



UPDATE OF STATUS OF ITER AND ITER DIAGNOSTICS

A E Costley

ITERO, Cadarache, France

**12th Meeting of the ITPA Diagnostic Topical Group
Princeton Plasma Physics Laboratory, 26 - 30 March, 2007**

ITER_D_25NY44



PLAN

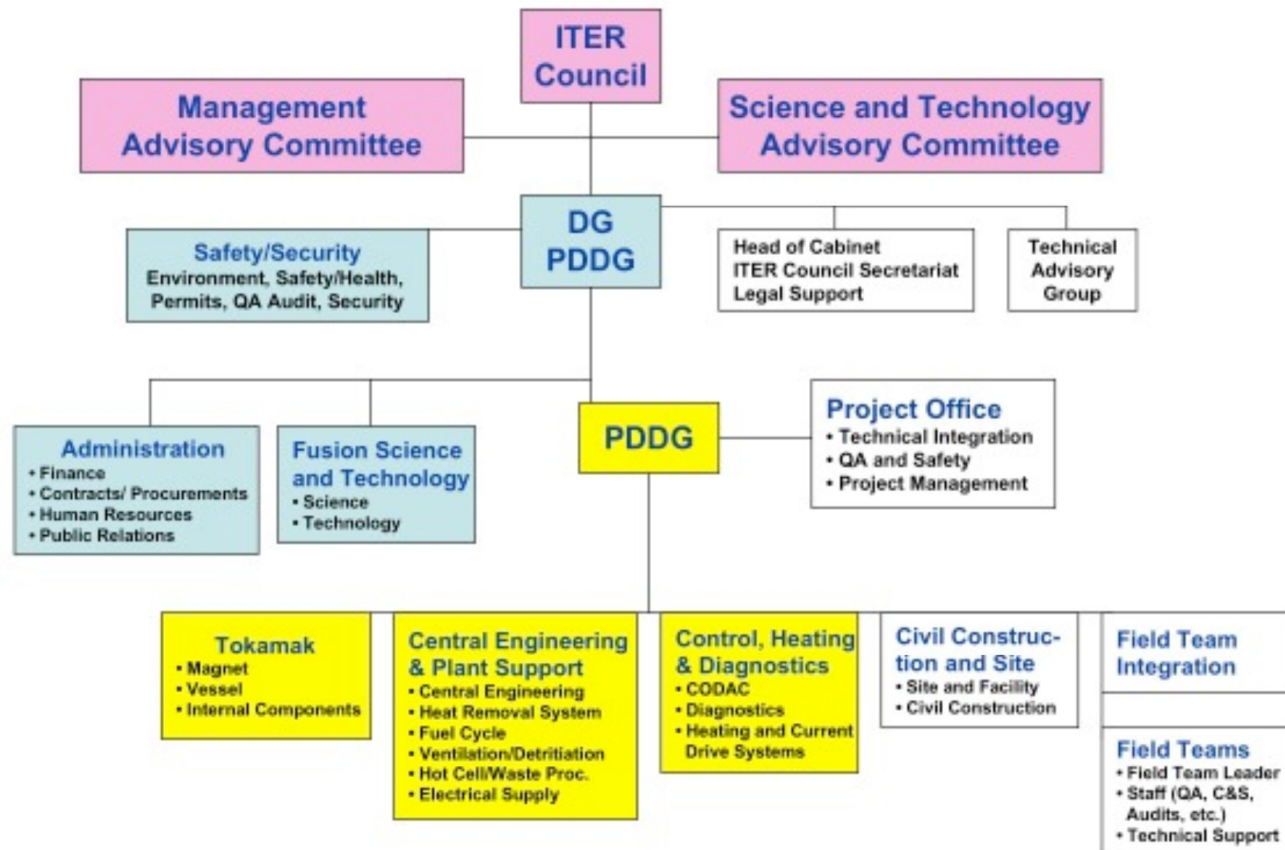


- **Development of ITER Organisation**
- **Principal Activities Undertaken and Ongoing**
- **ITER Design Review**
- **Some Recent Developments in Diagnostics**
 - Includes status of some key diagnostic related issues
- **Summary**



DEVELOPMENT OF ITERO

September '06

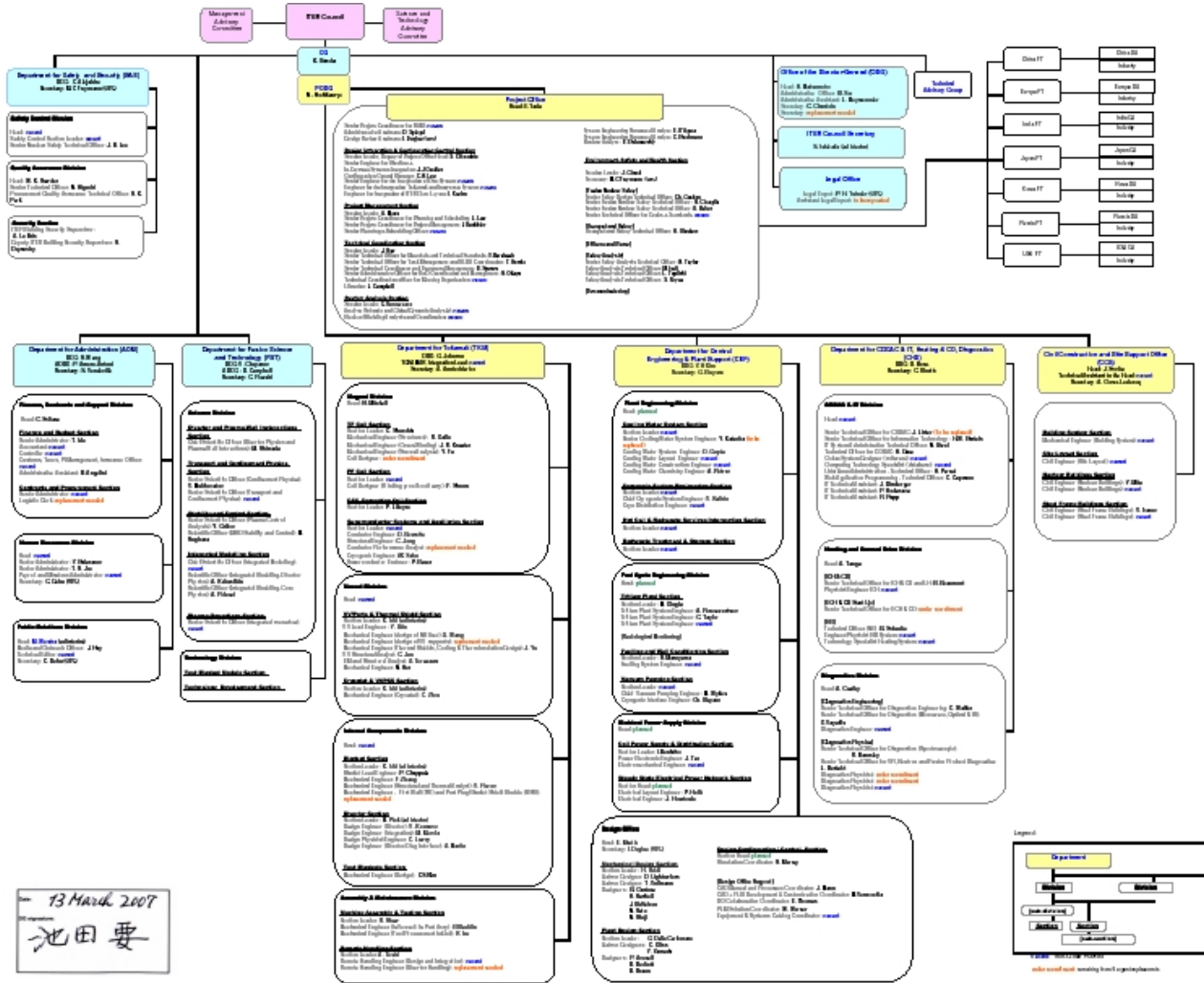


~ 30 staff at Cadarache



March, '07

DEVELOPMENTS IN ITERO

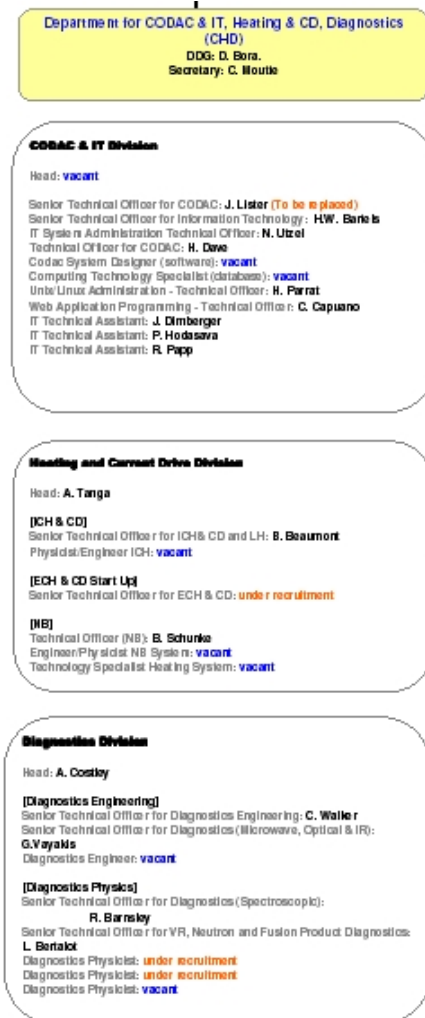


~ 130 staff at Cadarache + ~70 by summer + ~30 by end of year



CODAC, HCD AND DIAGNOSTICS DEPT.

17 staff --> 27
by summer



DIAGNOSTICS DIVISION

Diagnostics Division

Head: **A. Costley**

[Diagnostics Engineering]

Senior Technical Officer for Diagnostics Engineering: **C. Walker**
Senior Technical Officer for Diagnostics (Microwave, Optical & IR): **G.Vayakis**
Diagnostics Engineer: **vacant**

[Diagnostics Physics]

Senior Technical Officer for Diagnostics (Spectroscopic): **R. Barnsley**
Senior Technical Officer for VR, Neutron and Fusion Product Diagnostics: **L. Bertalot**
Diagnostics Physicist: **under recruitment**
Diagnostics Physicist: **under recruitment**
Diagnostics Physicist: **vacant**

5 staff --> 9 by summer, --
> 10 by end of yr hopefully.

Naka and Garching JWSs closed at the end of 2006.

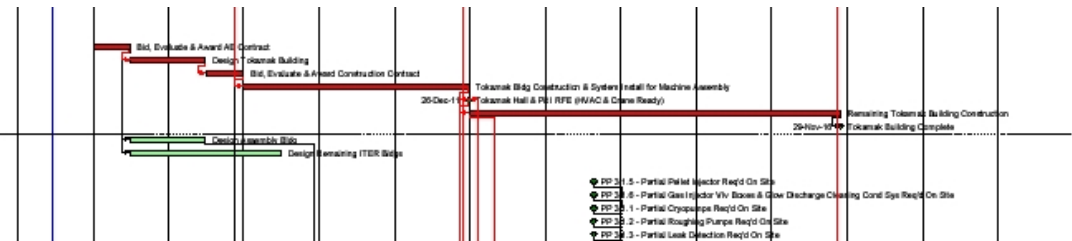


PRINCIPAL ACTIVITIES UNDERTAKEN AND ON-GOING

Development of an Integrated Project Schedule (IPS)

--> shows all major activities and their main links until the end of the construction plan. First plasma 24 Dec 2016.

Tokamak Building (I1)		2587	01-Jan-07	29-Nov-10	353		1088
Building Construction							430
61F101D	Bld, Evaluate & Award AE Contract	130	01-Jan-07	29-Jun-07	-63	y	J.01
61F102D	Design Tokamak Building	261	02-Jun-07	30-Jun-09	-63	y	J.01
61F103D	Bld, Evaluate & Award Construction Contract	130	01-Jun-07	29-Dec-08	-63	y	J.01
62A104D	Tokamak Bldg Construction & Systems Install for Machine ...	780	30-Dec-08	29-Dec-11	-63	y	J.01
62A105D	Tokamak Hall & PE1 RFE (M&C & Crane Ready)	0		29-Dec-11	-63	y	J.01
62A110D	Remaining Tokamak Building Construction	1286	27-Dec-11	29-Nov-10	-7	y	J.01
62A113D	Tokamak Building Complete	0		29-Nov-10	353	y	J.01
61F110D	Design Assembly Bldg	261	02-Jun-07	30-Jun-09	362	y	J.01
61F103D	Design Remaining ITER Bldg	522	02-Jun-07	30-Jun-09	2588	y	J.01
Tokamak Auxiliary Systems							136
31E215D	PP 3.1.5 - Partial Pellet Injector Req'd On Site	0	21-Aug-13	21-Aug-13	52	y	J.02
31E315D	PP 3.1.6 - Partial Gas Injector Vlv Boxes & Glow Discharge...	0	21-Aug-13	21-Aug-13	52	y	J.02
31C115D	PP 3.1.1 - Partial Cryopumps Req'd On Site	0	21-Aug-13	21-Aug-13	52	y	J.02
31B115D	PP 3.1.2 - Partial Roughing Pumps Req'd On Site	0	21-Aug-13	21-Aug-13	52	y	J.02
31D115D	PP 3.1.3 - Partial Leak Detection Req'd On Site	0	21-Aug-13	21-Aug-13	52	y	J.02



Development of PT Project Schedules

--> shows all major activities in the PTs. Dialogue to achieve consistency with IPS.

The integration of diagnostics in the IPS is a major undertaking and has only just begun.



Development of Resource Loaded Work Plan

- > shows all major activities, work required and needed resources
- > comparison with current and anticipated resources shows where extra help is required --> appeal to PTs.

Activity	Start Date	End Date	Feb-07				Mar-07				Apr-07				May-07				Jun-07				Jul	
			Phys	Eng	Anlys	Cad	P	E	A	C	P	E	A	A	P	E	A	C	P	E	A	C	Phys	Eng
Key Milestones																								
1. Interfaces																								
Identification	2007-02-01	2007-03-31	0.2	0.2	0	0	0.4	0.4	0	0														
Location of early procurement interfaces	2007-03-07	2007-06-30					0.2	0.1	0	0	0.2	0.1	0	0	0.2	0.1	0	0.2	0.4	0.2	0	0.4		
Location of remaining interfaces	2007-07-01	2007-07-31																				0.2	0.2	
Description	2007-08-01	2007-10-31																						
Scheduling	2007-11-01	2007-12-30																						
Review and sign off	2008-01-01	2008-02-28																						
2. Port Engineering																								
Initiation of Port Engineering Task Force	2007-01-20	2007-03-15	0.2	0.2	0	0	0.4	0.4	0	0														
Plan for detailed PT work on ports	2007-03-16	2007-12-31					0.2	0.2	0	0	0.2	0.2	0	0	0.2	0.2	0	0.5	0.2	0.2	0	0.5	0.2	
Design of diagnostics support structures for two representative ports		2007-12-31																	0.2	0.5	1	1	0.2	
Detailed specifications		2008-01-31																						

- > aim for consistency with IPS.
- > requested WPs from PTs.

Development of Criteria and Rules for Credit Accounting

- > defines what activities (design and R&D) will be credited in preparation for procurement.



Development of Task Tracking system

- > shows status of credited and voluntary tasks (tasks undertaken by PTs in preparation for procurement but included in ITER task system to validate that work is required for ITER and to bring documentation into ITER system) .**

Development of Integrated Procurement Planning

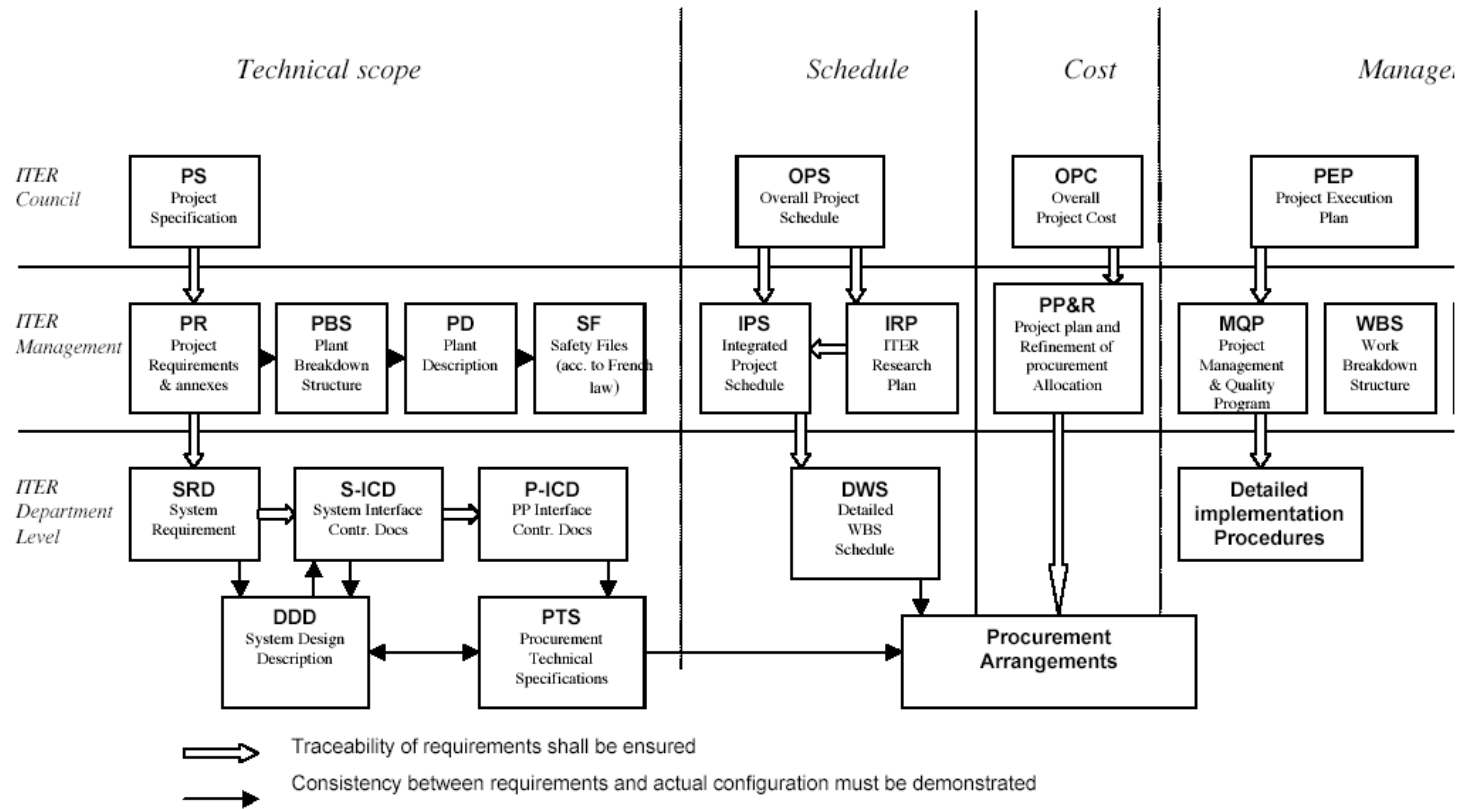
- > aiming for consistent plan of issuance from ITERO to acceptance and implementation by Domestic Agencies (DAs) and delivery of hardware to ITERO.**
- > aiming for overall consistency of IPS, ITER WP, PT WPs and procurement to achieve first plasma in 2016.**

Development of Definition of First Plasma

- > aim to define parameters of first plasma, I_p , B_t etc. Just started.**



Development of New Documentation Arrangementment



For diagnostics many elements are in place but restructuring and some additional writing will be needed.



ITER DESIGN REVIEW

(extracts report to ICII Prep. Mtg, 27-28 March, by G Janeschitz)

Three main goals:

- **To support the creation of an updated Baseline Design 2007 which:**
 - **confirms or redefines the physics basis and requirements for the project;**
 - **is the basis for the procurement of the long lead items (Vacuum Vessel, Magnets, Buildings);**
 - **provides input for the Preliminary Safety Report.**

For components and systems which are procured at a later date or for issues with lower priority review work will continue into the year 2008.

- **To put the ITER design decisions on a broad basis by involving the worldwide fusion community (physics and engineering)**
 - **Thus the fusion community and the parties will feel a higher level of involvement.**



- **To broaden the knowledge basis into the parties which is essential for a successful procurement of the ITER components in kind**
 - **A significant part of technical coaching of industry and of the QA will rest with the Domestic Agencies (DAs).**



- The design review is performed by **8 working groups (WGs)** covering those areas which are **essential for the goals 2007**:
 - WG-1: Physics and Requirements
 - WG-2: Safety and Licensing
 - WG-3: Buildings
 - WG-4: Magnets
 - WG-5: Vacuum Vessel
 - WG-6: Heating and Current Drive
 - WG-7: Tritium
 - WG-8: In Vessel Components

Other groups can be formed if needed.



- **The WGs have all together ~ 140 members from the parties and the IO**
 - **The membership consists of leading experts of the fusion community in each party;**
 - **The groups are chaired each by an expert from one of the parties with a co-chair from the IO;**
 - **The groups have written manifestos explaining the scope of their work (see ITER technical web);**
 - **In order to solve issues work packages need to be agreed with the parties based on the work plans established by the design review working groups (WGs) (see also later).**

Approximately every 6 weeks interface meetings between the chairmen, the ITER co-chairmen of the WGs and a few specialists take place either in person or by phone / video conference.



Status of the Design Review

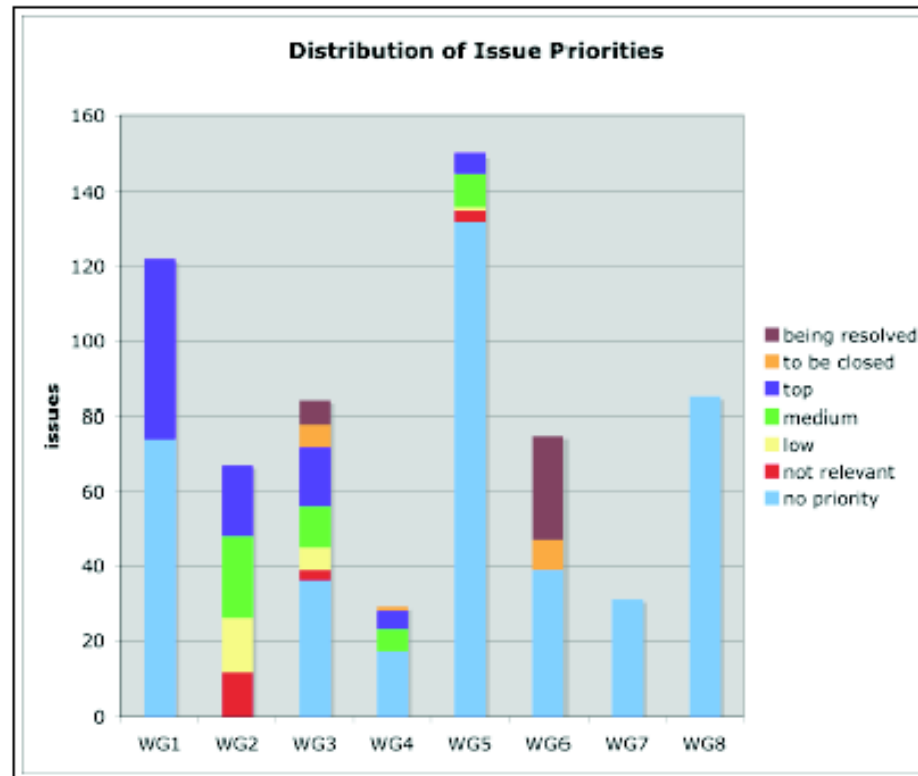
- ~ 200 issues existed for several years but were, for different reasons, not solved or rejected;
- Another ~ 250 were added by the parties last autumn when the design review process started;
- Thus ~ 450 issue cards existed when the design review working groups were formed in December of 2006 and started their work;
- ~ 70 issues relate to diagnostics.

The working groups have **prioritized the issues**, added issues where required (mostly interface issues with other groups) and have established a workplan to resolve them in time for the procurement schedule.



Status of the Design Review

Prioritisation and progress with issues is presented in the ITER document ITER_D_25DRSU.





Extract from Issues Data Base

Issues and Working Groups for ITER Design Review 2006/2007 (by name)

Priority: Low Med. Top Not rel.

Issue	Title	Status	Working Group	1	2	3	4	5	6	7	8
1.5-08	Design of the VV support to be finalised	on_going	Vacuum Vessel								
1.5-09	Design of the cryopump ports to be completed	on_going	Vacuum Vessel					☑			
1.5-10	Design of the NB port structures to be completed	on_going	Vacuum Vessel					☑			
1.5-11	In-port plug system - Definition of Concept	on_going	Vacuum Vessel								
1.5-14	Port tolerances and required gaps	on_going	Safety and Licensing, Vacuum Vessel								
1.5-15	Detailed thermal-hydraulic analysis	on_going	Vacuum Vessel								
1.5-16	Drain and drying of the VV coolant	on_going	Vacuum Vessel					☑			
1.5-17	Provision for Instrumentation (connectors, channels and holes) in vessel	on_going	Design requirements & Physics Objectives, Vacuum Vessel	☑				☑			
1.5-18	Detailed study of the necessity for leak and pressure tests	on_going	Design requirements & Physics Objectives, Safety and Licensing, Vacuum Vessel	☑							
1.5-19	WG1-D05-D06 Carbon erosion/ deposition/ control of tritium inventory and material choice	on_going	Design requirements & Physics Objectives, Safety and Licensing, Vacuum Vessel, In Vessel								☑
1.5-20	Interface with other In-Vessel Systems	on_going	Vacuum Vessel					☑			
1.5-21	Improvement of the VV Technical Specification Documents (TSD)	on_going	Vacuum Vessel					☑			
1.5-22	Rigid Blanket Manifolds - Optimisation or Re-Design to Flexible System	on_going	Vacuum Vessel, In Vessel Components								☑
1.5-23	In Service Inspection (ISI) requirements	on_going	Design requirements & Physics Objectives, Safety and Licensing, Vacuum Vessel, In Vessel	☑							☑
1.5-24	Assembly of the flexible cartridge	on_going	Vacuum Vessel, In Vessel Components								☑
1.5-25	Calculation basis of EM forces w.r.t. Code	on_going	Safety and Licensing, Vacuum Vessel					☑			
1.5-26	Finalisation of VV Design and Design Assumptions	on_going	Vacuum Vessel					☑			
1.5-27	VV tolerances at sector edge	on_going	Vacuum Vessel					☑			
1.5-28	Rules and regulations for the fabrication of Vacuum Vessel Sectors	on_going	Vacuum Vessel					☑			

Proposed status: to be closed Being solved



Extract from Issues Data Base

Issues and Working Groups for ITER Design Review 2006/2007 (by name)

Priority: Low Med. Top Not rel.

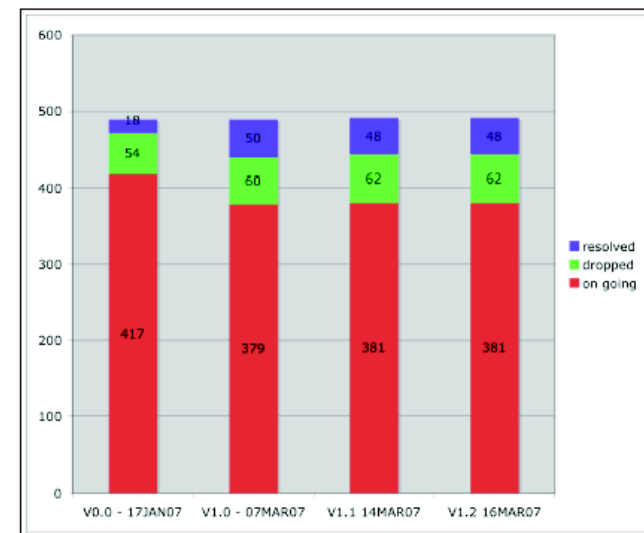
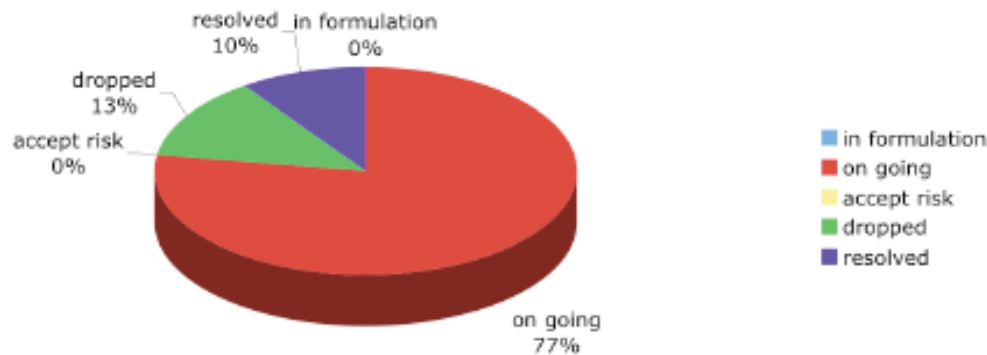
Issue	Title	Status	Working Group	1	2	3	4	5	6	7	8
5.5-07	Engineering Analysis for Diagnostic Port Plug Systems	on_going	Vacuum Vessel					<input checked="" type="checkbox"/>			
5.5-08	Integration of (non Diagnostic) In-Vessel Machine Instrumentation	on_going	Vacuum Vessel, In Vessel Components					<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>
5.5-09	Gaps Around Port-plugs	on_going	Vacuum Vessel					<input checked="" type="checkbox"/>			
5.5-10	Modifications to Poloidal-Going Gaps between modules	on_going	Vacuum Vessel, In Vessel Components					<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>
5.5-11	Cut-Outs In Blanket Modules adjacent to upper port	on_going	Vacuum Vessel, In Vessel Components					<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>
5.5-12	RGA heads in high pressure, magnetic, radiation fields	on_going	In Vessel Components								<input checked="" type="checkbox"/>
5.5-13	In-situ RGA calibration	on_going									
5.5-14	Upper ports above NBI	on_going									
5.5-15	Unused port utilization	on_going									
5.5-16	Design of a duplicate pressure gauge sensor system.	on_going	Design requirements & Physics Objectives	<input checked="" type="checkbox"/>							
5.5-17	ITPA: DI-4. Reliability of mirrors used in diagnostic systems	on_going	Design requirements & Physics Objectives	<input checked="" type="checkbox"/>							
5.5-18	ITPA: DI-5. Specifications of the diagnostic neutral beam	on_going	Design requirements & Physics Objectives, Heating	<input checked="" type="checkbox"/>					<input checked="" type="checkbox"/>		
5.5-19	ITPA: DI-7. Change of Toroidal Angle of Diagnostic Neutral Beam (DNB)	on_going	Design requirements & Physics Objectives, Heating, In Vessel Components	<input checked="" type="checkbox"/>					<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
5.6-01	Heat load on First Wall (effects of the TBM)	on_going	Design requirements & Physics Objectives, Vacuum Vessel, In Vessel Components	<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>
5.6-02	Insufficient space allocated for the TBM cooling system	on_going	Buildings, Vacuum Vessel			<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>			
5.6-03	Parking space for the TBM component in the port cell	on_going	Buildings, Vacuum Vessel			<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>			
5.6-04	Responsibility for the procurement of the TBM port plug frame and shielding	on_going	Vacuum Vessel					<input checked="" type="checkbox"/>			
5.6-05	Space and RH equipment in the Hot cell for TBM maintenance	on_going	Buildings			<input checked="" type="checkbox"/>					
5.6-06	WG1-D03 ITPA: Ripple-2. Minimization of the TF ripple caused by ferromagnetic Test Blanket Modules (TBMs)	on_going	Design requirements & Physics Objectives, Magnets		 			<input checked="" type="checkbox"/>			

Proposed status: to be closed Being solved



Many of these issues are similar and can be combined or are minor, or can be addressed after 2007, however, **~ 60 high priority issues** remain after the prioritization process and must be addressed.

- After the prioritization process several issues are already solved and some are dropped for different reasons (already included in another issue, or irrelevant, etc)
- The integration into 60 high priority issues is not reflected in the database yet.





Resolution of the Issues

- The WGs have also the charge to solve the **high priority issues** but cannot do this themselves
 - The work to solve the issues should be performed by **manpower provided by the parties** based on the work plans established by the WGs together with the IO
 - It is proposed to perform this work by **voluntary task agreements** based on a short technical specification for each task (written by WGs + IO)
 - The WG chairmen together with the corresponding IO co-chairman as well as the IO-RO for the system in question will then be responsible that the work is performed in time for the procurement schedule and that the required documentation is updated or established, i.e. the **Baseline 2007**.



Areas Where Changes Are Likely

- Thus far several areas have been identified where significant changes to the ITER Baseline design are likely to be necessary.
 - The provision of ELM and Resistive Wall Mode control
 - Plasma Facing Materials in particular in the divertor
 - Tritium Plant and T handling in the whole system
 - Buildings and in particular tokamak and Hot Cell buildings
- The aim is to have a first draft of the updated baseline, concentrating on project and system requirements, in July 2007.
- Within the same time frame we should have a good indication of what can be achieved by November 2007 when the new Baseline 2007 concentrating on the long lead items should be available.

Both goals require significant resources from the parties.



SOME RECENT DEVELOPMENTS IN DIAGNOSTICS

Contributed to all the project management activities

Development of IPS, development of work plan; assessment of manpower needs, estimate of procurement spend profile, assessment of outstanding R&D needs; contributions to design review, etc.

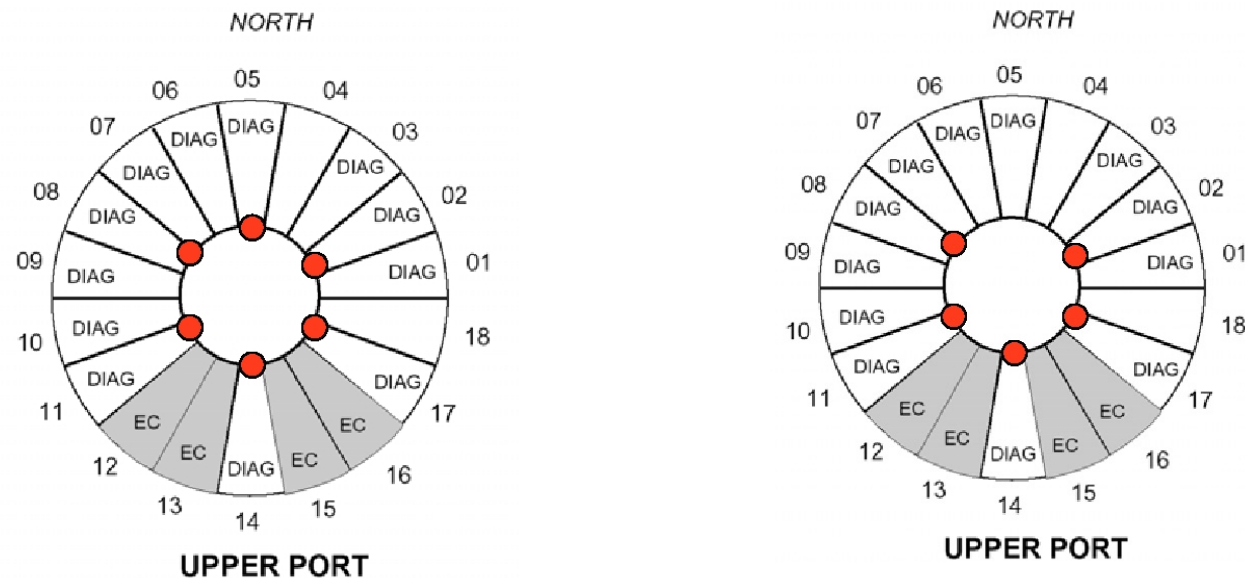
Review of buildings

Changes in the buildings are likely to reduce cost. Significant changes in the **Neutron Test Area (NTA) and the **Diagnostic Test Area (DTA)** are probable. Both are currently in the Hot Cell Building. The return of the NTA is under investigation. A reduction in size of the DTA is probable. No other changes which affect our 'real estate' are expected (except likely change in upper ports in NB Cell (DCR 49)).**



PROBABLE REDUCTION IN MEASUREMENT CAPABILITY IN UPPER PORTS 4, 5, 6 AND 7 (DCR49)

The necessity to maintain the neutral beams with vertical access means that it may not be possible to install all planned diagnostics in upper ports 4, 5, 6 and 7. The most serious loss would be the loss of the IR first wall viewing system in upper port 5 but upgrade capability would also be reduced.

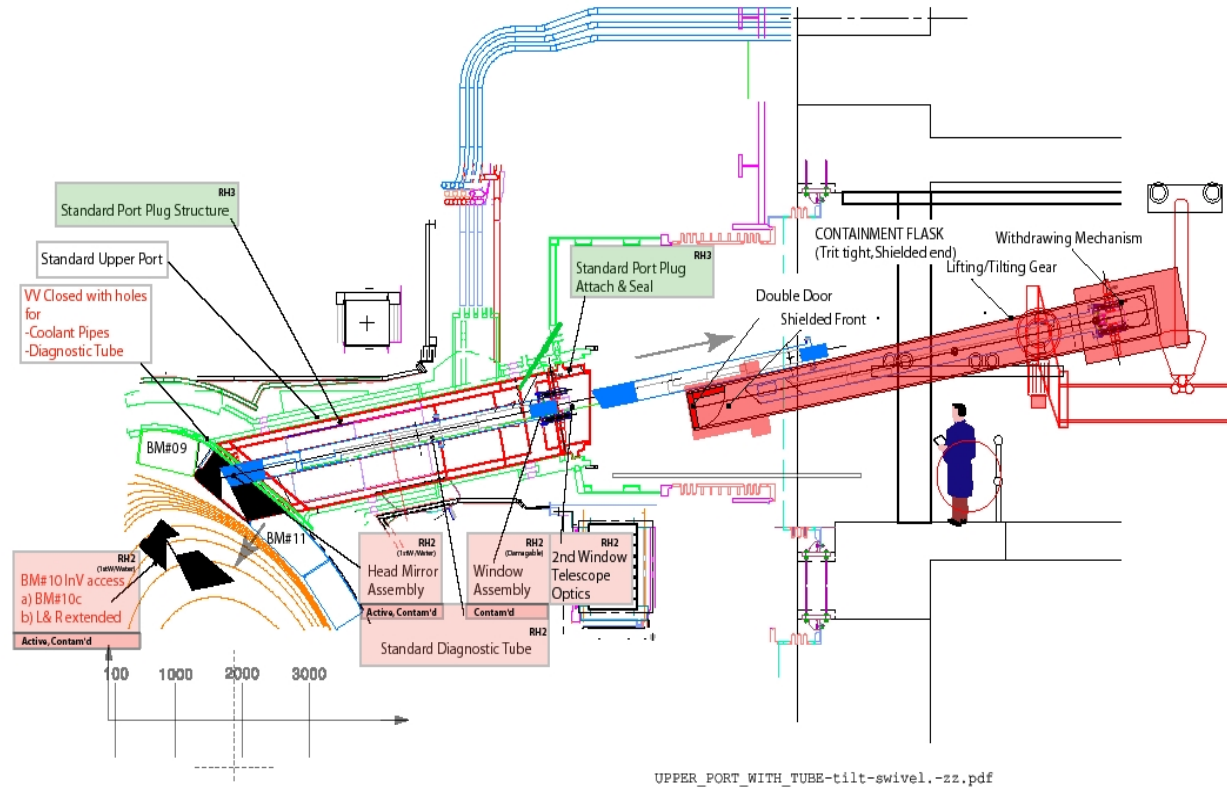


Location of first wall viewing systems in upper ports - symmetrically placed for maximum possible coverage of first wall and divertor ●



Upper Ports, 4, 5, 6, and 7

Considerable work in progress to maintain the use of these ports.



Looks possible but with reduced capability and possibly increased cost.



Status of NB Diagnostic Related Issues

Issue No	Issue	Assessment	Status
5.3-21	ITPA AUX 4 Compatibility of NBI specifications with diagnostic requirements (power modulation)	Included in EU-JA PT R&D task on beams	Dropped from Design Review (addressed in R&D effort). Dialogue between diagnostic designers and beam designers in progress.
5.3-22	ITPA DI-8: Specifications of the HNBs and MSE	Included in EU-JA PT R&D task on beams	As above
5.5-18	DNB: optimisation for MSE possible (modulation frequency of 20Hz and a longer duty cycle)	Included in IN PT task on beams	As above
5.5-19	Change of toroidal angle of Diagnostic Neutral Beam (DNB) -	Provide orbit calculations for cost / benefit analysis	Recommendation from H&CD WG => DCR in preparation



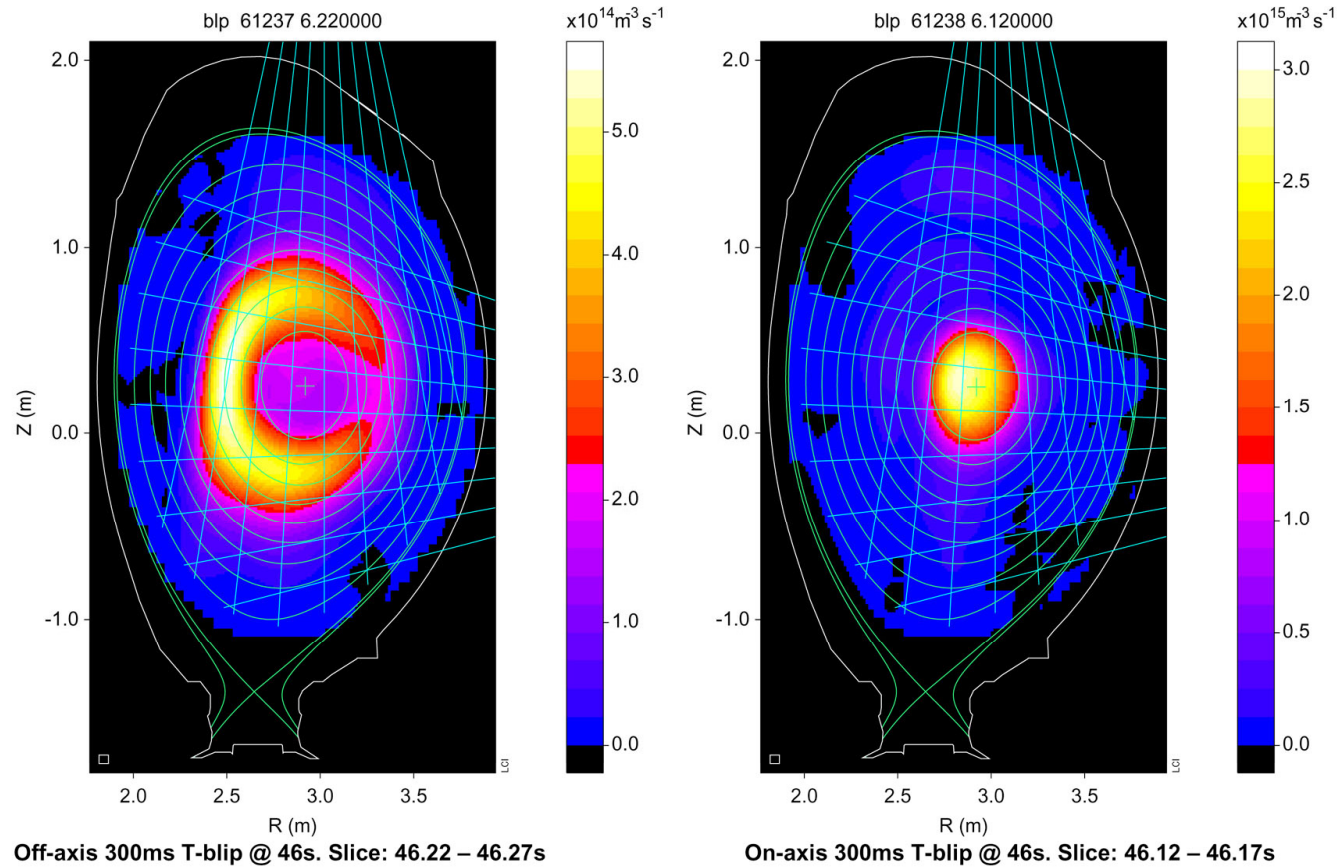
Status of NB Diagnostic Related Issues

Issue No	Issue	Assessment	Status
5.3-17	Adding low voltage (? 150kV) positive ion based NBI system	Technical expert report	Withdrawn
5.3-19	Reassess NB energy (reduce from 1 MeV to 500 KeV, doubling the number of sources)	Technical expert report	Dropped - impossible due to space constraints
5.5-20	Lower beam energy to increase rotation	Technical expert report	Pending - addressed in R&D effort



Lower Vertical Neutron Camera

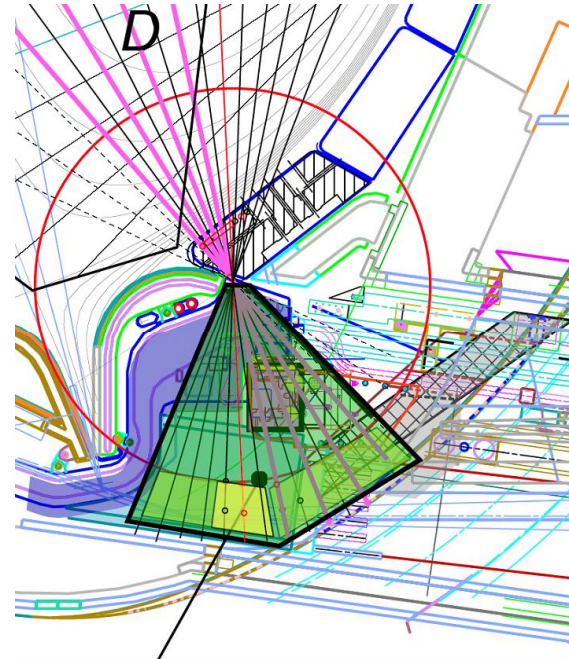
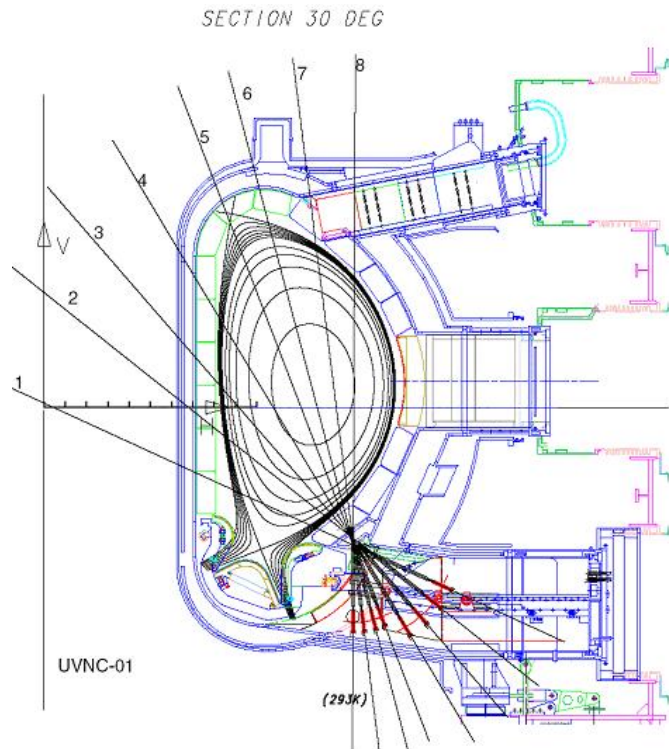
14-MeV neutron emission



Tomographic reconstructions of the neutron emission following the introduction of a small quantity of Tritium on JET.



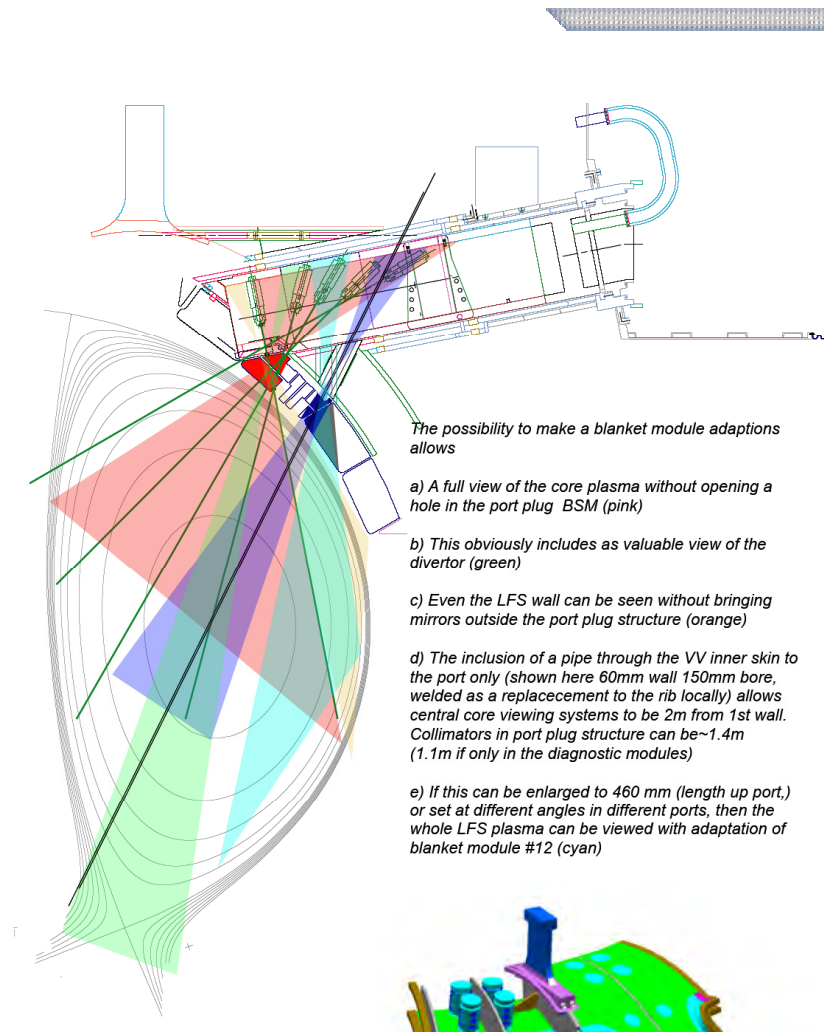
There are considerable interface difficulties with the LVNC.





The possibility of installing the VNC in a (modified) upper port has been revisited. Performance calculations are not promising and this option has been dropped.

LVNC is being pursued by Acceptance is contingent On acceptable results of Stress calculations on slot Needed in triangular support (expected in about 2 months).

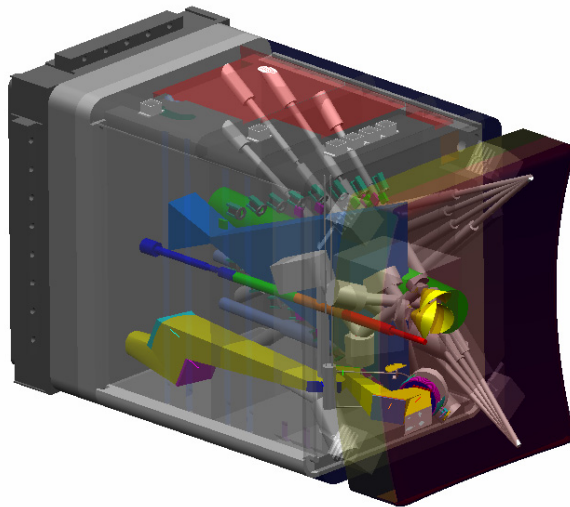


More details in presentation by A Krasilnikov.

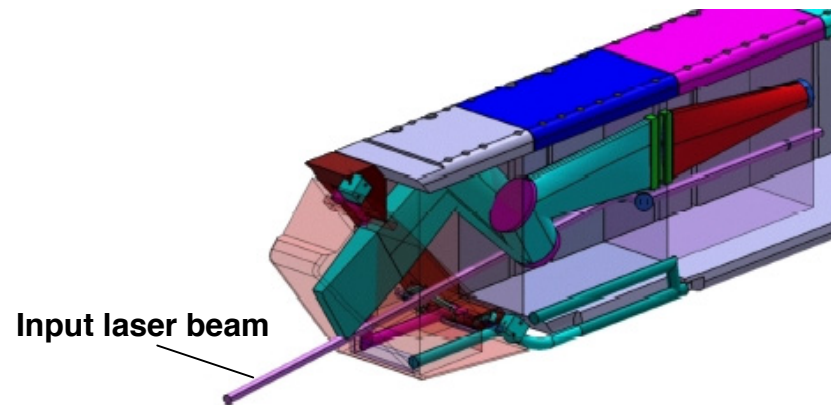


Port Engineering Task Force

In late January the ITER Participant Team Leaders approved the creation of an activity to harmonise the work on-going in the different parties and the ITERO on port engineering - --> **The Port Engineering Task Force (PETF)**.



Eq#01: Vis/IR viewing
Rad Neutron Camera
MSE, Div Imp Mon



Upper port: Optics for Edge Thomson
Scattering system

More details on engineering in presentation by C Walker.



Scope of PETF

The scope of the activity will be the **common components, interfaces, integration issues and procedures associated with diagnostic procurement.** The main components involved are:

- the diagnostic support structures in the ports, interspace, bioshield, and port cells,
- the diagnostic support frames in the divertor, and
- the diagnostic equipment in the hot cell.

The **integration of these components** and interfaces between them, including mechanical, electrical, fluid links and their tolerances, and allocations of shared resources – space, heat loads, neutron activation, installation time, etc – will be covered by this activity.



Membership And Method Of Working

There will be about two permanent members per party. At least one member from each party should have a managerial/organizational role in diagnostic procurement within the party. The work of the group will be coordinated by the ITERO. The group will meet regularly, approximately twice per year for two or three days, and work and communicate between meetings by electronic means. This will be a continuing activity through all phases of procurement, construction, and installation and commissioning.

Kick-off meeting was held, 12 - 13 March, 2007.



Diagnostic Review (Proposed)

The US (+ Diagnostic Division of ITERO) proposed a review of diagnostics to be undertaken this year: The objectives of the review would be:

to review the choice of selected diagnostics, port allocation, and prioritization (space allocation) in the light of ITER measurement requirements;

to assess measurement capability of integrated system in relation to ITER measurement requirements (assuming reasonable success with design and any needed supporting R&D);

to consider changes that may be necessary due to possible changes in requirements and/or the machine design coming from the wider ITER design review;

to handle any diagnostic related issues that have been raised through the design review process that are not currently owned or being dealt with by one of the existing working groups.



Diagnostic Review (Proposed)

The proposal was discussed yesterday at the Participant Team Leader's meeting in Marseille. The proposal for a stand-alone review was not accepted but it was suggested/decided(?) that there should be a subgroup of the WG1(Physics) group to handle the diagnostic aspects.



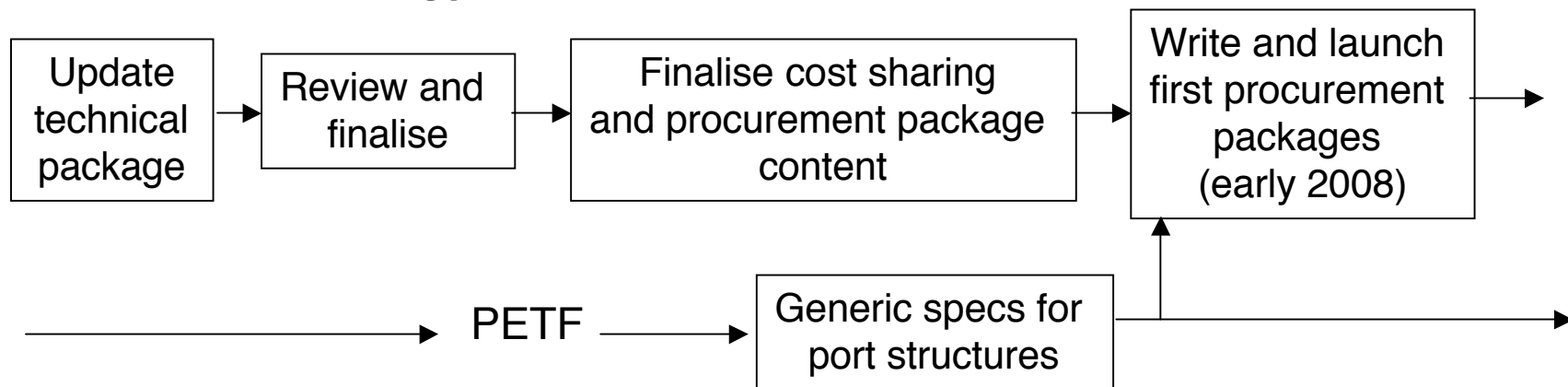
Summary

- There has been substantial **growth in the ITER central team** in recent months. (Despite this the number of staff in the IT working on diagnostics has actually gone down. Recruitment is in progress and hopefully we will grow to 9 or 10 later this year).
- Necessary **project engineering activities have been started - IPS, WPs, Procurement Planning, Documentation update** etc. Aiming for overall consistency and especially consistency between needed and available resources to achieve project goals. Diagnostics Division has contributed appropriately to these activities.
- The **issues-based ITER design review** has started. The issues have been formulated, a data-base established, eight Working Groups formed, work plan for issue resolution drawn up and an appeal to PTs to provide resources. It is expected that **some changes** will come from this review that will affect diagnostics.



Summary

- There are also **areas within diagnostics** where changes are necessary and in other cases where they would be beneficial.
- It is proposed to hold a **diagnostic review** around mid-summer to deal with these changes and other related matters including an assessment of overall measurement capability relative to requirements. This proposal was not accepted by the PTLs but it is likely that a **sub-group of WG 1(Physics)** will be formed to deal with the review of diagnostics (July 2007 (?)).
- **The basic strategy is:**



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THANK YOU FOR YOUR ATTENTION

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