STATUS OF THE ITER EDA

by Dr. R. Aymar, ITER Director

This article summarises progress made in the ITER Engineering Design Activities in the period between the ITER Meeting in Yokohama (20-21 October 1998) and February 1999.

The three main focusses of technical activity have been as follows:

- in Design work, the JCT and Home Teams have aimed at establishing design options which meet the revised guidelines for cost and performance targets (EIC ROD 3.1.a). Results of the work to date were discussed at a point design meeting in Garching, end of January (see article on this Meeting, Newsletter Vol. 8, No. 1, January 1999). The report "Study of Options for the Reduced Technical Objectives/Reduced Cost ITER" was presented to TAC before submission to ITER Council;
- in R&D, the JCT and Home Teams have worked to bring the remaining projects to completion - in particular, to complete the model coils and prepare for their testing. Highlights from this work are briefly summarised below;
- the ITER Physics Basis document has undergone further review and revision and is now in the final stages of refereeing and response in preparation for publication in a special edition of "Nuclear Fusion" expected around the middle of 1999. The preparation of this important document has been a major task undertaken within the voluntary framework of ITER Physics. The authors and editors of the various sections of this document are to be commended, and their supporting institutions thanked, for the quality and commitment of effort provided.

The project has worked against a backdrop dominated by the decision by US Congress in the 1999 budget to suspend further funding on ITER and consequential withdrawal of US members from the JCT, close-out of the San Diego JWS, and run-down or re-orientation of other aspects of US participation in the ITER process.

The withdrawal of US members from the Joint Central Team was completed over the period November/December 1998, with the exception of one team member in San Diego and one in Garching, whose assignments were extended for a few months to permit critical contributions to design studies and to complete major R&D. In addition to the withdrawal of US team members, there has been a fall in the number of the Japanese Team members on site because the normal process of rotation and replacement has been interrupted pending completion of an arrangement concerning continuation of ITER activities. Similarly, Russian Team members who left the project in July 98 have not yet been replaced.

In line with the conclusions of the three Parties' discussions noted in Yokohama, in November, the Director proposed to the three Parties a redistribution of their JCT members between the Garching and Naka Joint Work Sites, and requested the Parties to take the necessary actions to effect the transfers as soon as practicable. The Parties, with the co-operation of JCT members concerned, have made considerable progress towards meeting the goal of a prompt and coherent re-settlement of the staff from San Diego taking effect at around 1 March 1999.

The status of the Team on site as at mid February by Joint Work Site and by Party is summarised in the Table below:

Status of JCT Staff at Mid February 1999

Garching	Naka	San Diego		EU	JA	RF	US		Total
36	32	28		46	27	21	2		96

The cumulative Professional Person Year (PPY) effort on site between 21 July 1998 and 21 February 1999 is estimated at about 64 PPY.

The departure of JCT Members has led to different consequences among the Divisions and Groups. However all Divisions (Safety, Engineering, Integration, Physics Unit) in San Diego have seen their membership decrease so much that a modified structure of JCT has to be proposed and a much larger work contribution needs to be offered by the Parties to keep the previous missions.

Final data is now available on the distribution of tasks committed during the original duration of the EDA. Work has been completed and final reports submitted for 641 out of 681 technology R&D task agreements. It is also possible to finalize the total credits of more than 240 work orders issued under the Comprehensive Task Agreements for Design. These total amounts for R&D in IUA and PPY for Design are well below the planned respective numbers at the beginning of EDA. The Table below summarizes the pattern of assignment to Parties.

Summary of ITER Task allocations to July and post July 1998

	Until July 1998		After July 1998
Party	**IUA**	**PPY**	**IUA**
EU	180,251	202.06	37,000
JA	181,995	176.98	32,905
RF	80,936	140.45	15,600
US	112,767	174.78	–
Totals	555,949	694.27	85,505

Detailed statements of work for the new R&D task sharing during the EDA extension period have been developed with Home Teams in line with the proposals presented to and supported at MAC 14 for a total of 85,505 IUA distributed to Parties as shown below. The first tranche of work packages, covering R&D needed to continue existing R&D activities or to develop generic key technologies, is ready for formal release as soon as Home Teams will be able to accept it.

Arrangements have been made to redistribute selected computing equipment and software used for the JCT work in San Diego to Naka and Garching. Items purchased using the ITER Joint Fund in San Diego will be transferred to the respective Joint Fund Agents at Naka and Garching who will take over title and management responsibilities in accordance with the Joint Fund Financial Rules. In addition, some items of Host Equipment in San Diego are being sent to Garching under the terms of a loan agreement.

Project documentation is being redistributed to Naka and Garching as appropriate together with selected reference documents and other material from the project library in San Diego.

Work has continued on the seven large R&D projects. As illustrated in the highlights below, some are now complete as originally planned; others have witnessed significant progress towards their goals:

L-1 CS Model Coil Project. Manufacturing of the Inner and Outer Modules have been completed, in the US and Japan, respectively, and Acceptance Tests were successfully performed on the both modules.

The Outer Module was delivered to the test site at JAERI in November, 1998 (see Newsletter, Vol.7, No. 11, November 1998); the Inner Module, together with the support structure, has been shipped from San Diego and is expected to arrive at JAERI in mid April. After the installation work at JAERI, cooldown of the CSMC assembly is expected to start in late September or early October, 1999.

L-2 TF Model Coil Project. In the fabrication of the TFMC, two superconducting double pancakes have now been completed by Ansaldo and delivered to Alstom, where they will be assembled into the winding pack and inserted in the case. The conductor for the remaining three double pancakes has been heat treated, insulated and welded into the radial plate; impregnation of one of them is underway and insulation wrapping is nearing completion for the other two.

In the fabrication of the full size case sections, the square tube (representing the inner curved section of the TF coil case) has been completed. The final section weight is 37t. The tube will be cut into 2 U sections and rough machined before shipping for final machining and butt/closure welding trials. Suitable welding processes have already been qualified.

A trial 1 t cast section for the outer case section has been produced. The cryogenic properties of this special purpose alloy have been found to be acceptable for use in the less stressed regions of the TF coil case, such as the OIS/outer leg region. Repair and welding to forged sections of the casting has been demonstrated. The release of the casting of the full size section is now under discussion, with finalisation of the geometry.

L-3 Vacuum Vessel Sector Project. The L-3 project was successfully completed in August of 1998, and all objectives were achieved. Both half sectors were completed and shipped to the Tokai establishment of JAERI on schedule. It then was proved that it is possible to weld together two sector halves made with different segmentations and by different techniques, and achieve tolerances within those required for ITER. This supports the view that several manufacturers world-wide would be able to fabricate the vessel successfully, either alone or in co-operation with other manufacturers. The objectives for the port extension model have also been successfully achieved. All activities were completed in Russia and the port extension has been shipped to Japan in July 98 for integration with the full scale sector model.

L-4 Blanket Module Project. The main materials for the blanket system have been selected by the EU, JA, RF HTs efforts, and characterised in unirradiated and irradiated conditions and their properties improved Remarkable improvements have been obtained by all HTs in the development of the main joining techniques — Be/Cu-alloy, Cu/SS and SS/SS — to be used for the manufacturing of each component. Results of the R&D on ITER water chemistry show that corrosion/erosion of stainless steel and copper alloys is negligible for ITER coolant conditions, provided that water is purified, its conductivity is kept low and a reducing medium is added. Neutronics experiments have validated the transport codes and cross-section libraries that are used for neutronics design calculations of ITER. Results of calculations are used to define design margins. The basic manufacturing feasibility and the good performance of the primary wall, baffle and limiter modules has been assessed by manufacturing and testing several small and medium scale mock-ups in a first stage and prototypical components in a final stage Achieved tolerances in the manufactured prototypes and the results of the thermo-mechanical tests fully meet the requirements. The feasibility of the blanket module integration, of the attachment system and of the hydraulic and electrical connections is being assessed by manufacturing and testing mock-ups of the key parts and by preliminary assembly testing to verify the module installation and the crucial operations.

L-5 Divertor Cassette. The US Home Team completed a 4 t cassette body segment using cast 316LN. All the closure plates were welded using the penetration enhancement compound, and subsequently the component passed 100% ultrasonic inspection, as well as pressure and helium leak tests.

A US mock-up using 3 mm diameter tungsten rods hot pressed into the Cu substrate, showed no damage after testing at 30 MW/m2. and in Japan heating tests on full-scale monoblock divertor mock-ups, using 2-D CfC and CuMn braze. withstood a heat load of 20 MW/m2, 10s for 1,000 cycles without failure.

The EU Vertical Target medium scale, CfC and tungsten armoured prototype, consisting of two poloidal slices assembled to steel back plates, has passed He leak testing. The two units are now being assembled and the manifolds are being welded. The thermal fatigue test in the Le Creusot facility is planned early 1999.

A need identified late in the original duration of the EDA is to develop a technique for joining the CuCrZr tube to the Cu Active Metal Cast (AMC) layer of the CfC monoblock using a HIP process performed at ~ 500°C. This allows the joining to be carried out at the same temperature as the precipitation hardening cycle of the CuCrZr and avoids the over-ageing that occurs with higher temperature joining cycles. Furthermore, the residual manufacturing stresses blamed for infant joint failures are strongly reduced. On this basis, the EU have built CfC monoblock mock-up. The CuCrZr tube shows mechanical and thermal properties comparable with those of a typical solution annealed and aged CuCrZr alloy. The joint between the tube and the AMC appears better than the brazed joints of previous components. A high heat flux testing of this mock-up is planned early in 1999 in JUDITH facility.

L-6 Blanket Remote Handling Project. This project was completed successfully. The full-scale remote handling equipment for blanket maintenance was fabricated by Toshiba and assembled into the Blanket Test Platform at Tokai JAERI for demonstration of ITER blanket replacement. Through performance tests of the equipment, feasibility for handling 4 t blanket modules at any point on the first wall was fully verified.

In addition, the integrated performance test demonstrated the critical operations of rail-deployment/storage, module replacement and transfer, so that the vehicle manipulator system satisfies the maintenance scenario for the ITER blanket. On the basis of these results, the fundamental technology for blanket maintenance has been well established.

L-7 Divertor Remote Handling Project. This project was completed successfully. The validity of the concepts for divertor cassette handling and refurbishment by remote means was demonstrated on two test platforms at Brasimone (EU).

***Editor's Note**: Developments in the ITER Physics framework will be the subject of a separate article.*

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