone**	**DA responsible**	**Expected date**
Supporting R&D for ITER licensing			
WBS 8.1	TBD	EU	TBC
...	License to operate		
Implementation of response from Licensing Authorities			
WBS 8.1	TBD	EU	TBC
...	License to operate		
Nuclear engineering support for F4E Procurement Technical Specifications			
WBS 8.1	TBD	EU	TBC
...	In line with EU PAs Engineering Design review		
Safety of Test Blanket Modules			
WBS 8.1	TBD	EU	TBC

DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

N/A

MANUFACTURING READINESS

N/A

R&D and QUALIFICATION ACTIVITIES

N/A

PROCUREMENT STRATEGY

This activity should be conducted mainly through grants and to a lesser extent procurements. Some possible areas are listed below:

- Analysis of corrosion phenomenon:
  - Study of the generation and transport of the corrosion product.
  - Computer code development and Experimental validation in the CORELE loop
- Dust/Be/H2 explosion:
  - Experimental assessment of mitigation measures in the MISTRA facility.
  - Simulation Codes development (DM2S-SEMT and SFME)
  - Simulation Codes development, experimental validation, safety assessment. Use of the DUSTEX and FLAME facilities. Development of an integral experiment (HYDEX).
  - Quantification and mobilization of dust, measurement technologies, development of dust removal solutions,
- Radioprotection impact studies:
  - Dose calculation related to radioactive elements release
- Magnet and safety :
  - Computer code development and experimental validation in the VACARC devices.
- Occupational Safety
- Radioactive waste management
- Analysis of Accidental sequencies; plasma wall interaction code development (SAFALY project)
- Neutronic Analysis, simulation

NUCLEAR DATA.

SHORT DESCRIPTION

Nuclear Data includes data and validated computational tools required for quality assured neutronics and activation calculations. The EU is contributing to ITER with Nuclear Data as part of the F4E R&D programme, on a voluntary basis (not credited).

A well-qualified nuclear database and validated computational tools are required for quality assured neutronics and activation calculations including the assessment of the associated uncertainties. In this sense, F4E is driving a unique effort on the development of qualified nuclear data for fusion applications, mainly ITER but also IFMIF and DEMO, which brings together recognized EU experts and resources.

Nuclear data and tools to be provided by EU are outlined here below.

WBS	EU contribution	Design type	Other DA involved/remarks
NUCLEAR DATA - LIBRARIES			
N/A	European Fusion File (EFF) and European Activation File (EAF)	N/A	These both files (by means of the FENDL activities) are part of the nuclear data source for ITER, TBM and broader approach activities and safety studies (IO requirement from French Nuclear Authority)
N/A	Benchmarking of updated and extended nuclear data evaluations (libraries and files)	N/A	--
NUCLEAR DATA - EXPERIMENTS			
N/A	Development of measuring techniques for activation and tritium production	N/A	--
N/A	Integral benchmark experiments for data validation covering materials relevant to ITER and fusion in general, including neutronic and nuclear data analysis of specific impurities under fusion relevant neutron spectra	N/A	--
N/A	Design and implementation of experiments on ITER and fusion relevant mock-ups for evaluation and assessment of neutronic calculations	N/A	--
NUCLEAR DATA - TOOLS			
N/A	Development and validation of advanced numerical methods and computational tools, in the field of nuclear models to improve nuclear data	N/A	--

N/A	Development and validation of advanced numerical methods and computational tools, in the field of the covariances and uncertainties	N/A	--

PROCUREMENT ARRANGEMENTS PLANNING&STATUS

N/A

MAIN MILESTONES

WBS	Milestone	DA responsible	Expected date
TBM-HCLL mock-up experiment			
8.2	Selection of possible activation foils for thermal flux measurements.	EU	2010
8.2	Measurement of the thermal neutron flux in the HCLL mock-up using the activation foil technique and subsequent analysis for the accurate determination of Li average content in Pb-Li.	EU	2010
8.2	Measurement of the relative Li content in selected PbLi bricks from the mock-up assembly by means of neutron flux transmission.	EU	2010
8.2	Further tests of the new developed technique of the direct TPR measurement in LiPb.	EU	2011
8.2	Setting up of a spectrometer, testing and obtaining the response matrix in the energy range below 1-2 MeV (2010). Measurements in the HCLL (and HCPB) mock-ups with DT neutrons with the above spectrometer (2011).	EU	2011
8.2	Study of the capability of models/codes to calculate tritium production in the presence of streaming effect. A LiF diamond detector, calibrated in tritium response, could be inserted in a channel prepared for the spectrometer and the experimental results will be compared with code predictions.	EU	2011
8.2	Measurement of the ^{203}Hg production in LiPb(Pb) material in TBM mock-ups through ^{206}Pb(n,α), ^{207}Pb(n,n') reactions.	EU	2011
8.2	Experimental assessment of the ^{3}H escape from eutectics at elevated temperatures with the use of the technique of tritium production rate measured directly in Li-Pb.	EU	2011
Measurement techniques for TBM nuclear tests			

8.2	Investigation of available SPD designs and selection of suitable ones for testing. Design and construct prototype	EU	2010
8.2	Testing under DT neutron irradiation at blanket temperature	EU	2011
Validation of Co and Cr activation cross-sections and decay data in a FW neutron spectrum			
	To irradiate Co and Cr samples in a first-wall neutron field produced at FNG neutron source. The decay heats and the gamma ray spectra of induced gamma-emitting radioactivity of activated samples will be measured after different cooling time intervals, in order to obtain specific activities of single reaction products.	EU	2011
	Computational analyses will be performed with the MCNP-code and with the FISPACT inventory code and EAF activation data, to check the related cross-sections and identify discrepancies that need to be resolved.	EU	2012
	Validation of Co activation cross sections	EU	2012

DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

N/A

MANUFACTURING READINESS

N/A

R&D AND QUALIFICATION ACTIVITIES

One of the objectives of Nuclear Data activities is to provide the experimental data base required for the validation of the EFF/EAF nuclear data libraries and the development and testing of experimental techniques required for the nuclear test programme for the TBM in ITER. The data obtained in the above mentioned activities is peer reviewed by experts of the Nuclear Data fiel in a first step. In a second step, the data is submitted to a rigorous process to be included in European libraries of transport and activation, the so called JEFF project. The EFF/EAF libraries in the JEFF project feed the FENDL IAEA library (Fusion Evaluated Nuclear Data Library)

PROCUREMENT STRATEGY

N/A.

BROADER APPROACH

BACKGROUND

BA AGREEMENT

By Decision of 30 January 2007[13], the Council of the European Union approved the conclusion, by the Commission, of the Agreement between the European Atomic Energy Community and the Government of Japan for the Joint Implementation of the Broader Approach Activities in the Field of Fusion Energy Research (the BA Agreement). The BA Agreement was signed on 5 February 2007 and entered into force on 21 June 2007.

The Broader Approach Activities comprise the following three projects to be carried out jointly by Europe and Japan and located in Japan:

- Engineering Validation and Engineering Design Activities (EVEDA) to produce a detailed, complete and fully integrated engineering design of the International Fusion Materials Irradiation Facility (IFMIF) and all the data necessary for the future decisions on the construction, operation, exploitation and decommissioning of IFMIF and to validate the continuous, stable and reliable operation of each IFMIF subsystem assuring the required very high availability of the IFMIF facility;
- the International Fusion Energy Research Centre (IFERC) aiming at: contributing to fusion development by: allowing extensive plasma performance simulations with the use of a state of the art supercomputer to be procured by EU and installed in Rokkasho, Aomori prefecture, Japan; developing remote operation of the ITER device and promoting a possible early realisation of DEMO, a future demonstration power reactor by conducting joint R&D and design studies;
- the Satellite Tokamak Programme which includes EU participation in the upgrade of the tokamak experimental equipment owned by Japan to an advanced superconducting tokamak (JT-60SA) and the participation in its exploitation to support the exploitation of ITER and research towards DEMO by addressing key physics issues for ITER and DEMO.

As the Implementing Agency in the context of the BA Agreement with Japan, the Joint Undertaking will discharge Euratom obligations for the implementation of BA Activities. In particular, it will:

(a) coordinate and manage the contributions of the European Voluntary contributing member states to the BA activities;

(b) provide components, equipment, materials and other resources for BA Activities;

(c) prepare and coordinate Euratom's participation in the implementation of BA Activities;

(d) coordinate scientific and technological research and development activities;

(e) provide the Euratom financial contribution to BA Activities;

(f) arrange to make human resources available for BA Activities;

(g) carry out any other activities necessary for meeting Euratom's obligations in furtherance of the BA Agreement with Japan

[13] OJ L 246 of 21.09.2007, p.32.

BA Activities – Organisation, QA, Risk Management

Fusion for Energy is the Implementing Agency for the EU contribution to the 3 BA projects, designated by Euratom to discharge its obligations as defined in the BA Agreement. In particular, F4E is the organisation delegated to agree and conclude Procurement Arrangements (PAs) with the Japanese Implementing Agency (JAEA).

Nevertheless, with few exceptions, most of the activities to be undertaken in the frame of the BA agreement are to be carried out in-kind by the EU-Voluntary Contributors. These are some of the members states represented in the Governing Board of F4E which have pledged to contribute to the BA projects, namely Belgium, France, Italy, Germany, Switzerland and Spain. In turn, each VC will channel its contributions through the procurement arm of "Designated Institutions" (VC-DIs). F4E concludes Agreements of Collaboration (AoC) with the VC-DI, to secure delivery of the EU contributions to meet the requirements of each Procurement Arrangement.

Each of the BA Projects, while having some important differences, share the common feature of being based on a collaboration in which the Parties contribute both to the definition of the overall integrated design and to the detailed design and realisation.

JAEA and Fusion for Energy (F4E), nominated as Implementing Agencies (IA) by the Japanese Government and the European Commission, are the entities entitled to agree and sign any official document regarding the implementation of the BA agreement and in particular Procurement Arrangements.

The implementation of the projects is supervised by the Parties through the Broader Approach Steering Committee and its advisory bodies: the Project Committees for each project. In the case of the Satellite Tokamak Program and IFMIF/EVEDA, the organization put in place for their implementation includes at technical/operative level an "Integrated Project Team" which executes the project. It is formed by the union of a) the Project Team (with a small number of staff), b) the EU-Home Team, and c) the JA-Home Team. The organisation is depicted in figure 1.

The implementation of a similar structure for the IFERC project is in progress.

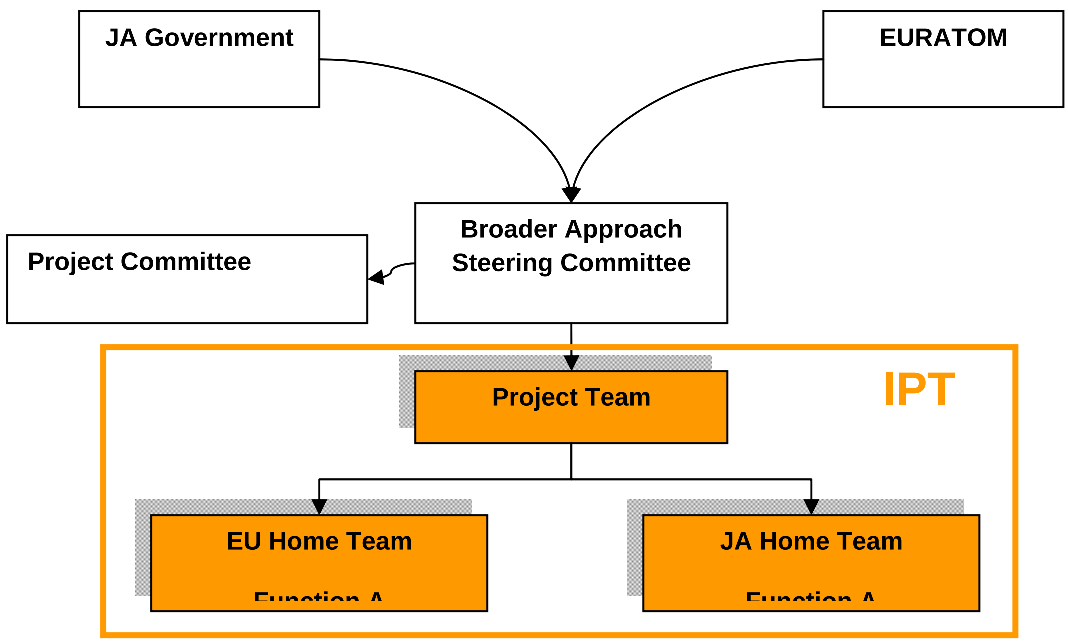


Figure 1 – Organization put in place at for the implementation of the STP

For each project, with particular emphasis on JT-60SA and IFMIF/EVEDA, a number of documents are prepared by the Integrated Project Team as well as by each Home Team to outline the detailed organisation of the project including roles and responsibilities, the implementation of QA measures, risk management, as well as project management. These are:

– At International Level: The "Integrated Project Team Common Quality Management System" (CQMS). This document, together with its implementing procedures, regulates the way the Integrated Project Team (IPT) collaborates, for example, in integration activities, in the preparation and agreement of Procurement Arrangements, in Configuration Management and Risk Management. This document is endorsed by the BA Steering Committee.
– At European Level: The "EU-Home Team Quality Management System". This document, again one for each project to capture any difference between them, defines the internal European organisation of each project (that includes F4E and the Voluntary Contributors) the implementation of Procurement Arrangements including provisions for Project management, Quality Assurance and Risk Management. The EU-HT QMS is connected to the F4E QA system specifically through the requirements set out in the F4E-QA Management Specifications. Some specific risks to F4E were outlined to the Governing Board in the Governing Board input document F4E(09)-GB-09-13.

For the IFERC project this activity is still in an early stage of implementation.

PROJECT IMPLEMENTATION PLANS

For each BA project, individual Project Plans covering the whole duration of the project and that include both European as well as Japanese activities are prepared by the Project Leaders and submitted annually to the BA Steering Committee. Below a summary is provided for each project. The F4E Project Plan to manage the European contribution to BA activities is constrained by these individual project plans.

SATELLITE TOKAMAK PROGRAMME

Background

After the executive summary of the CDR was approved at the first Steering Committee (Tokyo, 15th June 2007), during subsequent high level meetings it was recognised that in particular the TF magnet baseline design of JT-60SA presented some issues with respect to its foreseen cost. At a meeting of the Parties representatives (Tokyo, 12th October 2007) it was decided that a re-baseline of the machine was necessary to fit within the originally budgeted figures. The representatives of the Parties requested a swift process aiming to obtain a re-baseline within 6-12 months. In this effort, it was deemed necessary to try to recover the needed savings by limiting as much as possible the impact on systems other than the TF Magnet. By necessity however, in the light of the way tokamak devices are optimised, it has not been possible to limit the design change to the TF magnet only but some changes have been necessary for the plasma, vessel and in-vessel components, thermal shield, and cryoplant. This is also fortuitous, as the original design of these components also was a cause for concern regarding their foreseen cost. As the work progressed, it was recognized that there would be a significant benefit to somewhat expanding the scope of the work needed to re-baseline the design to meet the cost objectives. This view would require a significant amount of work, and time to find appropriate engineers to constitute the JAEA and EU Home Teams in both Parties and to increase interaction of the Implementing Agencies (IAs) with industry. At a meeting of Parties representatives (Garching, 13th February 2008) it was decided to expand the scope, and the representatives of the Parties requested the submission of the Integrated Design Report (IDR) by the end of 2008. The 3rd Steering Committee invited the Project Leader to submit it by the next Steering Committee in December 2008.

In October 2008 the STP-PC adopted the content of the IDR while supporting the technical options chosen by the Integrated Project Team for re-baselining of the JT-60SA project and recognizing that the original mission of the device is not affected by the re-baselining. The revision of the value estimates and allocation was consistently

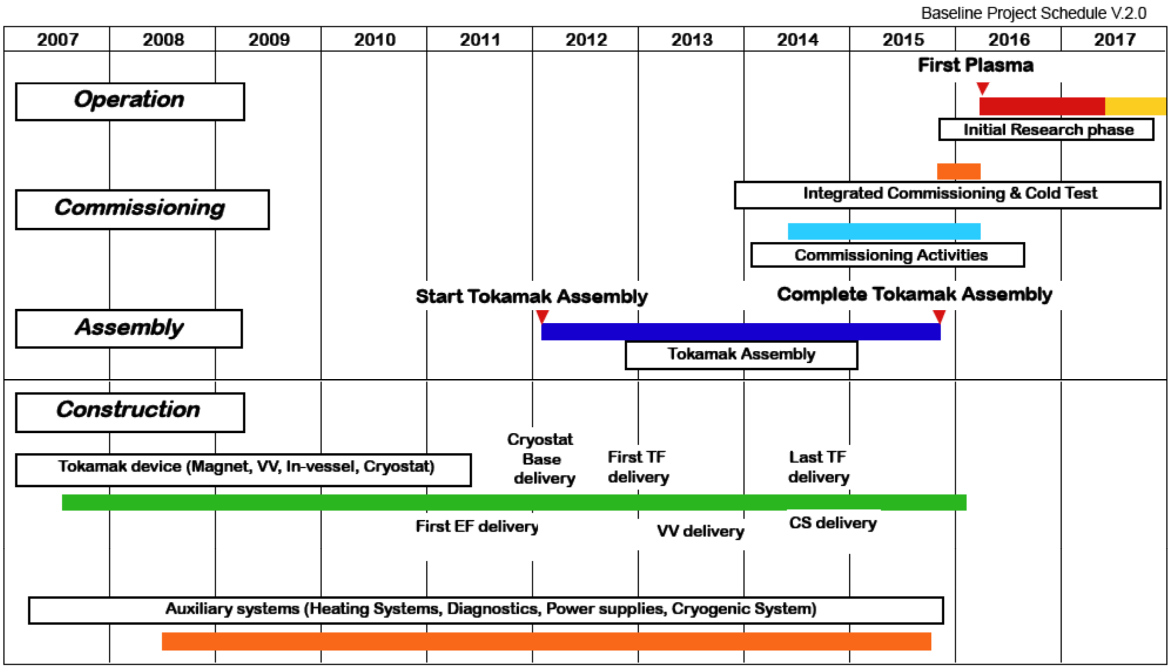


Fig.2: STP Baseline Project Schedule (approved at the SC-4 December 2008)

developed taking into account the agreed exploitation plan for a long term beyond the duration of the BA agreement as well as the re-designing and re-scheduling for the JT-60SA project.
In December 2008, the Steering Committee approved the Integrated Design Report comprising:

i) the Re-baselining report ;

ii) the Plant Integration Document ;

iii) the Reference Schedule;

iv) the Common Management and Quality Programme ;

v) the update of the document "Value Estimates and Allocations of Contributions of the Parties to the Satellite Tokamak JT-60SA".

The present reference Project Plan is therefore based on the IDR although some revision may be expected during 2010 due to uncertainties in when the industrial contracts on the TF magnet will be placed.

Overall Construction Schedule

The starting point of the Baseline Project Schedule (BPS) for the Satellite Tokamak Programme (STP) has been the overall time schedule, with major milestones such as "Start of Tokamak Assembly" and "First Plasma''. Moreover, in light of cost issues, it is now foreseen that the JT-60SA machine will be upgraded step by step according to a phased operation plan consisting of an Initial Research Phase and an Integrated Research Phase. Exploitation within the Broader Approach (BA) period is planned to be in the Initial Research Phase which includes 1) HH operation for plasma commissioning and 2) DD operation for identification of issues in preparation for full DD operation.

The current re-baselined plan takes into account a more detailed analysis of the manufacturing and assembly schedule as well as the delay incurred by the project due to the re-designing of the machine. As a result the milestone of "First Plasma" had to be shifted by ~1 year from the original Baseline Project Schedule. The revised major milestones of the project schedule are as follows:

- Start of Tokamak Assembly: February 2012,
- Completion of Tokamak Assembly: October 2015,
- First Plasma: March 2016.

Exploitation plan

The JT-60SA project assumes a phased approach to operation. The operational phases consist of 1) an initial research phase (hydrogen phase and deuterium phase), 2) an integrated research phase, and 3) an extended research phase as shown in Table 2.1.1. During the period of the BA agreement, the exploitation is planned for the hydrogen phase of the initial research phase in Table 1 below.

In the hydrogen phase of the initial research phase, the main aim will be the integrated commissioning of the system with and without plasma operation, as well as the preparation of the deuterium operation at full plasma current and high heating power up to 23 MW, including 10MW of positive ion source NB, 10MW of negative ion source NB and 3MW of ECRF at 110GHz. A lower single null divertor with partial mono-block target is planned in this phase.

Table 1: STP Operation phases and status of key components

<table>
<tr><th></th><th>Phase</th><th>Expected Duration</th><th></th><th>Annual Neutron Limit</th><th>Remote Handling</th><th>Divertor</th><th>P-NB</th><th>N-NB</th><th>ECRF</th><th>Max Power</th><th>Power x Time</th></tr>
<tr><td rowspan="2">Initial Research Phase</td><td>phase I</td><td>1-2y</td><td>H</td><td>-</td><td rowspan="3">R&D</td><td rowspan="2">LSN partial monoblock</td><td>10MW</td><td rowspan="5">10MW</td><td rowspan="2">1.5MW x100s + 1.5MW x5s</td><td>23MW</td><td rowspan="4">NB: 20MW x 100s
30MW x 60s
duty = 1/30
ECRF: 100s</td></tr>
<tr><td>phase II</td><td>2-3y</td><td>D</td><td>4E19</td><td rowspan="3">Perp. 13MW
Tang. 7MW</td><td>33MW</td></tr>
<tr><td rowspan="2">Integrated Research Phase</td><td>phase I</td><td>2-3y</td><td>D</td><td>4E20</td><td rowspan="2">LSN full-monoblock</td><td rowspan="3">7MW</td><td rowspan="2">37MW</td></tr>
<tr><td>phase II</td><td>>2y</td><td>D</td><td>1E21</td><td rowspan="2">Use</td></tr>
<tr><td>Extended Research Phase</td><td></td><td>>5y</td><td>D</td><td>1.5E21</td><td>DN</td><td>24MW</td><td>41MW</td><td>41MW x 100s</td></tr>
</table>

IFMIF/EVEDA

In the framework of the Broader Approach agreement, the main objective of the Engineering Validation and Engineering Design Activities (EVEDA) of IFMIF is “to produce a detailed, complete, and fully integrated engineering design of the International Fusion Materials Irradiation Facility (hereinafter “IFMIF”) and all data necessary for future decisions on the construction, operation, exploitation and decommissioning of IFMIF and to validate continuous and stable operation of each IFMIF subsystem”. The initial duration of the project is 6 years, starting from June 2007.

The IFMIF-EVEDA project includes four main lines of activity:

- The engineering design of the IFMIF facility, which is the principal objective of the EVEDA phase in view of preparing the construction of IFMIF;
- The design, construction, commissioning and operation of an accelerator prototype which is the low energy prototype of the two IFMIF accelerators, which represents a ambitious project to demonstrate full beam current performance and reliability;
- The engineering design and engineering validation activities for the Target Facility, which depends in particular on the design, the construction and the operation of the Li Test Loop;
- The engineering design and engineering validation activities for the Test Facility.

The last two lines form two sets of R&D programmes to provide the data bases needed to proceed to the engineering design of the IFMIF facility integrating the accelerator design with the Target Facility and the Test Facility designs.

The 2009-2013 Project Plan for the IFMIF/EVEDA underwent a revision by the relevant Project Committee as some delays had to be implemented in the reference schedule. The revised Project Plan, endorsed by Project and Steering Committees in 2009, foresees a number of important changes with respect to the previous one, the most important being that the drift tube LINAC of the accelerator (prototype + IFMIF) is now using a superconducting half wave resonator technology hence the Accelerator Prototype experiments are delayed by 18 months; the tentative date for the end of its tests in Rokkasho is now end 2014. Figure 3 below shows the revised summary schedule as agreed by the Steering Committee after the recommendation by the Project Committee.

In the process, the resulting credit allocation scheme in kBAUA has been revised, keeping constant the total for Europe and for Japan.

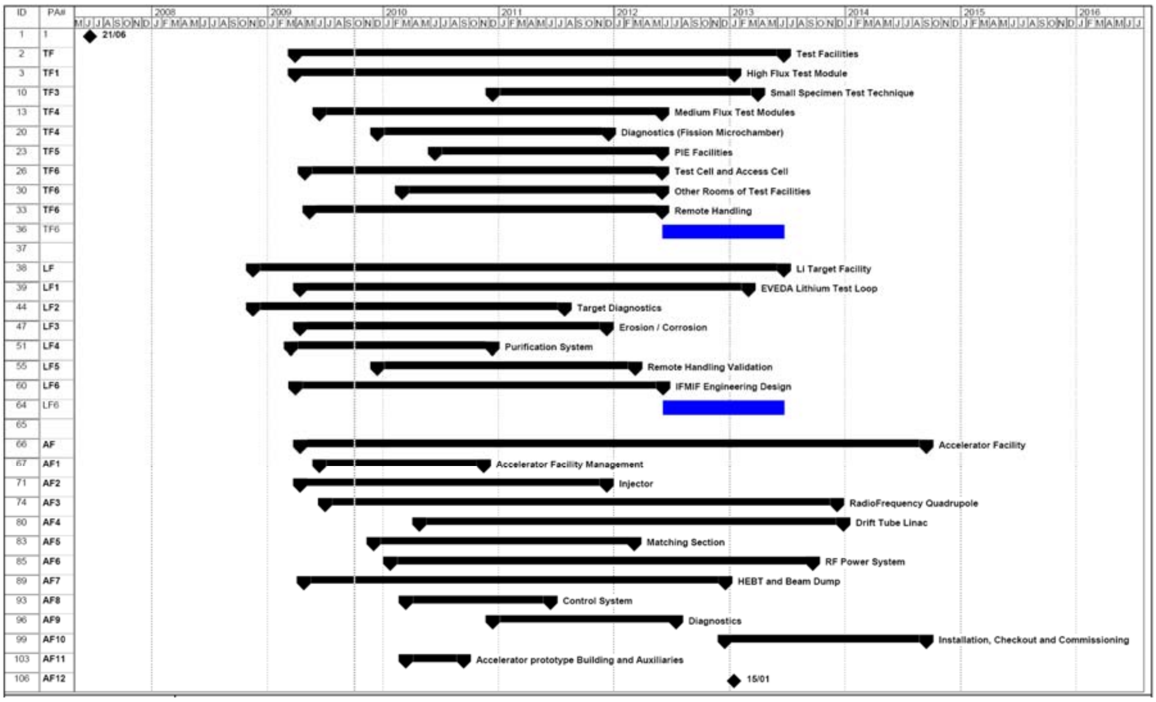


Fig.3: IFMIF/EVEDA Baseline Project Schedule

IFERC

The IFERC activities include three sub projects: DEMO R&D and Design activities, establishment and operation of a Computer Simulation Centre, and establishment and operation of a Remote Experimentation Centre and the construction of the buildings to house all these activities.

DEMO R&D

The DEMO R&D activities aim at establishing a common basis for a DEMO design from the technology point of view. Five tasks will be carried out:

- R&D on SiCf/SiC Composites

Deliverables: development of material database of advanced SiCf/SiC for DEMO relevant, physical/thermal/mechanical properties, assessment of the compatibility between SiC/SiC and liquid lithium lead, investigations of the self-coolant/dual-coolant liquid breeder blanket system and of the dynamic irradiation effects on transport properties of SiC and SiC/SiC, etc.

- R&D on Tritium Technology

Deliverables: development of tritium technologies towards the DEMO plant (continuous operation), preparation of Tritium Handling Equipment, development of Tritium Accountancy Technology, basic tritium safety research, tritium durability test, etc.

- R&D on Materials Engineering for DEMO Blanket

Deliverables: establishment of sound engineering bases for materials database, modelling/simulation/prediction methods of materials behaviour and design methodology, measurement of the fracture/rupture properties of the irradiated materials, development of data bases for DEMO design criteria and licensing, etc.

- R&D on Advanced Neutron Multiplier for DEMO Blanket

Deliverables: development of an Advanced Neutron Multiplier with low swelling and high stability at high temperature, the development of a manufacturing technology, preparation of test facility, etc.

- R&D on Advanced Tritium Breeders for DEMO Blanket

Deliverables: development of advanced tritium breeders with higher stability at high temperatures and lithium recycle capability, preparation of test equipment, the development of fabrication technologies of advanced breeder pebbles, characterization and reprocessing studies of the developed breeder materials, etc.

The DEMO design activities will take place in two phases: Phase one: analyse common elements for DEMO (three years) and Phase two: Develop potential Conceptual DEMO Designs (seven years)

Computer Simulation Centre:

The objective is to provide and exploit a super-computer for large scale simulation activities to analyse experimental data on fusion plasmas, prepare scenarios for ITER operation, predict the performance of the ITER facilities and contribute to the DEMO design.

- Phase One: Computer procurement phase: set-up a state-of-the-art computer center for simulation in Rokkasho *(five years)*

- Phase Two; Computer Operation Phase (five years)

For phase 1 several activities need to be implemented including:

- The procurement of the supercomputer and peripheral equipments, including installation, maintenance and support contract (EU).
- The preparation of the operation phase, including defining the organization and human resources needed for this phase and the way resources will be shared (EU/JA).
- The definition and implementation of interfaces (EU/JA) between the building and associated equipment (JA) and the supercomputer and peripheral equipment.

The CSC relies on activities implemented by JA including building and associated equipment and external high-speed internet connection.

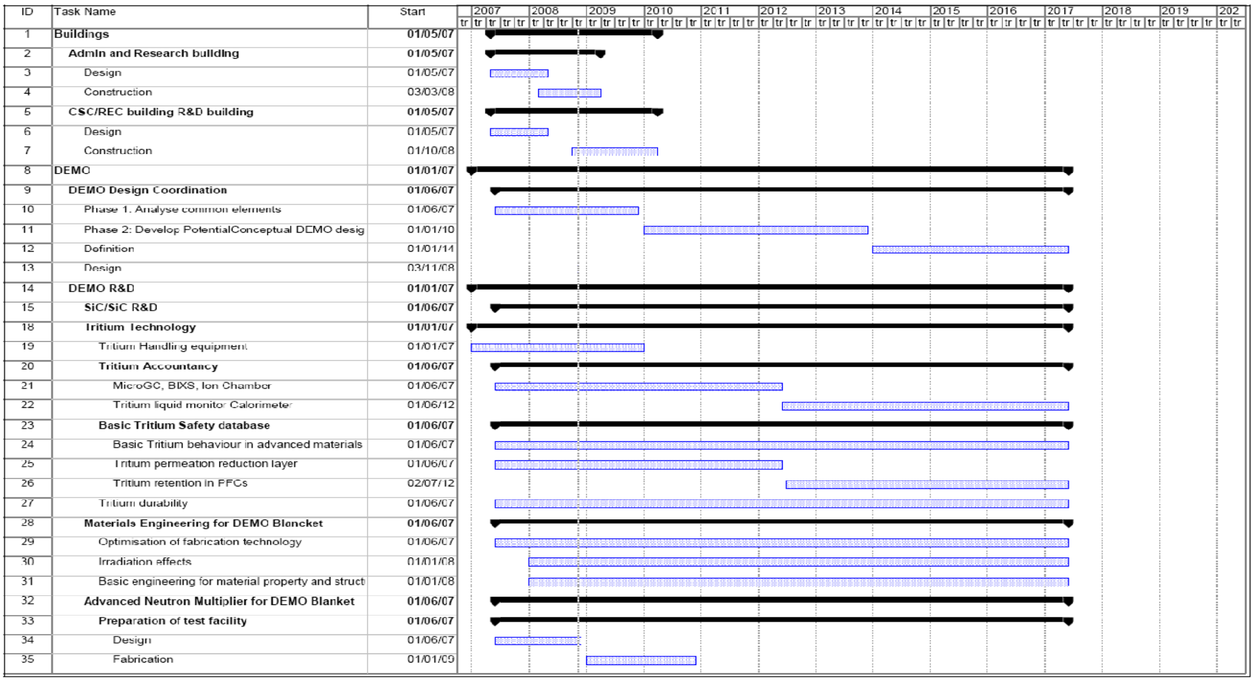
The selection of the benchmark codes is one of the critical issues for the selection process of a multi-purpose “state of the art” computer. For this activity, Special Working Group-1 (~3.5 years activities) was nominated by the Parties in 2008, with the mission of selecting the candidate benchmark codes and advising the Implementing Agency on the preparation of the technical specifications for the computer. Near the end of phase one (2010), a Special Working Group-2 (~2.5 years activities) will be nominated by the Parties to assist the PL in the definition of the user utilization rules of the installed computer system, and prioritization/management rules for the development of the fusion simulation codes.

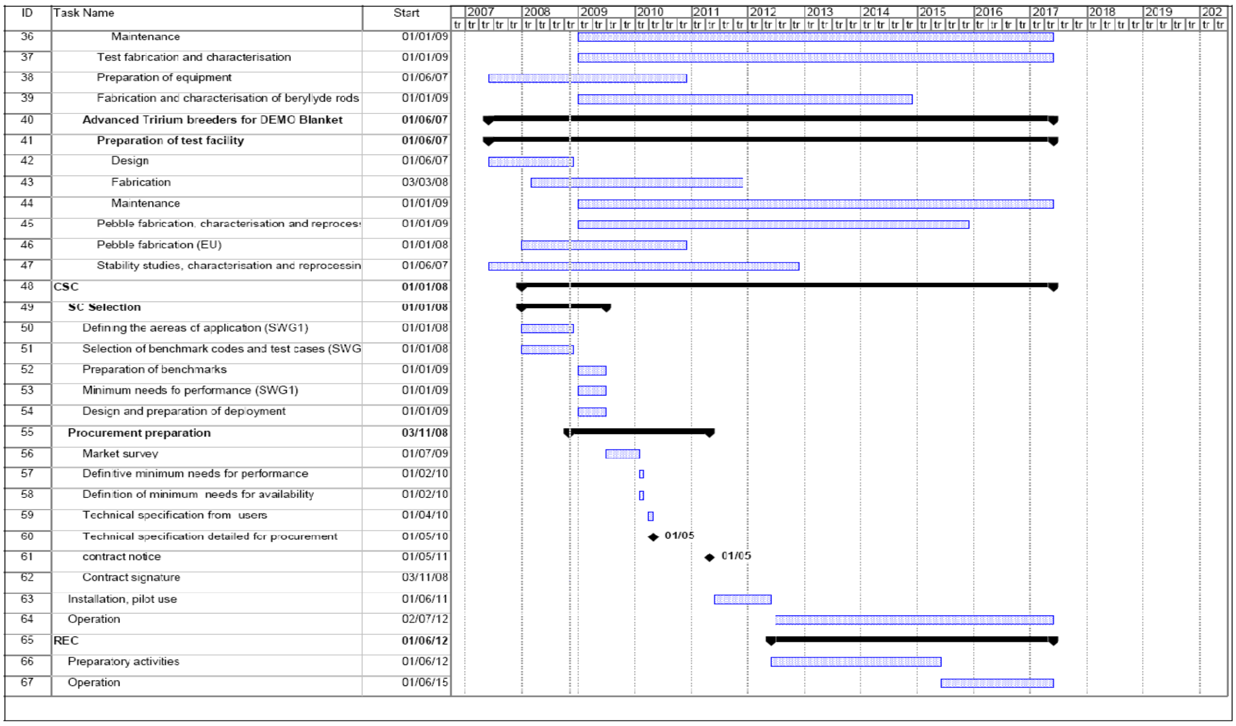
Remote Experimentation Centre (REC)

The Remote Experimentation Centre will facilitate broad participation of scientists into ITER experiments. Remote experimentation techniques will be tested on existing machines, such as the Advanced Superconducting Tokamak. Preparatory activities will start in BA year 6, and the exploitation of REC will take place during BA years 9 and 10.

The Project Plan for IFERC is provided in Figure 4 in the form of a summary schedule.

FIGURE 4: PROJECT SCHEDULE FOR IFERC





STATUS OF EU CONTRIBUTION TO IMPLEMENTATION OF THE PROJECTS

Table 2 below shows the status of preparation and foreseen signature date of the Procurement Arrangements of EU pertinence when compared with the agreed Project Plans. Significant delays are visible in some projects even at this stage. A summary report is provided below project by project.

Table 2: Status of preparation and signature of EU Procurement Arrangements

		Date		08-Sep-09	Tech Specification Status in IPT			AoC Status				
		Procurement Arrangement	PP Original date of signature	VC-Dis	Drafting Status	Draft Review status	Approved?	Sharing fully developed?	AoC Signed?	PA Signature foreseen date	Delay (Months)	Criticality on project schedule
JT-60SA		TF Coils	09-Jan-09	CEA, ENEA	100%	80%	N	Y	N	Dec-09	11	Very High
JT-60SA		HT Current Leads	29-Jan-09	FZK	100%	95%	N	Y	N	Nov-09	9	High
JT-60SA		TF test Facility and Testing	05-Feb-09	CEA, (ENEA, CRPP, SCK)	95%	90%	N	Y	N	Dec-09	11	Very High
JT-60SA		Cryostat base	27-Feb-09	CIEMAT	100%	90%	N	Y	N	Oct-09	7	Very High
JT-60SA		Quench protection circuit - QPC	10-Dec-09	Cons-RFX	50%	30%	N	Y	N	Dec-09	0	Medium
JT-60SA		Cryostat Body	04-Jan-10	CIEMAT	30%	0%	N	Y	N	Apr-10	3	Medium
JT-60SA		SC Magnet Power Supplies	01-Feb-10	CEA, ENEA	30%	0%	N	Y	N	Apr-10	2	Medium
JT-60SA		ECH Power Supplies	15-Feb-10	CRPP	30%	0%	N	Y	N	Apr-10	2	Low
JT-60SA		Cryogenic System	07-May-10	CEA	30%	0%	N	Y	N	May-10	0	Medium
JT-60SA		IN-Vessel Coils PS	04-Jun-10	ENEA	10%	0%	N	Y	N	Jun-10	0	Low
JT-60SA		Sector Coils PS	04-Jun-10	Cons-RFX	10%	0%	N	Y	N	Jun-10	0	Low
IFMIF/EVEDA	Test Facilities	01 Engineering Design of HFTM	Jun-09	FZK	90%	0%	N	Y	N	Oct-09	4	Medium
IFMIF/EVEDA	Test Facilities	02 Irradiation Test in Fission Reactor	Jun-09	SCK-CEN, FZK	90%	0%	N	Y	N	Oct-09	4	Medium
IFMIF/EVEDA	Test Facilities	04 Engineering Design of Other Modules	Jul-09	FZK, SCK-CEN, CIEMAT, CRPP	50%	0%	N	Y	N	Dec-09	5	Medium
IFMIF/EVEDA	Test Facilities	06 Other Engineering Design Tasks	Jun-09	FZK, CIEMAT	50%	0%	N	Y	N	Nov-09	5	Medium
IFMIF/EVEDA	Lithium Target Facility	01 EVEDA Li Test Loop	Dec-08	ENEA	100%	100%	N	Y	N	Oct-09	9	Very High
IFMIF/EVEDA	Lithium Target Facility	03 Corrosion/Erosion	Mar-09	ENEA	100%	90%	N	Y	N	Oct-09	7	Medium
IFMIF/EVEDA	Lithium Target Facility	04 Purification	Mar-09	ENEA	100%	100%	N	Y	N	Oct-09	6	Medium
IFMIF/EVEDA	Lithium Target Facility	05 Remote Handling	May-09	ENEA	90%	0%	N	Y	N	Oct-09	4	Medium
IFMIF/EVEDA	Lithium Target Facility	06 IFMIF Engineering Design	Mar-09	ENEA, SCK-CEN	0%	0%	N	Y	N	Dec-09	9	Medium
IFMIF/EVEDA	Accelerator Facility	01 Management & Design	Sep-09	CEA, INFN, CIEMAT	0%	0%	N	Y	N	Dec-09	3	Low
IFMIF/EVEDA	Accelerator Facility	02 Injector	Apr-09	CEA	100%	75%	N	Y	N	Oct-09	6	Very High
IFMIF/EVEDA	Accelerator Facility	03 Radiofrequency Quadrupole	Apr-09	INFN	90%	0%	N	Y	N	Nov-09	7	High
IFMIF/EVEDA	Accelerator Facility	04 1st Drift Tube Linac	Jul-09	CEA, CIEMAT	50%	0%	N	Y	N	Dec-09	5	High
IFMIF/EVEDA	Accelerator Facility	05 Matching Section	Jul-09	CIEMAT, CEA	0%	0%	N	Y	N	Dec-09	5	Medium
IFMIF/EVEDA	Accelerator Facility	06 RF Power	May-09	CIEMAT,CEA, SCK-CEN	100%	35%	N	Y	N	Oct-09	5	Very High
IFMIF/EVEDA	Accelerator Facility	07 Full Power Beam Dump, Transport Line	Aug-09	CIEMAT	25%	0%	N	Y	N	Dec-09	4	Medium
IFMIF/EVEDA	Accelerator Facility	08 Control Systems	Mar-09	CEA	0%	0%	N	Y	N	Dec-09	9	Medium
IFMIF/EVEDA	Accelerator Facility	09 Diagnostics	Jan-10	CEA	0%	0%	N	Y	N	Jan-10	0	Low
IFMIF/EVEDA	Accelerator Facility	10 Installation, Checkout, Start-Up and Commissioning	Nov-09	CEA, INFN, CIEMAT	25%	0%	N	Y	N	Dec-09	1	Medium
IFMIF/EVEDA	Accelerator Facility	12 Cryoplant	Jul-09	CEA	25%	0%	N	Y	N	Dec-09	4	Medium
IFERC		CSC-Supercomputer	Mar-10	CEA	80%	50%	N	N	N	Mar-10	0	High
IFERC		DEMO R&D Belgium	-	SKN	50%	0%	N	N	N	Nov-09	0	low
IFERC		DEMO R&D Germany	Jan-08	FZK	90%	50%	N	Y	N	Nov-09	21	low
IFERC		DEMO R&D Italy	Jan-08	ENEA	90%	50%	N	Y	N	Nov-09	21	low
IFERC		DEMO R&D Spain	Jan-08	CIEMAT	90%	50%	N	Y	N	Nov-09	21	low
IFERC		DEMO R&D Switzerland	Jan-08	CRPP	90%	50%	N	Y	N	Nov-09	21	low

JT-60SA

The re-baselining report of JT-60SA, made available to the STP-PC during the summer of 2008 was approved, at the SC held in Karlsruhe in Dec 2008. In this report a number of key milestones were indicated providing the basis for the approved project plan. The situation for each of the EU commitments is provided below.

From the organisational standpoint work has progressed well in the gradual implementation of the Common Quality Management System, introducing several project technical control methods which are key to the technical success of the project. Difficulties are, however, still evident in some areas of the project implementation.

Power Supplies (ENEA, CNR-RFX, CEA)

The EU contribution to the JT-60SA Power Supply system includes: Base PS for TF, CS and EF coils, HV generators for CS1-4 coils to provide the requested voltage for plasma breakdown, Quench Protection Circuits (QPC) for all coils, Power Supply (PS) for In-vessel coils for plasma control, and PS to control Resistive Wall Modes (RWM). Technical and procurement preparation activities are proceeding basically as planned. Details of the sharing as well as the drafting of the Technical Specifications are underway to meet the PA and contractual milestones later in 2009 and in 2010.

Main Cryogenic System (CEA)

The EU Contribution in this field is entirely handled by CEA-Grenoble and integrated in collaboration with the F4E Team. The supply includes the main refrigeration system for the entire magnet. Also, in this case, both technical and procurement preparation activities are proceeding as planned. Industrial studies are well-underway with encouraging results, an exchange of scope was agreed with JAEA simplifying the interfaces amongst EU and JA procurements, details of the design are being developed within the reference schedule. The planning outlined in 2008 is being followed.

ECH (CRPP)

The re-design of the JT60-SA tokamak, having a direct impact on the main magnetic field which has been decreased by a factor 1.15, imposed the need to review the ECRH physics for the initial phase of JT60-SA operation. Consequently, the EU procurement for ECRH has been resized, in agreement with the Swiss Voluntary Contributor, to two complete sets of power supplies powering two JA 110GHz gyrotrons rated at 1MW/100 sec. In the course of 2008, a partnership with Swiss industry had been initiated by the VC in order to study in more detail the optimal configuration to supply a depressed collector gyrotron of the triode type. Since the beginning of 2009, the effort placed on this task has been increased in order to prepare efficiently for TCM-5 in Naka. In parallel, information and characteristics of JT60-U gyrotrons operation have been provided by the JA ECRH team to clarify the requirements defined in the PID. Recently, the participation to the TCM5 meeting and the organisation of parallel session with the ECRH JA team allowed to: a) clarify on-site the delivery boundaries for the power supplies, b) look at improved supply topology integrating the ECRH scenario foreseen in the PID, and c) discuss the operation sequences to be followed and the interface to the remote JT60-SA system. Work within CRPP has recently re-accelerated towards the achievement of the schedule milestones.

TF Magnet Design and Fabrication (CEA, ENEA, F4E)

2009 required the resolution of important interfaces between the TF magnet and interfacing systems with the conclusion of the PAs for the TF magnet being planned for late 2009. Two separate PAs are assumed to be signed. The first will be for the set of 18 TF coils (conductor, windings, and structures), the second for the scope of the TF coil testing. A formal review meeting by external experts (panel chaired by Dr R. Aymar) was conducted in the summer of 2009. The panel concluded the review favourably and agreed that the design is mature enough to proceed with procurement initiation.

The EU Contributions in this sub-project include:

1. Conductor - to be procured by F4E. After the redesign of the conductor in late 2007, ENEA promptly prepared a sample with the same geometry as the reference design. This was made available for testing at Sultan in the summer of 2008 but regrettably, due to ITER priorities taking over, only tested in late March 09. However the test provided results matching the foreseen performance and margins. Therefore the technical specifications are now completed with procurement activities being initiated.
2. Structures – as planned in the September 2008 status report the structures have been redesigned to allow a clear sharing of work between ENEA and CEA. The conceptual design work was completed in late 2008 with work since then devoted to the completion of details. The structures are now divided into two well separated packages of approximately equal value: Coil-Casings (18 sets) and Outer Intercoil Structures plus Supports (18 sets). Regrettably, however, an agreement between ENEA and CEA on the sharing was only reached in September 2009.
3. Windings and final coil integration (and originally transportation to test facility and later Japan) - divided into 2 sets of 9 coils, each set to be managed by CEA and ENEA. Design work on the windings is proceeding to prepare the technical specifications, but lack of manpower and industrial involvement is delaying the effort. There is not enough information available at this time to estimate what the possible delay on this activity will be.

The difficulties of the TF magnet procurement are deemed to have a significant negative impact on the schedule, with expected delays now uncertain and with actions devoted to increase the effectiveness and resources required – in particular, adequate manpower dedicated to this quite challenging project needs to be made available in both CEA-Cadarache and ENEA-Frascati.

TF Test Facility and Magnet Testing (CEA, CRPP, SCK-CEN, ENEA)

A draft technical specification for the test requirements was recently issued and discussed with the involved VCs and a JAEA representative. The scope of tests to be followed is similar to the tests performed for the W7-X coils. The tests include quench tests for the first two coils and a temperature margin test at nominal current for all further TF coils. A second document has been prepared specifying the requirements for the test facility and defining the share of work between the VCs. A draft of this specification is being discussed within Europe. CEA has nominated its cryogenic group in Saclay to coordinate the design and setup of the test facility. This group has gained comprehensive experience during cryogenic testing of the W7-X coils. Switzerland will provide the refrigeration system and Belgium will provide the test cryostat. ENEA will support CEA in executing the coil tests. The chosen site for the testing has recently been confirmed at Cadarache but the progress of work in the design of the facility is delaying the entire project significantly.

HTS Current Leads (FZK)

The technical specification for the High-Tc-Superconducting (HTS) current leads has now been completed and the interfaces have been basically agreed with JAEA. The design of the current leads is largely based on the design for the current leads for the W7-X project. The final design review was successfully completed. High-Tc superconductor material was already ordered in advance because of its long delivery time. The Procurement arrangement documents are being finalized to allow signature by the parties by November 2009.

Cryostat (CIEMAT)

With CIEMAT actively and vigorously engaged in the project, work on the cryostat base is proceeding quite well with technical specifications now undergoing the final round of reviews within the EU and in JAEA. Work on the cylindrical part of the cryostat - the cryostat shell - is also proceeding well with significant simplifications compared to the original design now fully agreed with JAEA - additional simplifications are also being analysed and proposed. The technical specifications as well as the procurement arrangements are now ready to proceed. The call for tender will be initiated in 2009 for the cryostat base.

IFMIF/EVEDA

As with the JT-60SA Project, considering the small size of the Project Team in Rokkasho-Japan, most of the technical design and procurement activities in IFMIF/EVEDA are conducted within the EU and JA Home Teams. Both teams share design, integration, and procurement activities. The EU HT is organized as a collaboration between F4E and the Voluntary Contributors Designated Institutions (VC-DI).

Out of the 24 different Procurement Arrangements foreseen for the execution of the IFMIF/EVEDA project, the EU Home Team provides in-kind contributions to 20 Procurement Arrangements, representing 2/3 of the project expenditures and for which at first a total of 34 Agreements of Collaboration have to be prepared and signed bilaterally between F4E and each VC-DI participating in the specific Procurement Arrangement.

For this process, the basic features of a QA system were established in 2009 for the IFMIF/EVEDA Project. The thorough review process now implemented within the Integrated Project Team foresees that the completion of the signature process for the EU part of Procurement Arrangements will take place in the first quarter of 2010. This number may increase if the signature of some of the 7 Procurements, expected for the end of 2009, are not obtained until the first two months of 2010 (See table 2) .

Accelerator sub-project (CEA, INFN, CIEMAT, SCK-CEN)

Following the decision of the Steering Committee to choose the half wave resonator superconducting linac as the new reference, all activities have been focused with this new objective. A dedicated team has been put in place in

Saclay and in Madrid and a Preliminary Design Review was held in July 2009, confirming the main choices already made. The RadioFrequency Quadrupole (RFQ) successfully passed a Preliminary Design Review (end of definition phase) in June 2008. All major aspects (beam dynamics, technology) of this delicate system are now frozen and the Detailed Design Review is scheduled for end of November 2009. The Injector successfully passed its Preliminary Design Review and then its Detailed Design Review (end of engineering phase) and is now ready for procurement, pending the PA signature. The RF system has been redesigned and simplified, using now only two sets of amplifying chains (220 kW and 105 kW). The accelerator building in Rokkasho is progressing in line with the schedule.

Lithium Target (ENEA, SCK-CEN)

The EVEDA lithium test loop is under detailed design (the corresponding Japanese Procurement Arrangement has been signed). The contract for its manufacturing and installation has been awarded to ***Shinryo High Technology***. In order to be in line with the most probable solution for IFMIF's target assembly, the choice was made to use low activation ferritic/martensitic (RAF/M) steels such as F82H and Eurofer for this crucial element of the whole project. In Japanese universities (Tokyo and Kyushu), the preparation of experiments to check the capacity of traps to purify the lithium have been completed. Similarly, promising results have been obtained in Osaka thanks to a high speed camera monitoring the lithium flow. First results of erosion/corrosion work were obtained in ENEA Brasimone, confirming the better behaviour of RAF/M steels with respect to 316L stainless steel (this is crucial for the target assembly nozzle lifetime). What about SCK-CEN contribution?

Test Facilities (FZK, SCK-CEN, CRPP, CIEMAT)

A major installation, called HELOKA LP (low pressure) has been assembled in Karlsruhe and is now under commissioning. This facility will be used to characterize the cooling capacity and all performances expected for the High Flux Test Module (HFTM), to be tested in the next few years. Major modifications have been brought to this module, improving irradiation conditions and their mastering. Thanks to Belgium becoming a voluntary contributor in Europe, a more ambitious irradiation programme for the HFTM capsules has been proposed and is now under detailed definition. The Test Cell, core of the whole IFMIF plant, is still under deep revision, to improve its initial design and the expected availability and maintainability of IFMIF. No major work has been conducted in Japan, most of the efforts being put on the preparation of procurement arrangements.

IFMIF Engineering Design Activities

Considering the importance of the IFMIF Engineering Design Activities and the difficulties of the Implementing Agencies in providing adequate human resources, a revised work execution document has be submitted at the last Steering Committee for approval. This document proposes a new strategy from the Project Leader with:

- The immediate creation of a "Specification Working group", charged to define IFMIF specifications,
- A detailed work breakdown between the Rokkasho Project Team and the Home Teams,
- A reporting process to the BA Steering Committee, with in particular:
    - Autumn 2009: first set of IFMIF specifications
    - Autumn 2010: Outline Design Report
    - Autumn 2011: draft Site Specifications
    - Autumn 2012: draft version of the IFMIF Engineering Design Report
    - Autumn 2013: final version of the IFMIF Engineering Design Report
    - Spring 2015: Final Report, including outcome of the Accelerator Prototype tests

IFERC

DEMO R&D (CRPP, SCK-CEN, ENEA, CIEMAT, FZK)

The work in the R&D activities progresses well, and is regularly presented at two annual Workshops on DEMO R&D. Most Procurement Arrangements will be signed by the end of 2009, at which time the accrued credits will be formally assigned. At the last workshop in October 2009, besides the regular reports of ongoing activities, Belgium (newly joined EU voluntary contributor) presented a proposal for two R&D tasks which were discussed by the representatives of the two Parties and the Project Team. In view of the consensus on the interest of the proposals, the Project Leader proposed to include these new tasks in the 2010 Work Programme. It is proposed that the credits for this new contribution will be balanced by deducting the appropriate amount (about 0.7k BAUA, to be confirmed) from the EU contribution labelled "Mobility for EU'' (3.8kBAUA). An amendment to the table of contributions will be proposed in that direction to the Steering Committee.

According to the IFERC Project Plan (document BA SC 04-5.3) the total credit allocated to each voluntary contributor will be, at the completion of the tasks:

- Belgium: 0.7 kBAUA (to be confirmed)
- Germany: 1.472 kBAUA
- Italy: 2.949 kBAUA
- Spain: 2.949 kBAUA
- Switzerland: 0.51 kBAUA

The table 3 gives the detailed level of credit allocation by task agreed until 2010. Further credit allocation will be defined in future Work Programmes.

	WP2007	% BA credit	WP2008	% BA credit	WP2009	% BA credit	WP2010	% BA Credit	Accumulative total value	Accumulative %	Total per task (BA agreement)	Comments
T1-1-3	0.011	4.98%	0.07	31.67%	0.05	22.62%	0.08	36.20%	0.211	95.48%	0.221	
T1-2.1	0	0.00%	0.1106	10.00%	0.1106	10.00%	0.1106	10.00%	0.3318	30.00%	1.106	
T1-2.2	0	0.00%	0.1106	10.00%	0.1106	10.00%	0.1106	10.00%	0.3318	30.00%	1.106	
T1-2.3	0	0.00%	0.0737	10.00%	0.0737	10.00%	0.0737	10.00%	0.2211	30.00%	0.737	
T1-2.4*	0.05	22.62%	0.171	77.38%	0	0.00%	0	0.00%	0.221	100.00%	0.221	budget exhausted
T1-2.5	0	0.00%	0.3	29.07%	0.4	38.76%	0.2	19.38%	0.9	87.21%	1.032	
T3-1	0	0.00%	0.221	14.98%	0.221	14.98%	0.331	22.44%	0.773	52.41%	1.475	
T3-2	0	0.00%	0.085	16.67%	0.085	16.67%	0.085	16.67%	0.255	50.00%	0.51	
T4-1	0.11	24.89%	0.11	24.89%	0.11	24.89%	0.11	24.89%	0.440	99.55%	0.442	
T4-2	0	0.00%	0	0.00%	0.073	16.55%	0.073	16.55%	0.146	33.11%	0.441	
T5-2	0	0.00%	0	0.00%	0	0.00%	0.1475	50.00%	0.1475	50.00%	0.295	
T5-3	0	0.00%	0	0.00%	0	0.00%	0.03	41.10%	0.03	41.10%	0.073	
T5-4	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0	0.00%	0.221	
total	0.171	2.17%	1.2519	15.89%	1.2339	15.66%	1.3514	17.15%	4.0082	50.87%	7.88	

Table 3: Accrued credit per Task (in kBAUA and percentage of agreed total) for EU DEMO R&D Tasks.

DEMO Design

The phase one DEMO design activities (0 kBAUA) consisting in analysing common elements for DEMO was to last three years and is nearing completion in June 2010 according to the original plans. The phase 2 (develop potential Conceptual DEMO Designs, seven years, EU contribution 2.21 kBAUA) should start in mid-2010 with common design activities in Rokkasho executed by staff contributed in kind to the IFERC Project Team (EU: 14ppy, JA: 20ppy).

However due to the slow rate of domestic DEMO design activities in both Parties, alternative ways of fulfilling the programme are being discussed. At the DEMO Design Workshop in Garching in October 09, the two Implementing Agencies have set up a small group to explore tasks of common interest and to propose a way to implement these tasks. The group will make a proposal in mid 2010, and the common activities will be defined in the 2011 Work Programme.

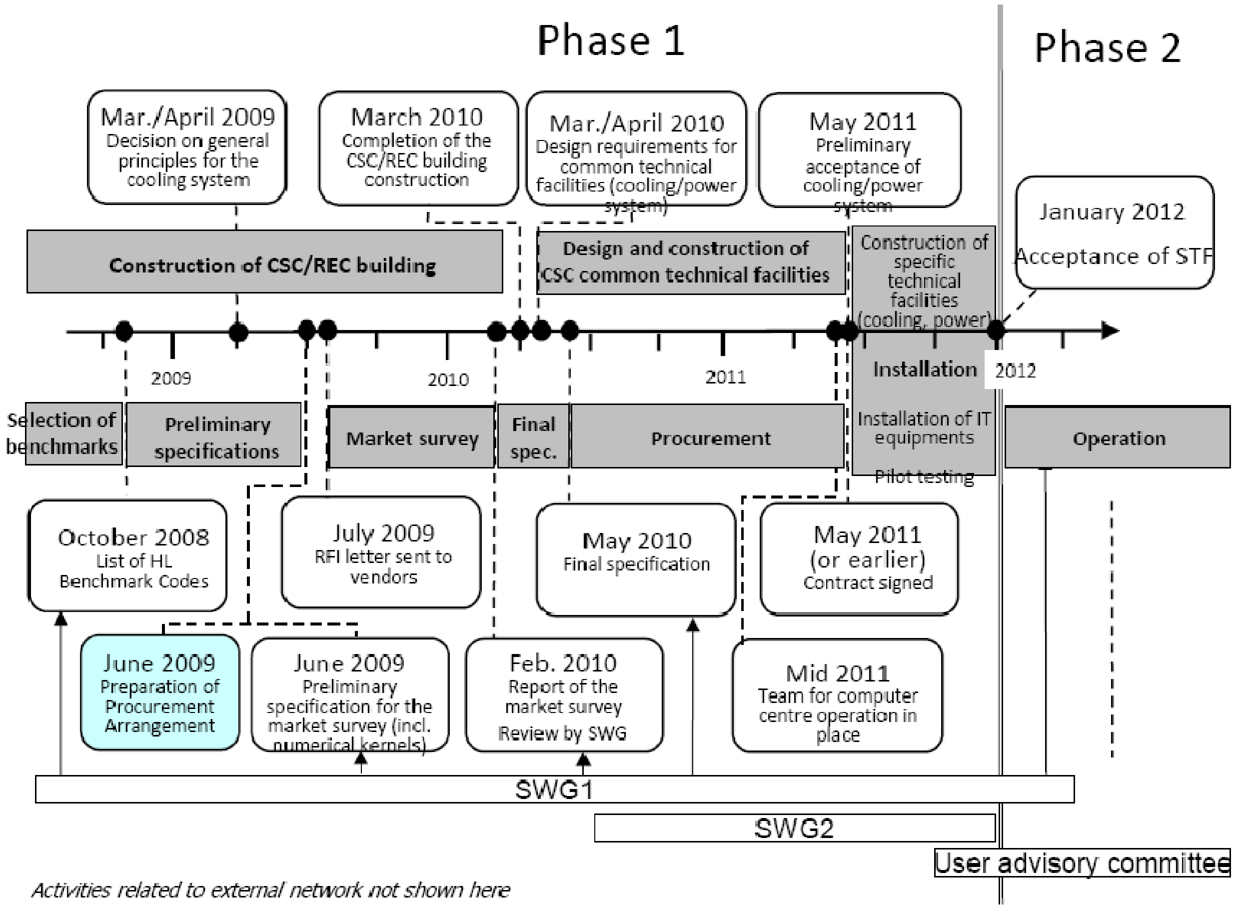
CSC (CEA)

In the Computer Simulation Centre, the EU contribution is entirely covered by the French Voluntary Contribution and amounts to 98.9 kBAUA, comprising

- State of the art High Power Computer (81.52 kBAUA)
- Peripherals (16.3 kBAUA)

- Professional staff (1.09 kBAUA)

The supercomputer should come into operation in 2012. The activities progress according to the schedule summarised below.



Based on the results obtained in 2008 and 2009 including

- the preliminary specifications agreed for the market survey (July 2009),
- the list of HLBC (high level benchmark codes) agreed for the procurement of the supercomputer (September 2008)
- the preliminary work done by both IAs under the supervision of the PL in the definition of interfaces and roles (started in December 2007),

the work in 2010 has the following objectives:

1. gather all necessary information for preparing the technical specifications for the equipments and services that have to be procured by EU.
2. agree on the definition of interfaces with enough details to be able to include their definition in the technical specifications that will be used for the procurement and start to implement them early enough.
3. agree on the definition of the organization and human resources needed for the operation phase.
4. produce the technical specification and start the procurement process.

In addition, the following items will be produced.

	Item	Date	HP NP RP Del	Approving	Providing IA	Value (kBAUA)
2	Report of the market survey with input from SWG1	Feb. 1, 2010	RP	PL + JAEA	F4E	0
3	Technical requirements (for procurement of the computer, peripheral equipments and associated maintenance)	April, 2010	HP	PL + JAEA (*)	F4E	0
4	Start of the procurement	May, 2010	NP (***)		F4E	0

HP: hold point; NP: notification point; RP: report point; Del: deliverable; MS: Milestone

(*) Reviewed by SWG1
(**) Contributed by SWG1
(***) PL and JAEA will be notified

BROADER APPROACH ACTIVITIES DIRECTLY FUNDED BY F4E

In order to better understand the relation of the BA Project Plan with F4E Resource Estimate Plan, below are listed the activities directly contracted and funded by F4E, as complement to the in-kind commitments of the EU Voluntary contributors:

- Procurement of stand and conductor for JT-60SA Toroidal Field Coils (committed already in 2009)

- EU Contribution to the Assembly of JT-60,

- EU contribution to the operation of JT-60SA (beyond 2016),

- EU contribution to the Remote Experimentation System (linked to ITER start of operation),

- Transportation of some of the components procured by the EU-VC from the place of fabrication/assembly/testing in EU to the port of entry in Japan (activity distributed in time in the period 2011-2014),

- Cash Contributions to IFMIF-EVEDA Project (contribution distributed on yearly bases up to the expiration of the BA Agreement),

- Mobility fund for researchers in the frame of the IFERC project (fund distributed on yearly bases up to the expiration of the BA Agreement),

- F4E Grants for the execution of specific tasks in the area of DEMO Design and R&D beyond what committed by EU-VC (details of this activities are to be developed and a provisional distribution in time has been assumed),

According to the fast-track scenarios at the end of the IFMIF-EVEDA phase, the start of the construction of IFMIF is considered as possible. As a consequence, in addition to the activities that derive from BA agreement obligations, a line of activity is open for IFMIF construction for funding beyond 2014.

DEMO

In the period 2010-2014 very few activities are currently foreseen to be carried out by Fusion for Energy related to DEMO, in addition to the activities foreseen in the Test Blanket Module and materials development programme associated with ITER. Some detail of the F4E Materials development for DEMO is provided here after.

SHORT DESCRIPTION

The mission of Materials Development (MD) is related to development, characterization and qualification of (structural) materials for breeding blankets (BB) for the next generations, (i) TBM (Test Blanket Modules) in ITER (*see note below), and (ii) DEMO BB.

The candidate material for the EU reference breeding concepts foreseen for DEMO is the family of ferritic-martensitic EUROFER steels. The material should have a design window in excess of 350°C-550°C, a lifetime equivalent to 50-70 dpa and should aim for recycling limit of ~100 years.

The main R&D objective towards DEMO is, therefore, to further develop EUROFER steels with respect to (a) optimized mechanical properties (improved radiation resistance), (b) improved low activation and low level waste properties. Both directions of development can be conducted to a large extent independently. Historically the two lines of development are called EUROFER-2 and EUROFER-3.

The new EUROEFR-steels have to be characterised and qualified, first in a stage of screening followed by a broad characterisation programme in particular within a series of neutron irradiation campaigns addressing various issues and accompanied by multi-ion beam experiments.

The near-term goal is to have a well-defined and in-depth pre-qualified material ready before IFMIF operation. The products of the F4E MD programme towards DEMO are, therefore, the supply of

- a specification describing the production of a EUROFER reference steel for DEMO,
- a data base collecting all physical and mechanical properties needed for design, construction and licensing DEMO breeding,
- a consistent framework of design rules needed for the design and licensing of breeding blankets.

Notes:

- *<u>(*) Relation to F4E development performed towards TBM in ITER</u>: The development and validation of EUROFER-97 (the reference grade for TBM) is described within the ITER part. The same holds for EUROFER-ODS and SiC-Dual as materials for a DCLL (test) blankets.*
- *<u>Relation to R&D under EFDA</u>: The development of ferritic ODS steels and W-alloys, which are candidate materials for gas-cooled divertor options in DEMO, is managed within the EFDA programme for Emerging Technologies.*
- *The F4E MD shall benefit from the REMEV (Radiation Effect Modelling and Experimental Validation) Programme run under EFDA, which aims to increase knowledge on the stability and evolution of microstructure under irradiation (e.g. driving mechanisms, time scales). The benefit shall be through (i) guidelines on improved alloy composition, (ii) established relationship between processing and microstructure, which shall, in particular, result in an accelerated development.*

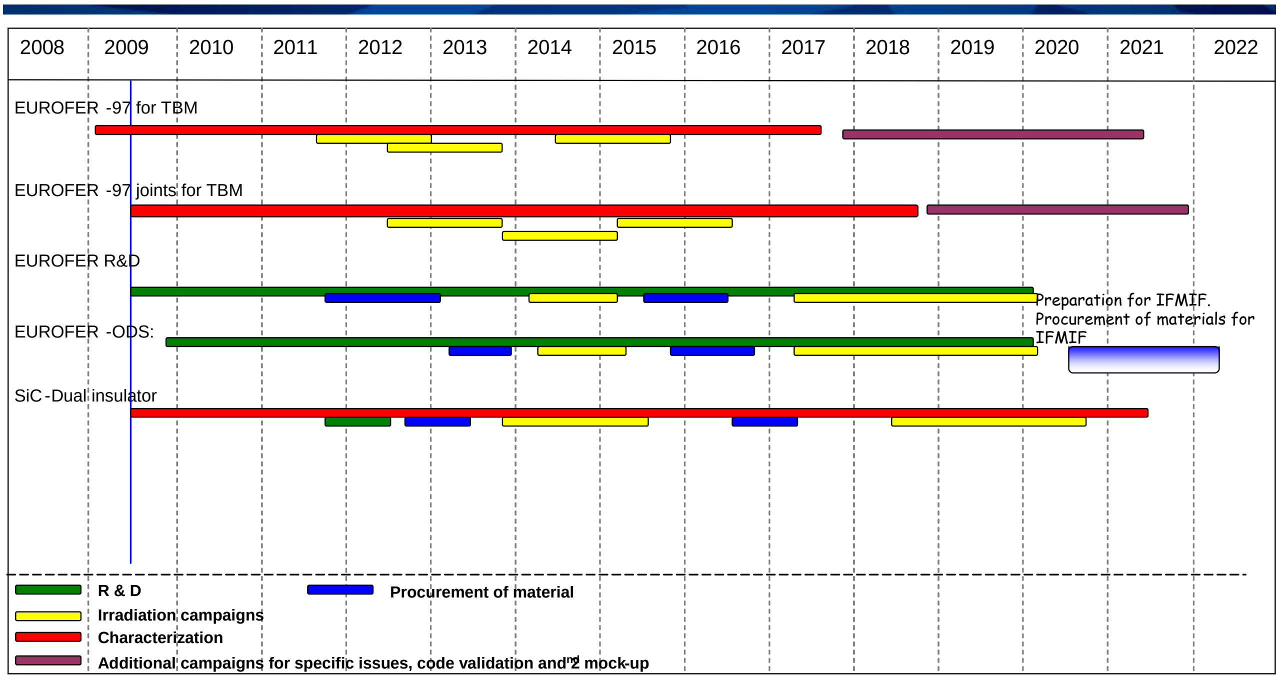
WBS	EU activity
N/A	R&D for improved radiation resistance and low activation of EUROFER steels
N/A	Procurement of improved EUROFER

N/A	Qualification of new EUROFER heats in irradiation campaigns

MAIN MILESTONES

EUROFER development and qualification towards DEMO:

WBS	**Milestone**	**Expected date**
N/A	Procurement of low activation EUROFER-3	Dec. 2011
N/A	Procurement of EUROFER-2 (improved radiation resistance)	Dec. 2014
N/A	(Pre-) Qualification of new EUROFER in irradiation campaigns completed	Dec. 2020
N/A	Ready to procure materials for IFMIF irradiation	Dec. 2020



Overall picture of, both, materials R&D towards TBM and DEMO.

DESIGN AND MANUFACTURING READINESS

DESIGN READINESS

N/A

MANUFACTURING READINESS

N/A

READINESS OF TECHNOLOGY AND INFORMATION

A key date for readiness of EU DEMO reference structural materials is the start of IFMIF operation. By then materials well pre-qualified in a series of irradiation campaigns and complemented with data from a modelling programme should be ready for an international pre-selection exercise prior to IFMIF exploitation.

R&D AND QUALIFICATION ACTIVITIES

Materials Development for Breeding Blankets

EUROFER

Development and qualification of EUROFER towards use in DEMO

For use in DEMO breeder blankets EUROFER will be further developed.

There are two main directions (i) to improve mechanical properties and radiation resistance (for short called EUROFER-2) and (ii) to further reduce the activation towards a low activation/low level waste material (EUROFER-3), with the aim to achieve reprocessing/recycling limit after ~100 years. Several small heats produced at industrial level shall be qualified in a series of irradiation campaigns at medium to high n-irradiation dose.

PROCUREMENT STRATEGY

New EUROFER-2 and EUROFER-3 steels:

Impurity control (EUROFER-3):

Two heats of ~1 ton should be procured in two steps around 2012 and 2015 in order to demonstrate the capability to produce steels reproducibly with low impurity content (Mo, Nb, Al of less than 10-50 ppm) at industrial scale and to maintain competences in EU industry (that otherwise might disappear).

Radiation resistance (EUROFER-2):

To increase irradiation resistance and tolerance against He-embrittlement a R&D phase of 3 years in EU Associations should be followed by production of the improved grades EUROFER-2. Depending on R&D results one or more heats shall be procured with EU industry.

First trial heats, typically, should be in the order of 100-500 kg (size of industrial R&D fabrication lots), followed by heats in the order of tons for a real qualification programme.

ANNEX I
TABLE OF ACRONYMS AND ABBREVIATIONS

A/E	Architect Engineer
ALARA	As Low As Reasonable Achievable
ANB	Authorized Notification Body
ANS	Analytical System
ATS	Air Transfer System
BSM	Blanket Shield Module
BTP	Build-to-Print
CFC	Carbon Fibre Composites
CMM	Cassette Multifunctional Mover
CVB	Cold Valve Boxes
CVD	Chemical Vapour Deposition
CXRS	Core Plasma Charge-Exchange Recombination Spectroscopy System
DA	Domestic Agency
DEMO	Demonstration Fusion Reactors
DNB	Diagnostic neutral beam
DTP	Divertor Test Platform
EAF	European Activation File
EB	Electron Beam
EC	Electron Cyclotron
EC UL	Electron Cyclotron Upper Launchers
ECH	Electron Cyclotron Heating
EFDA	European Fusion Development Agreement
EFF	European Fusion File
ELM	Edge Localized Mode
F4E	Fusion for Energy
FS	Functional Specification
FW	First Wall
HCLL	Helium-Cooled Lithium-Lead
HCPB	Helium Cooled Pebble Bed
H&CD	Heating & Current Drive
HIP	Hot Iso-static Pressing
HNB	Heating Neutral Beam
HV	High Voltage
HVAC	Heating Ventilation &Air Conditioning
HVD	High Voltage Deck

HW	Hardware
IC	Ion Cyclotron
ICH	Ion Cyclotron Heating
IFMIF	International Fusion Materials Irradiation Facility
IO	ITER Organization
IR	Infra Red
ISEPS	Ion Source and Extraction Power Supplies
ISS	Isotope separation system
ITA	ITER Task Agreement
IVT	Inner Vertical Target
IVVS	In-Vessel Viewing System
MHD	Magneto-HydroDynamics
MV	Medium Voltage
NB	Neutral Beam
NBI	Neutral Beam Injector
NBPS	Neutral Beam Power System
NBTF	Neutral Beam Test Facility
ODS	Oxide Dispersion Strengthened
P&ID	Process and Instrumentation Diagram
PA	Procurement Arrangement
PF	Poloidal Field
PFC	Plasma Facing Components
PFD	Process Flow Diagram
PIE	Post Irradiation Examination
PMU	Prototypical Mock-Up
PP	Procurement Package
PrSR	Preliminary Safety Report
PTC	Prototype Torus cryopump
QA	Quality Assurance
R&D	Reasearch & Development
RAFM	Reduced Activation Ferritic Martensitic
RF	Radio Frequency
RH	Remote Handling
RNC	Radial Neutron Camera
RWM	Resistive Wall Mode Control
SDC	ITER SDC (Structural Design Criteria/Code)
SHPC	Safety and Health Protection Coordination
Sic-Dual	SiC/SiC composite material for electrical and thermal Insulation (for use in Dual Coolant Breeder Blankets)

SS	Steady State
SW	Software
TBC	To be confirmed
TBD	To be determined
TES	Test Extraction System
TF	Toroidal Field
TH	Thermal Hydraulical
UT	Ultrasonic
VV	Vacuum Vessel
WAVS	Wide Angle Viewing System
WBS	Work Breakdown Structure
WDS	Water Detritiation System
WP	Work programme

ANNEX II

PRELIMINARY ASSESSMENT OF RISKS

A preliminary assessment of the main risks associated with the procurement of the components on the critical-procurement path according to the so-called modified-Scenario-1 (namely buildings, superconducting magnets, and vacuum vessel) has been carried out and the results are briefly described in this section. Also, the assessment of the risks associated with the procurement of the neutral beam system and the diagnostics is included as an example of systems, which, albeit not on the critical path, entail significant levels of risks. In particular, the diagnostic systems are included here as an example because even if they are all at a much earlier phase than systems such as the Vacuum Vessel and detailed designs do not exist in most cases and, for many systems, considerable R&D remains before even conceptual designs could be agreed, focus is on a quite different type of risks. Fabrication risks cannot yet be usefully evaluated but the risks associated with F4E Procedures; ITER IO documentation; and near monopoly supply are severe, very apparent and very near term. Precisely because of the early phase nature of these risks (which implies long extrapolation) many of them must also be rated as very high.

The attached tables summarise the resulting risk plan, the main areas of risks, the associated risk levels and the mitigation actions to be implemented to mitigate the risks:

- Appendix A: toroidal field coils
- Appendix B: vacuum vessel
- Appendix C: buildings
- Appendix D: neutral beam system
- Appendix E: diagnostic systems

The assessment of the risks has been conducted according to the F4E Risk management plan[14], and the methodology adopted for the quantitative risks analysis is briefly described below. The common method which is followed is that of giving a “risk level” to each risk by using a probability over project duration–impact scoring.

Each risk is assessed by giving it a probability of occurrence over the project duration (see Table 1) and the amount of impact (technical, cost and schedule) to the project (see Tables 2-4). The resulting probability-Impact matrix is showed in Figure 1 and is used to prioritize the risks and spend the appropriate amount of time depending on the severity of the risk.

It must be noted that in the tables below, the assumption is made that the risk of design changes coming from IO during fabrication of components is negligible. Obviously, if they occur there will be high risk of non-conformities/rejection and high cost claim from supplier due to design changes after award of contract. To minimise the risk of design changes after award of contract IO should (i) finalise the design and conduct the required design verifications to ensure

[14] Process Risk Management - PM-22 F4E_D_MSV2CU, version 00.2 July 2009

consistency of the load specifications and of models being delivered and that the geometrical details included in the design are consistent with the results of the calculations and satisfy the requirements; (ii) conduct in accordance with its QA programme peer independent reviews of the entire technical documentation, including compliance with applicable codes and standards and the appropriateness of the assumptions, engineering methods and input data used to support the design; (iii) conduct all necessary efforts to seek possible simplifications/optimisations of the design that could lead to minimisation of manufacturing risks and ultimately to cost savings;

Table 1: Likelihood of risk occurrence

LIKELIHOOD of risk occurrence

Value		Description	
Not Credible	(1)	probability of occurrence < 1%.	the probability of the risk is very low
Unlikely	(2)	probability of occurrence > 1% but <10%	the probability of the risk is low or if its occurrence is late in relation to the lifetime of the project.
Not likely	(4)	probability of occurrence > 10% but <40%	
Likely	(8)	probability of occurrence > 40% but <80%	the risk is identified. There exists a high probability that it will occur
Very Likely	(16)	probability of occurrence > 80%	the probability of the risk identified is almost certain

Table 2: Technical impact factors

TECHNICAL / OTHER IMPACT

Value		Impact on: Technical Performance	Human health, safety and well being	Environment	Reputation and Image	Political
Negligible	(1)	Minimal or no consequence to technical performance	No injuries	No environmental impact	No damage to reputation/image	No political/ organizational impact
LOW	(2)	Minor reduction in technical performance or supportability, can be tolerated with little or no impact on program	Minor injuries; no public health risk; short term well being impact	Minor,/recoverable short-term isolated/ localized environmental impact	Recoverable / short term local damage to reputation/image	Local political / organizational impact
MEDIUM	(4)	Moderate reduction in technical performance or supportability with limited impact on program objectives	Limited public health risk &/or injuries requiring medical & mental health treatment	Moderate, medium term, medium spread environmental impact	Medium term / regional damage to reputation/image	Regional political / organizational impact
HIGH	(8)	Significant degradation in technical performance or major shortfall in supportability; may jeopardize program success	Major public health risk &/or major injuries/well being impact	Serious, long term, widespread environmental impact	Long term/ state damage to agency reputation/image	State political / organizational impact
VERY HIGH	(16)	Severe degradation in technical performance; Cannot meet baseline or key technical/ supportability threshold; will jeopardize program success	Significant public health risk &/or human deaths/ long lasting well being issues	Irreversible environmental impact	Long term / (inter) national damage to reputation / image irreversibly impacted	National political / organizational impact

Table 3: Cost impact factors

COST IMPACT

Value	Cost Increase by
Negligible (1)	< 3 M€
Low (2)	3-30 M€
Medium (3)	30-60 M€
High (4)	60-120 M€
Very high (5)	> 120 M€

Table 4: Schedule impact factors

SCHEDULE IMPACT

Value		DELAY on Milestone (at project level Integrated Project Schedule Milestones)	
		NON Critical Path Milestone	Critical Path Milestone
Negligible	(1)	No delays on milestones (< 1 month)	No delays on milestones (<1 week)
LOW	(2)	1 month ≤ DELAY < 3 months	DELAY < 1 month
MEDIUM	(4)	3 month ≤ DELAY < 6 months	1 month ≤ DELAY < 3 months
HIGH	(8)	6 month ≤ DELAY < 1 year	3 month ≤ DELAY < 6 months
VERY HIGH	(16)	DELAY ≥ 1 year	DELAY ≥ 6 moths

Figure 1: Probability-Impact matrix

IMPACT					
Very High (16)	HIGH (16)	HIGH (32)	VERY HIGH (64)	VERY HIGH (128)	VERY HIGH (256)
High (8)	MEDIUM (8)	HIGH (16)	HIGH (32)	VERY HIGH (64)	VERY HIGH (128)
Medium (4)	MEDIUM (4)	MEDIUM (8)	HIGH (16)	HIGH (32)	VERY HIGH (64)
Low (2)	LOW (2)	MEDIUM (4)	MEDIUM (8)	HIGH (16)	HIGH (32)
Negligible (1)	LOW (1)	LOW (2)	MEDIUM (4)	MEDIUM (8)	HIGH (16)
	Not Credible (1)	Unlikely (2)	Not Likely (4)	Likely (8)	Highly Likely (16)

LIKELIHOOD

The defined four levels of risks (low, medium, high, and very high) determine appropriate actions, which are described in table 5.

Table 5: Actions associated to risk levels.

RISK Level	Actions
LOW	They are included in the risk file and reviewed by WPM concerned. Actions are evaluated in order to reduce the risk.
MEDIUM	An owner is appointed to monitor the risk evolution and report to the WPM concerned. Actions are evaluated in order to reduce the risk.
HIGH	Same as level MEDIUM plus definition of specific mitigation actions. These actions are defined by the WPM concerned with the risk, who identifies also possible trigger events to start them. The owner monitors the risks and these trigger events.
VERY HIGH	Planned mitigation actions are started as scheduled. The risk owner is designated directly by the PM, who closely monitors the effectiveness of the mitigation actions at each project review meeting

Appendix A: Toroidal Field (TF) Coils

Identification			Rating Pre-Mitigation						Disposition	Rating Post-Mitigation					
Risk Label			Likelihood	Impact			Level		Mitigation Strategy / Actions	Likelihood	Impact			Level	
("As a result of...")	("There is a risk that...")	("Resulting in...")		TECH	COST	SCHED					TECH	COST	SCHED		
Only 1 consortium in Europe has the combination of financial strength and technical capabilities broad enough to carry out the whole TF coils procurement (radial plates, winding packs, coil insertion and cold tests). (***Market risks***)	a monopoly situation will arise	higher price	Very Likely	Medium	High	Negligible	128	VERY HIGH	(i)) Split procurement in smaller technologically-homogenous work packages accessible to more competitors with specific competences: Radial Plates, Winding Packs and Coil Case Insertion.	Not Credible	Negligible	High	Negligible	8	MEDIUM
No previous experience on production of radial plates of this size • 2 types of radial plates (side and regular) with different technological issues present in a TF coil.(***Technological risks: Radial Plates)***	Failure in producing the first radial plates.	delay in the starting of the series production and/or major technical issues	Not likely	High	High	Very High	64	VERY HIGH	i) Manufacture 2 prototypes before starting the series production: 1 side and 1 regular) Utilize a common strategy with JAEA by exploring different manufacturing technologies for each prototype in order to explore different manufacturing options. iii) Select for the series production, to the light of the experience gained with the prototypes, the best technology also in terms of cost & production time.	Not Credible	High	High	Medium	8	MEDIUM
No previous experience on production of coils of this size with wind, react and transfer technology. Risk of delay due to development and learning curve. (**Technological risks: The winding Packs)**	Failure in producing the first DPs	delay in the starting of the series production and/or major technical issues	Not likely	Medium	High	Very High	64	VERY HIGH	i) Carry out an intense R&D program addressing all critical manufacturing issues before starting series production. ii) Manufacture 1 Full-Size DP prototype (most difficult component to produce in the TF coil) before starting the series production. iii) Procure a portal machine capable to manufacture radial plates according to DP as-built geometry, in case of a non conformity in the DP geometry V) Utilize experience gained with the TF Model Coil by involving experts who participated to the project.	Unlikely	Medium	Low	Medium	8	MEDIUM

EU receives conductors from different suppliers, and each one of them could have slightly different thermal mechanical and thermal expansion behaviour. (***Technological risks: The winding packs***)	Each conductor after the winding and the heat treatment would have a slightly different geometry and would not fit in the the radial plate grooves.	Non conformity and possible rejection of DP. Necessity to make a new conductor length, and wind and react it.	Likely	Negligible	Medium	High	**64**	VERY HIGH	(i) Conduct during the qualification phase specific heat treatment trials for each type of conductors, determining the thermal mechanical behavior for each type of conductor. (ii) Define a specific double pancake geometry for each type of conductor such that after the change length during the heat treatment they all fit in the same radial plate groove geometry. (iii) If in spite of the mitigation actions above, the problem remains, the so-called portal-machine would be used to manufacture the radial plates based on the as-built geometry of the heat treated double pancake in question.	Not Credible	Negligible	Medium	High	**8**	MEDIUM
Conductors and coil cases, produced by several DAs, are integrated in the TF coils as sub-components. (***Interface risks***)	These sub-components will arrive late compared to the TF coil production needs in the schedule.	WP suppliers being on hold with likelihood of consequent financial claims to F4E.	Likely	Negligible	Low	Medium	**32**	HIGH	(i) F4E requires conductors and coil-cases, at least 3 months before required in the TF coil production schedule. (ii) F4E exercise a close monitoring with the relevant DAs of the progress-status for the production of such components.	Not Credible	Negligible	Medium	Medium	**4**	MEDIUM
• Welding of the coil case is very complex due to the variable thickness (from 30 to 120 mm) and because there is a risk to damage the winding pack during the operation. NDT is also critical due to geometrical contains. (***Technological risks: The coil insertion)***	Failure in producing the first TF coil	delay in the starting of the series production and/or major technical issues	Not likely	Medium	Low	High	**32**	HIGH	i) Carry out an intense R&D program addressing all critical manufacturing issues before starting series production.	Unlikely	Medium	Medium	Medium	**8**	MEDIUM
IO very slow in carrying out analysis and/or producing modified drawings	a delay in providing feedback to suppliers in case of issues encountered during the construction	delay in the construction and financial claims by the suppliers	Likely	Negligible	Low	Medium	**32**	HIGH	i) minimize number of design changes proposed to IO ii) In case of issues during production focus on solution not affecting the magnet design.	Unlikely	Negligible	Medium	Medium	**8**	MEDIUM
Inconsistency in the mechanical behaviour of different conductor lengths from the same supplier	difficulty in controlling the geometry of the conductor during winding	delay in the winding process	Unlikely	Negligible	Medium	Medium	**8**	MEDIUM	A strategy to mitigate this risk will be devised together with the winding pack supplier, responsible for the winding (winding pack supplier)						
Issues during the process of welding the cover plates of the radial plates	excessive deformation of the radial plate	Double Pancake module being outside required tolerances	Unlikely	Medium	Low	Medium	**8**	MEDIUM	A strategy to mitigate this risk will be devised together with the winding pack supplier, responsible for the welding of the cover plates (winding pack supplier)						

Appendix B: Vacuum Vessel (VV)

Identification			Rating Pre-Mitigation						Disposition	Rating Post-Mitigation					
Risk Label			Likelihood	Impact			Level		Mitigation Strategy / Actions	Likelihood	Impact			Level	
("As a result of...")	("There is a risk that...")	("Resulting in...")		TECH	COST	SCHED					TECH	COST	SCHED		
Starting Construction activities before finalization of design interfaces	Change notices will be issued to the Supplier (Procurement of VV: Contract Implementation Interfaces)	Scrap and changes paid by F4E	Very Likely	High	Medium	High	128	VERY HIGH	**Negotiate with ITER Requests for Changes** No construction activity starts before the finalization of design for the interface components	Not Credible	Low	Low	High	8	MEDIUM
Lack of a full-size sector prototype of " first-of- a- kind"	Prescribed tight tolerances not achieved (Procurement of VV: Contract Implementation Technological)	Rejection of first Sector	Likely	High	Medium	Very High	128	VERY HIGH	Extensive Mock ups and distortion modeling to be completed before critical stages of first sector construction	Not Credible	Low	Low	High	8	MEDIUM
Lack of Control over IWS plates supply due to lack of control over IN-DA	The IWS blocks will arrive with low quality dimensional and cleanliness specifications (Procurement of VV: Contract Implementation Interfaces)	correction works are required by VV Supplier at additional F4E responsibility	Very Likely	High	Low	High	128	VERY HIGH	Improve interface with IO and IN DA	Unlikely	Low	Low	Negligible	4	MEDIUM
Market Situation and perceived difficulty of material production	Work Overload of Material Suppliers (Procurement of VV: Contract Implementation Commercial/Procurement)	Difficulties in material supply	Likely	Negligible	Low	High	64	VERY HIGH	Include liquidated damages for the procurement of the material in order to incentive the VV Supplier to give priority to the order	Unlikely	Negligible	Medium	Negligible	8	MEDIUM
ANB stringent and late input of requirements	Additional quality requirement will be placed in the supply (Procurement of VV: Contract Implementation Schedule)	Production difficulties	Very Likely	Negligible	Negligible	Medium	64	VERY HIGH	Improve communications with ANB	Unlikely	Negligible	Negligible	Low	4	MEDIUM
Lack of detailed information and changes to CfT drawings due to design changes	Underestimate the real cost since Received Offers are based on drawings before design is finalized (Procurement of VV, Tender Phase: Commercial)	Difficulties during tender negotiations	Likely	Low	Medium	Negligible	32	HIGH	F4E to launch contract to produce best possible CfT which accommodates change management	Not likely	Negligible	Low	Negligible	8	MEDIUM
Anticipation of Material Ordering (required due to tight Schedule)	Unsuitable blank material will be procured (Procurement of VV: Contract Implementation Schedule)	Production problem of final shaped product	Not likely	Low	Negligible	Medium	16	HIGH	Recovery material from over ranges and reuse in other components	Unlikely	Negligible	Negligible	Medium	8	MEDIUM
Difficult Technical and Commercial Requirements	companies perceive that the contract is high risk (Procurement of VV: Tender Phase: Commercial/Procurement)	No technically and commercially acceptable offer	Not likely	Negligible	Low	Medium	16	HIGH	Negotiate waiver on requirements						
Limited EB Welding Facilities	Large size EB facility required (Procurement of VV: Contract Implementation Schedule)	Production Bottlenecks for EB Welding	Unlikely	Low	Low	Medium	8	MEDIUM	Negotiate for prioritizing VV work						

Appendix C: Buildings

Identification			Rating Pre-Mitigation						Disposition	Rating Post-Mitigation					
Risk Label			Likelihood	Impact			Level		Mitigation Strategy / Actions	Likelihood	Impact			Level	
("As a result of...")	("There is a risk that...")	("Resulting in...")		TECH	COST	SCHED					TECH	COST	SCHED		
Large and wide contract comprising all design and monitoring activities in a "One of a kind project". Difficulties for F4E to make accurate estimate of the assistance contracts price from the functional requirements provided by ITER Organization	High Bid value for Architect Engineer Contract *(Commercial - Architect Engineer contractTendering Phase)*	Delay in procurement process. Higher cost than expected	Very Likely	Negligible	High	Medium	128	VERY HIGH	(I) Produce clear detailed specification (II) Clear selection criteria for prequalification phase (III) Stimulate competition by proper advertising of tender (IV) Give access to the additional French rules in order to keep equity (V) Clear definition and limitation of risk transferred to companies (VI) Prepare scope with possibility of reduction and deferral (options)	Likely	Negligible	Medium	Low	32	HIGH
First of such a type of contract launched by F4E.	Non compliant Architect Engineer offer with insurance, liability consequential liability. *(Commercial - Architect Engineer contractTendering Phase)*	Delay in procurement process	Very Likely	Negligible	Negligible	High	128	VERY HIGH	(I) Open prior discussion with the selected companies (II) Organize insurance meetings (III) Adapt our requirements to current practices	Not likely	Negligible	Negligible	Low	8	MEDIUM
(I) Duration too short to answer to Call for Tender; (II) Absence of agreement of the panel of adjudicators. Commercial Architect Engineer Contract-tender phase.	Possible objections raised by non selected consortia to the Architect Engineer after the award of the contract *(Commercial - Architect Engineer contractTendering Phase)*	delay in procurement process	Likely	Negligible	Negligible	High	64	VERY HIGH	(I) To have clear criteria and associate weight award formula (II) To partially accept delay request (III) To choose independent and impartial experts and change the expert if there is a good reason	Unlikely	Negligible	Negligible	Low	4	MEDIUM
IO's final functional requirements were not ready when the call for tender was launched	Impact of the replacement of Initial Functional Requirement by the Final Functional Requirement before signature of the Architect Engineer Contract. Requirement Final Functional Requirement . *(Commercial - Architect Engineer contract tendering Phase)*	delay in Architect Engineer contract signature	Not likely	Negligible	Low	Medium	16	HIGH	(I) Not to increase the scope (II) Try to simplify or reduce the scope (III)Trace and explain every changes (IV) Inform the tenderers of the replacement of Initial Functional Requirement by the Final Functional Requirement since the beginning	Unlikely	Negligible	Low	Low	4	MEDIUM

Missing information in the data provided by other Plant Breakdown Structure responsibles to ITER Organization	Insufficient quality of the Final Functional Requirements provided by ITER Organization. *(Technical: Architect Engineer Contract- detailed design phase)*	Delay in preliminary design phase and possible over cost in Architect Engineer contract	Likely	Medium	Medium	Medium	**32**	HIGH	I) To review the System Requirement Document and System Design Description with an expert panel (II) To organize a weekly meeting with ITER Organization/ Civil Construction & Site Office (CCS) (III) To give two additional months to ITER Organization to achieve the works (IV) To work jointly with ITER Organization on Interface Control Document and Interface Sheet	Likely	Low	Low	Low	**16**	HIGH
(I) Delay in the interface data provision by ITER Organization; (II) Insufficient quality of the Final Functional Requirements by ITER Organization; (III) Delay in ITER Organization approval after Design Reviews; (IV) Underestimate of the duration by F4E. Technical Architect Engineer - contract detailed design phase	Delay of the delivery of the tender and construction design by the Architect Engineer *(Technical: Architect Engineer Contract- detailed design phase)*	Start of construction works delayed and possible over cost in Architect Engineer contract	Very Likely	Negligible	Low	High	**128**	VERY HIGH	(I) To define with ITER Organization a procedure for the release by ITER Organization of interface data, each interface data associated with a deadline (II) To review the System Requirement Document and System Design Description with an expert panel, to organize a weekly meeting with ITER Organization / Civil and Construction Site office, to give two additional months to ITER Organization to achieve the works (III) To associate ITER Organization early in the Design process before launching the official Design Reviews	Likely	Negligible	Negligible	Medium	**32**	HIGH
Unattractive (too small) construction packages from a contractor's point of view	Lack of competition for the construction contract resulting in very high costs. *(Commercial Construction Contracts)*	Higher costs on the construction bids	Very Likely	Negligible	Low	Medium	**64**	VERY HIGH	(I) Attract international competition by tendering civil engineering packages of more than 200 MEUR	Not likely	Negligible	Negligible	Low	**8**	MEDIUM
High number of design changes Unforeseen additional works	Claim risk - Assistance Architect Engineer - Health and Safety - Support to the Owner and Construction contracts *(Commercial and Technical Assitance and construction Contracts)*	High increase of costs for assistance and construction Contract	Very Likely	Negligible	High	Low	**128**	VERY HIGH	(I) Panel of adjudicators (II) Assistance of Architect Engineer, Support to the Owner and legal expert (III) Make sure that the design specifications are fully and consistently defined.	Likely	Negligible	Medium	Negligible	**32**	HIGH
Large number of buildings, some of nuclear type, in a relatively small space with associated large risks to manage construction site activities	Constructability risk (logistics, access, storage areas) (*Technical construction Contracts)*)	Conflict in time and space use between construction contractors leading to delay and over cost	Very Likely	Medium	Medium	Medium	**256**	VERY HIGH	(I) To launch the call for tender for site preparation will be launch in 2010 to anticipate the arrival of companies and thousands of workers in 2011-2012 (II) To negotiate with ITER Organization to differ assembly of equipments that are not essential (III) To limit interfaces between construction companies by limiting the number of contracts	Not likely	Low	Low	Medium	**16**	HIGH

Appendix D: Neutral Beam (NB) Systems

Identification			Rating Pre-Mitigation						Disposition	Rating Post-Mitigation					
Risk Label			Likelihood	Impact			Level		Mitigation Strategy / Actions	Likelihood	Impact			Level	
("As a result of...")	("There is a risk that...")	("Resulting in...")		TECH	COST	SCHED					TECH	COST	SCHED		
Delays in the operation of NBTF-MITICA or in the achievement of the expected results	Not all the key components could have been tested and the relevant risk could not have been completely mitigated	Procurement contracts for the HNB could start without knowing whether the key components will work at full performances or not	Likely	High	Low	High	64	VERY HIGH	1) Delay as much as possible the start of the affected procurement contracts 2) To draw up procurement contracts will all the possible clauses to allow changes 3) Accept a delay in the start of HNBs operation	Unlikely	Medium	Negligible	Medium	8	MEDIUM
Assembly takes place in the ITER environment and several issues outside EU control may arise. The NB cell may not be ready in time with all the required services or The starting date may be delayed because the NB cell may not be accessible due to scenario 1 experiments	the NB cell is not accessible for the assembly or the assembly sequence is affected by other ITER activities	delay in start of operation and contractual implications	Likely	Negligible	Low	High	64	VERY HIGH	Control & Update the Schedule - The IO Milestones shall be ; i) identified (done), ii) incorporated in the schedule (done), iii) activated (not yet done), iiii) regularly reviewed by IO and F4E or the NB assembly is transferred to IO	Unlikely	Negligible	Negligible	Medium	8	MEDIUM
Technical problems during manufacture of individual NB components	may delay their availability following the schedule	delays in start operation	Likely	Negligible	Negligible	Medium	32	HIGH	Control & Update the Schedule - The IO Milestones shall be ; i) identified (done), ii) incorporated in the schedule (done), iii) activated (not yet done), iiii) regularly reviewed by IO and F4E	Not likely	Negligible	Negligible	Low	8	MEDIUM
Services unavailability (PS, CODAC, …) on the ITER site	the electric test (1MVolt) of the Transmission Line and Bushing may be delayed	delays in the start of operation	Likely	High	Negligible	Medium	64	VERY HIGH	Control & Update the Schedule - The IO Milestones shall be ; i) identified (done), ii) incorporated in the schedule (done), iii) activated (not yet done), iiii) regularly reviewed by IO and F4E	Not likely	Negligible	Negligible	Low	8	MEDIUM
Technical difficulties and lack of integration	The 1MVolt connection (electrical, hydraulic & mechanical interface) between the Bushing (Japan Procurement) and the Beam Source (EU) may be not defined enough.	delays in the start of operation	Not likely	High	Negligible	High	32	HIGH	A contract is planned to be placed. One of the deliverable is the writing of a detailed assembly procedure with a particular chapter detailing the connection between the Bushing and the NB Source.	Not likely	Negligible	Negligible	Low	8	MEDIUM

The not availability on the market of the Absolute Valve	a Supplier may not be found and/or the procurement of the Absolute Valve with a metallic seal of 1,6 meter may incur in serious difficulties	impossibility of procuring it and.or delays and extra costs	Likely	High	Negligible	Medium	64	VERY HIGH	A specific R&D program has been launched directly by IO for the manufacture and the test of a size 1 metallic seal & seat. Experts covered by a Grant placed by F4E will follow-up the fabrication and test.	Unlikely	Medium	Negligible	Low	8	MEDIUM
Time pressure,	PA may be launched without adequate specifications	Call for tender specifications not adequate and contractual difficulties	Unlikely	High	Negligible	High	16	HIGH	A contract is being placed well in advance to: - first design the components - then produce the 2D built-to-print drawings	Unlikely	Medium	Negligible	Low	8	MEDIUM
1MV DC bushing non standard and integration technically challenging	no guaranteed industrial interest to deliver	potential non-delivery	Very Likely	High	Negligible	Medium	128	VERY HIGH	Consultation with external expert, procurement strategy (competitive dialog), bushing prototype as part of procurement	Not likely	Low	Low	Low	8	MEDIUM
limited access to industry estimates, non-standard mode of operation, options, potential storage	cost uncertainties	extra costs	Likely	Negligible	Low	Negligible	16	HIGH	external cost estimates (engineering support contract, business intelligence,..) Encourage good commercial offers (weight of financial points in award criteria)	Not likely	Negligible	Low	Negligible	8	MEDIUM
Acceptance by F4E and IO do not coincide in time and scope	tricky transfer of responsibility	Project delays	Likely	Negligible	Negligible	Low	16	HIGH	Phased acceptance agreed with IO in the PA, in line with CAS	Unlikely	Negligible	Negligible	Low	4	MEDIUM

Comment: the NBTF is the main mitigating action for the most important risks on the core components of the ITER NB injectors. In this table, which refers to the risks for the components for the ITER injectors, it is assumed that the mitigating actions produced by the Test Facility have been carried out. Only therefore the residual risks are taken into account. It is remarked that since the core components, and the one requiring more development, of the NB system are to be specified by IO on the basis of build-to-print specifications, the ultimate responsibility for the activities necessary to achieve a full performing NB system lies with IO. IO is therefore the actual owner of many of the risks listed in the table (for instance the ones related to the injector performances). However, Europe has taken, over the last years, a leading position in supporting IO in those activities and consequently a certain level on co-responsibility is felt and therefore both IO and F4E are shown as Risk Owners. However, the final decisions on the design features and on most of the activities necessary are taken by IO.

Appendix E: Diagnostic Systems

Identification			Rating Pre-Mitigation						Disposition	Rating Post-Mitigation					
Risk Label			Likelihood	Impact			Level		Mitigation Strategy / Actions	Likelihood	Impact			Level	
("As a result of...")	("There is a risk that...")	("Resulting in...")		TECH	COST	SCHED					TECH	COST	SCHED		
Diagnostic components viewing the plasma exposed to combination of erosion by energetic neutrals and deposition of migrated carbon/beryllium eroded at the divertor and first-wall	Very demanding specifications for 'first mirrors' in diagnostic optical systems (LIDAR, CXRS and WAVS) for which no design solutions exist.	First mirror lifetime not consistent with RAMI requirements for diagnostic systems	Likely	Very High	Medium	High	128	VERY HIGH	1) Transfer to IO liabilities for design underperformance against RAMI requirements for systems including first mirrors; 2) Agree with IO a set of minimum mitigation measures to be incorporated in the design (likely to include mechanical shutters and calibration systems)	Not Credible	Very High	High	High	16	HIGH
ITER procedures envisage conduct of design reviews for whole diagnostic systems but sub-systems of individual diagnostics have a wide range of delivery dates in IPS from 2013 to 2021	R&D and design effort being conducted (in support of the design reviews) well before required for manufacture of the sub-system	Commitment profile inconsistent with budget	Likely	Medium	Low	High	64	VERY HIGH	1) Organise PA along the lines of 'separable sub-systems', with limited and easily defined interfaces, to allow phasing of design and supply meeting DA resource-levelling requirements	Unlikely	High	Low	Medium	16	HIGH
Slow contractual procedures, e.g. due to insufficiency of F4E technical personnel; a very small supplier base (single bidders); inadequate contract tender responses; or protracted contract negotiations	Inability to place timely contracts or complete R&D/Design on time	PA schedule not met and liabilities incurred in connection with delays in cross-party interfaces	Likely	Medium	Negligible	High	64	VERY HIGH	1) Minimize the number of R&D/design contracts by structuring system development as one large, initial contract (for suppliers to prove their ability to deliver complete, technically competent work to schedule) and a longer-term framework contract to complete the design (i.e. ensuring a very close collaboration between F4E and suppliers, making it possible to manage the development with a limited number of F4E personnel); 2) Carry out time-critical tasks using contracts with full supplier liability rather than on a 'best-efforts' basis	Unlikely	Medium	High	High	16	HIGH
High radiation environment experienced by in-vessel diagnostic components	Very demanding specifications for in-vessel electrical joints for which no qualified design solutions exist.	Electrical joining concepts not consistent with RAMI requirements for in-vessel diagnostic systems	Likely	High	Negligible	Medium	64	VERY HIGH	1) Conduct of urgent R&D as far as possible before PA signature - Urgent R&D for all diagnostic systems included in 2009 and 2010 Workprogrammes; 2) Follow several, parallel R&D paths	Unlikely	High	Medium	Medium	16	HIGH
Hardware needed for R&D and design activities undertaken in one contract has to be procured in a second, independent contract and is thus inconsistent with the first contract's schedule	Delays in the R&D and design	Incomplete R&D and PA schedule not met	Likely	Medium	Medium	High	64	VERY HIGH	1) Implement framework contracts in a number or areas for the supply and support of R&D/design activities. Pre-selected suppliers should be able to respond quickly to the procurement needs arising from R&D/design contracts; 2) Use contracts allowing both R&D/design and procurement activities	Unlikely	Low	Medium	Low	8	MEDIUM

System-level design fails to meet the ITER requirements as defined in the Project Requirements	If the PR requirement is required by the PA, this is a non-conformity	Significant cost increases, if ITER IO insist that requirements must be met	Likely	Low	Low	High	64	VERY HIGH	1) At the PA negotiations, agree reduced requirements for system that are more likely to be achievable; 2) Agree higher target requirements to be achieved by the design, on a best effort basis only; 3) Design system to be upgradeable to higher performance later during the ITER operational life, for maximum compatibility with the ITER Project objectives	Not Credible	Medium	High	High	8	MEDIUM
Immature state of diagnostic designs, including the need for significant R&D	Conceptual designs whose performance cannot be accurately evaluated relative to ITER requirements	Not possible to meet PA specifications with design approach proposed at conceptual design review	Not likely	Medium	Medium	High	32	HIGH	1) Conduct of urgent R&D as far as possible before PA signature - Urgent R&D for all diagnostic systems included in 2009 and 2010 Workprogrammes; 2) Break PA into 2 stages: design and manufacture. Once design approved at final design review, IO accepts full responsibility for functional performance	Unlikely	Low	Negligible	Medium	8	MEDIUM
Absent, incomplete or poor ITER documentation, forming part of the PA specifications	ITER Documentation which evolves over the PA lifetime	Not possible to meet PA specifications with design approach proposed at conceptual design review	Not likely	Medium	Medium	High	32	HIGH	1) Ensure that specifications in PA uniquely identify versions of documentation available at time of signature - any subsequent changes require PCR and mutual IO/F4E agreement; 2) PA specifications superceed ITER documentation if necessary	Not likely	Low	Negligible	Low	8	MEDIUM
R&D and design work carried-out with research-oriented organisations, who have limited experience of completing projects under 'commercial' terms and where fully adequate resources may not be available	Work being conducted by individuals without necessary skills, especially for Project Management	R&D and design activities not completed to cost and PA schedule	Not likely	Negligible	Low	High	32	HIGH	1) Ensure Calls for Proposals for R&D and design contracts incorporate measures enforcing close F4E control, such as: project boards involving senior management, weekly co-ordination meetings, experienced project managers, visits and working periods at F4E etc.	Unlikely	Negligible	Low	Medium	8	MEDIUM
Interfaces in PA to designs and components provided by other ITER Parties and thus outside of direct F4E control	Late delivery of interfacing designs and components	Design activities and assembled components not completed to PA schedule	Not likely	Negligible	Negligible	High	32	HIGH	1) Ensure interface responsibilities are always F4E-IO (i.e. no direct Party to Party interfaces); 2) Provide measures in the PA for adequate and frequent communication with interfacing Parties; 3) Synchronise, where possible, with PA signature of interfacing Parties	Unlikely	Negligible	Negligible	Medium	8	MEDIUM
Immature state of diagnostic designs, including the need for significant R&D	Difficulties in estimating total costs (design and manufacture) and thus an insufficient budget for completing the PA	Not possible to meet PA specifications	Not likely	High	Medium	High	32	HIGH	1) Conduct independent cost reviews using external 'Experts'; 2) Regular review and update of costs as PA proceeds; 3) Break PA into 2 stages: design and manufacture. Once design approved at final design review, IO accepts full responsibility for functional performance	Unlikely	Medium	Medium	Medium	8	MEDIUM
Cost-containment pressure to undertake R&D and design work using contracts defined on a 'best efforts' basis	Insufficient or inappropriate resources allocated to the work	R&D and design activities not completed to cost and PA schedule	Not likely	Negligible	Low	High	32	HIGH	1) Ensure Calls for Proposals for R&D and design contracts incorporate measures enforcing close F4E control, such as: project boards involving senior management, weekly co-ordination meetings, experienced project managers, visits and working periods at F4E etc.	Unlikely	Negligible	Low	Low	4	MEDIUM

High radiation environment experienced by in-vessel diagnostic components	Very demanding specifications for which no commercially available cables have been qualified as suitable	Cables not consistent with RAMI requirements for Magnetics Diagnostic and In-vessel Services	Unlikely	High	Low	Medium	**16**	HIGH	1) Conduct of urgent R&D as far as possible before PA signature - Urgent R&D for all diagnostic systems included in 2009 and 2010 Workprogrammes; 2) Follow several, parallel R&D paths; 3) Procure POZh cable (which preliminary tests have suggested may be suitable) now in order to allow more time to recover should manufacturing quality issues cause problems (as suspected)	Not Credible	High	Medium	Medium	**8**	MEDIUM
IPS requirement to install 'on-vessel' components (e.g. for Magnetics Diagnostic and In-vessel Services) in EU and Korean vacuum vessel factory, due to limited time available for installation after delivery of vacuum vessel sectors to ITER site	Very tight schedule for R&D, design and manufacture of on-vessel components	On-vessel components not completed to PA schedule	Not likely	Negligible	Negligible	Medium	**16**	HIGH	1) Negotiate for time to be allocated in the IPS for diagnostic installation at the ITER site, at least for first few vacuum vessel sectors; 2) Split fabrication schedules to allow earlier delivery of components required for installation in first few vacuum vessel sectors.	Unlikely	Negligible	Negligible	Low	**4**	MEDIUM

ANNEX III
ITER WORK BREAKDOWN STRUCTURE

ITER WORK BREAKDOWN STRUCTURE (APRIL 2009)-TOKAMAK BASIC MACHINE

Level 0	Level 1	Level 2	Level 3	Level 4	Level 5	Description	EU Share	PA Date	PA Status	Main Procurements Contracts Launched
X						ITER				
	X					ITER Construction				
		X				Tokamak Basic Machine				
			X			TKM Department / Program Management				
			X			Magnets				
				X		TF Coils		TF Conductor: Dec 2007	Signed	Cu Strand; Nb3Sn Strand; Radial Plate; Expr. Interest Winding Pack
					X	TF Coil No. 01 (TF01)				
					X	TF Coil No. 02 (TF02)				
					X	TF Coil No. 03 (TF03)	EU			
					X	TF Coil No. 04 (TF04)				
					X	TF Coil No. 05 (TF05)	EU			

					X	TF Coil No. 06 (TF06)				
					X	TF Coil No. 07 (TF07)	EU			
					X	TF Coil No. 08 (TF08)				
					X	TF Coil No. 09 (TF09)	EU			
					X	TF Coil No. 10 (TF10)		TF Coils: 01/06/2008	Signed	
					X	TF Coil No. 11 (TF11)	EU	TF Coils: 01/06/2008	Signed	
					X	TF Coil No. 12 (TF12)		TF Coils: 01/06/2008	Signed	
					X	TF Coil No. 13 (TF13)	EU	TF Coils: 01/06/2008	Signed	
					X	TF Coil No. 14 (TF14)		TF Coils: 01/06/2008	Signed	
					X	TF Coil No. 15 (TF15)	EU	TF Coils: 01/06/2008	Signed	
					X	TF Coil No. 16 (TF16)		TF Coils: 01/06/2008	Signed	
					X	TF Coil No. 17 (TF17)	EU	TF Coils: 01/06/2008	Signed	
					X	TF Coil No. 18 (TF18)	EU	TF Coils: 01/06/2008	Signed	
					X	TF Coil No. 19 (TF19)	EU	TF Coils: 01/06/2008	Signed	
					X	Pre-compression Rings	EU	Jan-2010		
				X		PF Coils		PF Conductor: May 2009	Signed	
					X	PF coil No. 1 (PF1)		PF Conductor: May 2009	Signed	
					X	PF coil No. 2 (PF2)	EU	PF Conductor: May 2009	Signed	
					X	PF coil No. 3 (PF3)	EU	PF Conductor: May 2009	Signed	

					X	PF coil No. 4 (PF4)	EU	PF Coils: June 2009	Signed	
					X	PF coil No. 5 (PF5)	EU			
					X	PF coil No. 6 (PF6)	EU			
				X		Central Solenoid (CS)				
				X		Correction Coils (CC)				
				X		Coil Feeder Sets				
			X			Vacuum Vesssel				
				X		Main Vessel & Supporting Systems		Nov 2009		Expr of Interest Fabrication
					X	VV Sector 1	EU			
					X	VV Sector 2	EU			
					X	VV Sector 3	EU			
					X	VV Sector 4	EU*			
					X	VV Sector 5	EU			
					X	VV Sector 6	EU			
					X	VV Sector 7	EU			
					X	VV Sector 8				
					X	VV Sector 9				
				X		In Vessel Coils				
			X			Cryostat Systems				

				X		Cryostat				
			X			Thermal Shields				
				X		Cryostat and VV Thermal Shields				
			X			Plasma Facing Components				
				X		Blanket System		July 2012		
					X	Wall Mounted First Wall & Shield	FW: 50% ; BS: 0			
					X	Upper Port Mounted	EU			
				X		Divertor		Cassette Integration: June 2011		
					X	Cassette 1-6	Cassette Integration & Inner Vertical Target: 100%			
					X	Cassette 7-24	Cassette Integration & Inner Vertical Target: 100%	Inner Vertical Target: Jan 2010		
					X	Cassette 25-60	Cassette Integration & Inner Vertical Target: 100%			
				X		Test Blanket Modules				
					X	EQ-Port No. 16	EU	TBD		

* A new sharing under discussion foresees this VV sector assigned to KO

ITER WORK BREAKDOWN STRUCTURE (APRIL 2009) - ANCILLARY SYSTEMS

Level 0	Level 1	Level 2	Level 3	Level 4	Level 5	Description	EU Share	PA Date	PA Status	Main Procurements Contracts Launched
X						ITER				
	X					ITER Construction				
		X				Ancillary Systems				
			X			CHD Department / Program Management				
			X			Diagnostics		Dec 2010 (TBD)		
				X		Upper Port Structure				
					X	Upper Port 01	EU	TBD		
					X	Upper Port 02				
					X	Upper Port 03	EU	TBD		
					X	Upper Port 05				
					X	Upper Port 07				
					X	Upper Port 08				
					X	Upper Port 09				
					X	Upper Port 10				

					X	Upper Port 14	EU	TBD		
					X	Upper Port 17				
					X	Upper Port 18				
					X	Generic Up Port Plug				
				X		Equatorial Port Structure				
					X	Equatorial Port 01	EU	TBD		
					X	Equatorial Port 03				
					X	Equatorial Port 09				
					X	Equatorial Port 10	EU	TBD		
					X	Equatorial Port 11				
					X	Equatorial Port 12				
					X	Generic Eq Port Plug				
				X		Lower Port Structures				
					X	Lower Port 04	EU	TBD		
					X	Lower Port 08				
					X	Lower Port 10				
					X	Lower Port 14				
					X	Lower Port 16	EU	TBD		
				X		In-Vessel				

				X		Services Hardware				
					X	In-Vessel	EU	TBD		
					X	Ex-Vessel				
					X	Windows				
					X	Port Plug Test Stand				
				X		Diagnostic Sub-Systems				
					X	Activation System				
					X	Beam Emission Spectroscopy				
					X	Bolometers Mini-Camera	EU	TBD		
					X	Bubble Chambers				
					X	Collective Thomson Scattering (LFS)	EU	TBD		
					X	CXRS Based On DNB (Core)	EU	TBD		
					X	CXRS Based On DNB (Edge)				
					X	Diamagnetic Loop	EU: 73%	TBD		
					X	Divertor Magnetics	EU: 73%	TBD		
					X	Divertor Neutron Flux Monitors				
					X	Divertor VUV Spectroscopy				
					X	Dust Monitor				
					X	ECA (Divertor)				

					X	ECE Front End / Receiver				
					X	ECE Transmission and Receivers				
					X	Erosion monitor				
					X	Fast Wave Reflectrometry				
					X	Halo Current Sensors	EU: 73%	TBD		
					X	H-Alpha (+ visible spectroscopy)				
					X	Hard X-ray Monitor (H-phase)	EU	TBD		
					X	High Resolution Neutron Spectrometer	EU	TBD		
					X	Impurity Influx Monitor (Div. Vis/UV)				
					X	Interferometer (Divertor)				
					X	In-vessel Magnetics	EU: 73%	TBD		
					X	IR Cameras, Vis/IR TV (Midplane)	EU: 89%	TBD		
					X	IR Cameras, Vis/IR TV (Upper)				
					X	IR Thermography (divertor)				
					X	Langmuir Probes				
					X	Laser-Induced Fluorescence				
					X	Lost Alpha Monitor				
					X	Microfission Chambers				
					X	MSE Based On Heating Beam				

					X	Neutral Particle Analyser				
					X	Neutron Flux Monitors				
					X	Outer-Vessel Magnetics	EU: 73%	TBD		
					X	Plasma position reflectometry	EU: 91%	TBD		
					X	Polarimeter				
					X	Pressure Gauges	EU: 89%	TBD		
					X	Radial Gamma Ray Spectrometers				
					X	Radial Neutron Camera	EU	TBD		
					X	Radial X-ray Camera				
					X	Reflectometer (Divertor)				
					X	Reflectometer (Main Plasma, HFS)				
					X	Reflectometer (Main Plasma, LFS)				
					X	Refractometry				
					X	Residual Gas Analyzers				
					X	Rogowski Coil Magnetics	EU: 73%	TBD		
					X	Thermocouples (inner target + vessel)	EU	TBD		
					X	Thermocouples (outer target)				
					X	Thompson Scattering Divertor (Inner)				
					X	Thomson Scattering (Core)	EU: 95%	TBD		

					X	Thomson Scattering (Divertor, Outer)				
					X	Thomson Scattering (Edge)				
					X	Thomson Scattering (X point)				
					X	Toroidal Interferometer/Polarimeter				
					X	Vertical Neutron Camera				
					X	Visible Continuum Array				
					X	VUV (Main Plasma)				
					X	X-Ray Crystal Spectrometer (core high-resolution)				
					X	X-Ray Crystal Spectrometer (Survey & Edge High Res)				
			X			Heating and Current Drive (Includes PS)				
				X		Ion Cyclotron H & CD				
					X	IC Control System				
					X	IC Antenna Equatorial Port 13 & 15	EU	Sep 2013		
					X	IC Transmission Lines Port 13 & 15				
					X	IC RF Power Sources Port 13 & 15				
					X	IC RF Power Supply Port 13 & 15				
					X	IC Test Facilities and Power Loads				
					X	IC System Assembly				

					X	IC Global System Integration & Management				
				X		Electron Cyclotron H&CD				
					X	EC Equatorial Launcher				
					X	EC Upper Launchers Upper Ports 12, 13, 15 & 16	EU	1st Part: Sep 2012 2nd Part: Oct 2013		
					X	EC Transmission Line				
					X	EC Gyrotrons	EU: 31%	Aug 2011		
					X	EC Power Supply	EU: 92%*	Dec 2011		
					X	EC Auxiliary Systems				
					X	EC Syst Integration, Assembly & Management				
				X		Neutral Beam H&CD System				
					X	Beam Source and HV Bushing	EU: 41%	Jan 2017		
					X	Beamline Components, Vessels & Magnetic Shielding				
						Beamline Components	EU	Sep 2015		
						Pressure vessel, drift duct, shutter, valve	EU: 76%			
						Magnetic shielding	EU: 50%	June 2013		
						ACC Coils	EU	Nov 2013		
					X	HNB Power Supply	EU: 31%	July 2009		HNB Ion Source Power Supplies

										(ISEPS)
					X	NB System Assembly and Testing	EU	June 2014		
				X		Diagnostic Neutral Beam				
					X	DNB Injector				
					X	DNB Power Supply				
					X	DNB System Assembly and Testing				
				X		Neutral Beam Test Facility	EU: 68%	June 2010		
					X	MVTF Neutral Beam Test Facility				
					X	ISTF Neutral Beam Test Facility				
				X		Lower Hybrid H&CD system				
					X	LH Control System				
					X	LH Launcher				
					X	LH Transmission Lines				
					X	LH RF Power Sources				
					X	LH RF Power Supply				
					X	LH Test Facilities and Power Loads				
					X	LH System Assembly				
					X	LH Global System Integration & Management				

			X			Instrumentations & Controls				
				X		CODAC				
				X		Central Interlock Systems				
					X	System Development Activities				
					X	Development of Central Interlock Systems				
					X	System Integration and Verification				
					X	Commissioning				
				X		Central Safety Systems				
					X	Planning and management				
					X	Reviews & Communications				
					X	System Development Activities				
					X	Development of Central Safety Systems				
					X	System Integration and Verification				
					X	Commissioning				
				X		Plant Systems I&C Support (to be developed together with IPT)	EU			

* A new sharing under discussion foresees a lower percentage for EU

TABLE VI - ITER WORK BREAKDOWN STRUCTURE (APRIL 2009) - PLANT SYSTEMS

Level 0	Level 1	Level 2	Level 3	Level 4	Level 5	Description	EU Share	PA Date	PA Status	Main Procurements Contracts Launched
X						ITER				
	X					ITER Construction				
		X				Plant Systems				
			X			CEP Department / Program Management				
			X			Electrical Power Supply & Distribution System				
				X		AC Power Distribution System				
					X	Steady State Electrical Network	EU et al.	Det.Design: Oct 2009 Assembly: Apr 2010 Mat.Proc: June 2011 Mat Proc.emergency PS: June 2011		
					X	Pulsed Power Electrical Network	EU et al.			
				X		Electrical Support Systems				
					X	Cable Trays & Cables	EU			

					X	Earthing Systems	EU			
				X		Coil Power Supply				
			X			Cooling Water Systems				
				X		Tokamak Cooling Water System				
				X		Heat Rejection				
			X			Cryogenic System				
				X		Cryo Plant				
					X	Liquid Helium Plant				
					X	Liquid Nitrogen Plant	EU	Dec 2010		
					X	Auxiliary Systems	EU			
					X	Interconnection Box				
				X		Cyro & Warm Lines				
				X		Distribution Boxes				
			X			Radioactive Materials Support				
				X		Hot Cells & Radwaste Facilities				
					X	Refurbishment, Maintenance & Storage of Component Cells				
					X	Port Plug Test Cells				
					X	Mock-Up, Remote Handling Maintenance & Storage Cells				

					X	Type B & PurelyTritiated Waste Cells				
					X	Low Level Radwaste Facility Integration				
				X		Radwaste Treatment & Storage Systems				
					X	Type B & Purely Tritiated Radwaste Treatment and Storage System				
					X	Low-level (Type A) Radwaste Treatment and Storage System	EU	Dec 2015 (TBD)		
					X	Very Low-level (TFA) Radwaste Treatment and Storage System	EU et al.			
			X			Fuel Cycle Systems				
				X		Tritium Plant				
					X	Tritium Exhaust Processing				
					X	Highly Tritiated Water Processing Systems				
					X	Isotope Separation System	EU	Feb 2015		
					X	Storage & Delivery System				
					X	Water Detritiation System	EU	1st Part: June 2010 2nd Part: Dec 2013		
					X	Detriation System				

					X	Analytical System				
					X	Automated Control System				
					X	Tritium Transportation				
				X		Vacuum Systems				
					X	Cryopumps	EU	Cryopumps:June 2013; CVB & Cryojump.: Jul 2012; NB & DNB Cryo: TBD		
					X	Roughing pumps				
					X	Leak detection system	EU	Apr 2011		
					X	Vacuum Auxiliary Systems				
					X	Vacuum Commissioning Support				
				X		Fuelling and Wall Conditioning				
					X	Gas Distribution System				
					X	Gas Injection System				
					X	Pellet Injection System				
					X	Glow Discharge Conditioning System				
					X	Disruption Mitigation System				

				X		Radiological Protection Systems				
					X	Radiological Protection	EU	Sep 2010		
					X	HVAC Trigger Monitors	EU			
					X	Occupational Protection Systems	EU			
					X	Environmental Monitoring	EU			

ITER WORK BREAKDOWN STRUCTURE (APRIL 2009) - BUILDINGS

Level 0	Level 1	Level 2	Level 3	Level 4	Level 5	Description	EU Share	PA Date	PA Status	Main Procurements Contracts Launched
X						ITER				
	X					ITER Construction				
		X				Buildings and Site				
			X			Site Preparation				
				X		Site Preparation - Overall	EU/France			
					X	Annexe Buildings				
					X	400 kV Electrical supply (FC)				
					X	Site Preparation Works				
			X			Buildings & Site Infrastructures				
				X		Common Work				
				X		Buildings	EU			
					X	Tokamak Excavations (12)		PF Coil Bui: Nov 2008		Design & Construction PF Coils Fabrication Building
					X	Seismic Isolation Basemat (19)				
					X	Tokamak Bldg (11)				

					X	Assembly Building (13)				
					X	Tritium Bldg (14)				
					X	RF Heating Bldg (15)				
					X	Cleaning Facility Building (17)				
					X	Hot Cell Bldg (21)				
					X	Rad Waste Bldg (23)				
					X	Personnel Access Control Bldg (24)		Architect/Eng Services: May 2009		Architect Engineer for ITER Buildings & Civil Infrastructures
					X	Magnet Power Conversion Bldg 1 (32)				
					X	Magnet Power Conversion Bldg 2 (33)				
					X	NB Power Supply Bldg (34)				
					X	Main Alternating Current Distribution Bldg (36)				
					X	NB High Voltage Power Supply Bldg (37)				
					X	Reactive Power Control Bldg (38)				
					X	Fuel Tanks Train A (42)				
					X	Fuel Tanks Train B (43)				
					X	Emergency Power Supply Bldg Train A (44)		Excavations: May 2009		
					X	Emergency Power Supply Bldg Train B (45)				
					X	MV Distribution Bldg LC/1A (46)				
					X	MV Distribution Bldg LC/1B (47)				

					X	Cryoplant Compressor Bldg (51)				
					X	Cryoplant Coldbox Bldg (52)				
					X	Infrastructure for Cryoplant Storage Tanks (53)				
					X	PF Coil Fabrication Bldg (55)				
					X	Site Services Bldg (61)				
					X	Hot Basin & Cooling Towers (67)				
					X	Cooling Water Pumping Station (68)				
					X	Heat Exchangers (69)				
					X	Control Bldg (71)				
					X	Diagnostic Bldg (74)				
					X	Fast Discharge Unit & Switching Network Resistor Bldg (75)				
				X		Site Infrastructures				
					X	Service Trenches		Anti-Seismic Pads: May 2009		
					X	Plant Bridges				
					X	Precipitation Water Drainage		Construction (Reinforced Concrete and Steelframe Bui): Jan 2010		Safety & Health Protection Coordination;
					X	Industrial Water Drainage				
					X	Sanitary Water Drainage				
					X	Roads, Parking & laydown Areas				

					X	Special foundations				General Support to the Owner Contract
					X	Nuclear Fence				
					X	Non-nuclear Fence				
					X	Outdoor Lighting Equipment				
				X		Liquid and Gas Distribution				

ITER WORK BREAKDOWN STRUCTURE (APRIL 2009) - SITE ASSEMBLY

Level 0	Level 1	Level 2	Level 3	Level 4	Level 5	Description	EU Share	PA Date	PA Status	Main Procurements Contracts
X						ITER				
	X					ITER Construction				
		X				On-Site Assembly / Installation / Testing				
			X			On-Site Assembly				
				X		Machine Assembly				
				X		Tokamak Plant Assembly				
			X			Assembly Tooling				
			X			Assembly Operations				
			X			Logistics				
			X			Manufacturing Oversight				
			X			Preparation for Hands-on Maintenance / Repair				
			X			Remote Handling Equipment				
				X		In-Vessel				
					X	Blanket RH System				
					X	Divertor RH System	EU	Feb 2011		

					X	In-Vessel Viewing System	EU	Apr 2011		
				X		Ex-Vessel				
					X	Neutral Beam RH System	EU	Apr 2012		
					X	Hot Cell RH System				
					X	Cask & Plug RH System	EU: 50%*	Mar 2011		
					X	RH Control System				

* A new sharing under discussion foresees this RH component to be a EU procurement at 100%