INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR

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INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, AUSTRIA

ITER EDA PROGRESS REPORT

by Dr. P.-H. Rebut, ITER EDA Director

Dr. Rebut joined the Fusion Research Division of the CEA (Commissariat à L'Energie Atomique) in 1958 after studying physics at the Ecole Polytechnique and the Ecole des Poudres.

In 1973 he was appointed Head of the Joint European Torus (JET) Design Team and then Deputy Director of the JET Joint Undertaking when the Joint Undertaking was established in 1978. From 1985 to 1992 he was the Director of the JET Joint Undertaking.

In September 1992 he was appointed Director of the International Thermonuclear Experimental Reactor Engineering Design Activities.

The November 1992 issue of the ITER EDA Newsletter highlighted the decisions made by the ITER Council at its September 1992 meeting (IC-1). Since those decisions were made the ITER Engineering Design Activities (EDA) have progressed in several areas. The following sections summarize the progress.

Joint Central Team

The task of selecting and assembling the Joint Central Team (JCT) is my top priority, and I have instructed the Deputy Directors and Division Heads to diligently pursue the selection of qualified team members. Several steps are involved in assembling the JCT: specification of posts, nomination of candidates, selection of team members, arrival and startup of work, and completion of secondment procedures. Only after these steps have been completed are staff able to take up their full responsibilities within the management structure of the JCT. Even then, a period of some months of acclimatization and adjustment may be required before the staff can be expected to work fully effectively.

The general quality of the nominees has been high, although the overall number of nominations received from some of the Parties has been limited. Since the staffing of the JCT has proven to be a time consuming process, the interview and selection process remains a heavy burden on the few senior team members who are already present in the JCT. We continue to push building up the team as quickly as possible in order to have 150 JCT members in place by the end of Protocol 1 (March 1994).

It is understandable that the nature of this unique international project has created some challenging administrative issues. For example, nearly three quarters of the JCT staff at each of the Joint Work Sites must relocate to a new continent.

Having only a skeleton JCT staff also means that the senior members must carry a particularly heavy burden of travel and meetings.

As of the first week in February 1993, 190 nominations had been received. Of the approximately 100 candidates interviewed to date, 47 have been selected and 25 are on site.

Joint Work Sites

I am pleased to report that the three Joint Work Sites (or Co-Centres) are all in operation. It is interesting to note that because the JCT is distributed across several continents, someone is always working on ITER - 24 hours a day.

An electronic communications network has been established between the three ITER Co-Centres. The network will be a strategic tool for the scientists and engineers collaborating on this geographically distributed project. The ability to exchange Computer Aided Design (CAD) drawings and physics data via the high-speed computer network connections is critical to meeting the schedule of the ITER EDA.

Another critical component for collaboration among the Co-Centres is the rapid deployment of an integrated management process. To this end, I have asked the three Host Parties to jointly contract for the design of an electronic Integrated Process Management System.

Status of EDA

Technical meetings have been held at the Naka, Garching and San Diego Co-Centres on the topics of Magnets, Divertors and Safety. These meetings, which included experts from each of the Home Teams, have been useful forums for focusing on key aspects of the ITER design and identifying programmes of technical R&D work.

Some of the results of the Conceptual Design Activities have been updated to take into account the evolution of Tokamak physics and the detailed technical objectives of ITER as defined in the report of Special Working Group 1. In particular, it was found necessary to increase the major radius to allow a long steady-state operation of the machine (1000 to 2000 seconds) and to provide space to accommodate a high power divertor.

Our preliminary analysis of the modified concept has shown an overall coherence. There are still two main areas of the design where the concept needs development: the divertor, and the first wall and shielding blanket. The Home Teams have provided valuable analysis in exploring and testing many aspects of the coils, the vacuum vessel, and divertor concepts. In these scientific and technical domains, the collaboration among the scientists and engineers has been efficient and fruitful. Collaborations among all the Parties and their Home Teams are being pursued and already discussions involving industry have started. I am encouraged by the general enthusiasm and co-operation among the scientists and engineers of the four Parties.

ITER Work Programme

The priority task for the JCT as it assembles is to formulate the Work Programme including the assignment of tasks. It is hoped to submit the first Work Programme to the third meeting of the ITER Council.

While achieving the recommended staffing level of the JCT is a gradual process, the demands placed on the current JCT members have intensified. For example, the JCT is striving to meet the request made at IC-1 to produce the outline design of ITER within just ten months, as well as responding to additional charges from the Management Advisory Committee (MAC). This level of workload will require additional support from the Home Teams to help meet the schedule of the ITER Council.

To meet the programme objectives within the agreed time scale of the EDA, it will be essential to adopt efficient management procedures, in particular, the assignment of tasks, which is a dynamic process. In general, the specifications of any particular task will depend on the results of ongoing design and R&D activities. Therefore, it is important that procedures for assigning tasks remain flexible and efficient. The success of ITER depends greatly on the evolution of an overall management aimed at streamlining many of these procedures.

Although the start of the EDA has been an unprecedented managerial challenge to meet ITER's needs within the existing administrative systems of the Parties, good progress has been achieved on both the scientific and technical sides. I attribute much of this progress to the continuing informal discussions at the working levels among the Parties. Using and continuing to build this co-operative spirit and mutual confidence will be of crucial importance to the overall success of the ITER EDA.

SWG-2 COMPLETES ITS FIRST ACTIVITIES AT IC-2 MEETING

by Dr. M. Roberts, SWG-2 Chair

At IC-2, SWG-2 presented its report on "guidelines for implementation of task assignments" as required by Protocol 1. The Council reviewed the SWG-2 proposal, accepted the report and adopted guidelines as shown below. In this report, SWG-2 also made recommendations for the practical application of the guidelines. The Council discussed these recommendations and asked the MAC to meet as frequently as necessary to consider the Director's proposals for task assignments. Unanimous recommendations from MAC would be approved rapidly by the Council. The Council also agreed that, in a year or so, it would review the guidelines and could modify them as required. Finally, SWG-2 expressed its views on the matter of Physics R&D in support of the EDA; these views are shown after the guidelines below. On this matter, the Council agreed that the Director should interact with persons designated by the Parties regarding specific Physics R&D for ITER, as appropriate for the benefit of the project.

Furthermore, the Council directed SWG-2 to prepare a draft of Protocol 2 at a minimum length, agreed that the Director should provide input to the drafting process and be given the opportunity to comment on the drafts, and asked for the Parties' designation of membership of SWG-2 for Protocol 2 drafting (shown below). Finally, the Council asked SWG-2 to consider questions of longer term disposition of facilities and assets.

MEMBERSHIP OF SWG-2 FOR PROTOCOL 2 DRAFTING ACTIVITIES

EC: Dr. E. Canobbio
Mr. J. Grunwald - TL
Mr. P. Kind

JA: Mr. M. Aniya
Mr. S. Aoyama
Mr. S. Hino
Mr. T. Ide
Dr. A. Kitsunezaki
Mr. S. Takizaki - TL

RF: Dr. Yu. Balasanov
Dr. L. Golubchikov
Dr. A. Mostovets - TL

US: Ms. L. Howe
Mr. W. Marton
Mr. A. Opdenaker
Dr. M. Roberts - Chair
Mr. G. Taft - TL

[TL = Treaty Lawyer]

Guidelines for the Implementation of Design and Technology R&D Tasks - Adopted by the Council

A. Approval and Revision of Task Agreements

(1) Each Task Agreement exceeding 300 IUA in value shall be concluded only after the task with its technical description and assignment to a Party has been approved by the ITER Council.

(2) Task agreements equal to or below 300 IUA in value may be concluded directly between the Director and the Home Team Leader concerned. The Director shall promptly inform the other three Home Team Leaders of such Task Agreements.

(3) The total value of Task Agreements equal to or below 300 IUA assigned by the mechanism established in paragraph (2) above should not exceed 3,000 IUA in any period between meetings of MAC, which is providing recommendations on the Director's proposals for Council approval.

(4) Revisions to Task Agreements to incorporate minor technical changes within the scope of work already approved by the Council may be implemented upon agreement of the Director and the affected Home Team Leader. Task scope changes up to a limit of +/- 300 IUA or 20% per task, whichever is smaller, may also be implemented upon agreement of the Director and the Home Team Leader. Tasks concerning work whose results are no longer required may be terminated by mutual consent of the Director and the Home Team Leader affected; the ITER credit for such tasks must be revised appropriately. All revisions other than 1) minor technical changes, 2) scope changes less than or equal to 300 IUA, and 3) termination as defined above must be approved by the Council through procedures defined in the Agreement for new tasks assignments; in these cases, the Director shall adjust the ITER credit as appropriate.

(5) All revisions or Task Agreements not requiring Council approval must be reported to the Council.

B. Task Identification, Definition and Valuation

In identifying and defining tasks in accordance with Protocol 1, the following guidelines shall apply:

(1) While acting in close interaction with the Home Team Leaders to identify tasks, the Director shall also establish the ITER credits that the Parties undertaking the tasks would receive. This interaction should, as far as possible, lead to a common understanding on feasible, effective approaches to identification and definition and the valuation of the tasks.

Before the list of these tasks is sent to the Home Team Leaders in accordance with Protocol 1, the Director should inform the Home Team Leaders of the list of tasks together with the credits the Party undertaking each of the tasks would obtain; any Party with an interest in performing a task should rapidly inform the Director so that if more than one Party expresses such an interest, the Director shall, in close interaction with Home Team Leaders, identify how these interests could best be taken into account, either through splitting into smaller tasks, parallel efforts or joint efforts.

In concluding particular Task Agreements, consideration will be given by the Director to including in the ITER credit the relevant work that pertains to those tasks and was initiated by the Party after the signature of the ITER EDA Agreement and Protocol 1.

(2) Within each task system area, there should be a reasonable balance of tasks shared among the Parties. In assessing this balance, the qualitative characteristics of the tasks to be assigned, e.g., the nature of test facilities and the level of technology, should be taken into account.

(3) Where no Party expresses an interest in performing a particular task, the Director shall, through close interaction with the Home Team Leaders, attempt to interest at least one of the Parties. If the Director fails to interest one of the Parties, he may appeal to the ITER Council, in accordance with Article 12(1).

(4) For some individual tasks, parallel efforts by more than one Party may be justified because of high perceived technical risk or uncertainty, which would involve staged assignments.

(5) The ITER Director shall, in close interaction with the Home Team Leaders, ensure that the disaggregation of work into tasks covered by Task Agreements does not exceed what is necessary to ensure an efficient execution of the work, bearing in mind the need to ensure a reasonable sharing of the work between the Parties. Each Task Agreement shall describe a reasonable, coherent, self-contained scope of work with well defined interfaces.

(6) The distribution of design work between the JCT and the Home Teams should, in general, respect the principle that the JCT should perform only that work which can be more appropriately performed by a central team. The total ITER credit for design tasks assigned to the Home Teams is understood to be the equivalent of about 500 Professional Person Years.

C. Selection Criteria

(1) Expressions of interest to perform a task should be considered for selection only if they document the capability to meet the specifications and schedules as well as the availability of necessary facilities and know-how.

Before rejecting any expression of interest on the grounds that the technical requirements are not satisfied, the ITER Director shall inform the relevant Home Team Leader, who for a short period will be given the opportunity to revise the Party's proposal.

(2) The selection from among those expressions of interest that meet these technical requirements shall be based primarily on:

(a) technical experience and capability of the proposed implementing institution,
(b) technical risk of the proposed approach, and
(c) demonstrated understanding of the technical and managerial requirements.

Other factors, such as the need to maintain a reasonable balance of tasks in a task system area, the priorities assigned by the Parties to the work, or the quality of the proposed approach, should be taken into account as appropriate.

TERMINOLOGY USED IN THE GUIDELINES

The following definitions are used in the development of the guidelines for the implementation of task assignments.

Task - that work which is performed by the Joint Central Team (JCT) or a Home Team. A task which is assigned to a Home Team is the subject of a Task Agreement, of which there may be hundreds. A task assigned to one Home Team may involve other Home Teams.

Task System Area - A group of tasks that comprise a natural ITER system, of which there may be ten(s).

Task Assignment - the process by which tasks are assigned to each of the Home Teams and the JCT.

Task Agreement - the agreement document that contains the technical description of the task, the results of the task assignment process, and the terms and conditions of its execution.

Staged Assignment - an approach to assigning those tasks whose technical complexity or risk warrants a step-by-step assignment process in which conceptualizing, designing, developing, and testing (or other steps) may be successively assigned either to the same Party or multiple Parties or to a narrowing set of Parties in which case the initial tasks involve multiple Parties but subsequent tasks are refined to involve fewer Parties.

Design Tasks - those tasks needed to carry out the design (both engineering and physics design) activities to be assigned to both the JCT and the Home Teams, and whose cost estimate was included within the estimated 250 million January 1989 US$ for design work in the Final Report of the ITER Conceptual Design Activities (CDA).

Technology R&D Tasks - those tasks supporting the design which include the Basic Technology R&D and the Specific Engineering R&D as defined in the above-mentioned Final Report and whose total cost was estimated to be about 750 million January 1989 US$ (400 and 350 million respectively) in that Report.

Work Program - introduced in Article 11 of the ITER EDA Agreement, the Work Program is understood to be an evolving document receiving regular refinement throughout the EDA.

ITER Credits - the value in ITER Units of Account (IUA) [equivalent to 1000 US$ at January 1989 values] attributed to a particular design or technology R&D task by the ITER Director at the time the task is sent to the Home Team Leaders with a request for expressions of interest. The only corrections to this value will be those related to changes in the scope of the task. The sum of all such credits should be comparable with the estimate in the Final Report of the CDA.

MAGNET TECHNICAL MEETING

by Dr. B.J. Green, Senior Scientist, ITER Co-Centre Naka

A Magnet Technical Meeting was held at the Naka Co-Centre from January 26-29, 1993. The majority of the activity was in three parallel sessions involving a Conductor Group, A Model Coil Group, and a Full Scale Coil & Design Integration Group. Each group prepared and followed a detailed agenda. Co-ordination of activities and presentation of issues and conclusions were carried out in three joint sessions.

The structure of the three groups was as follows, but some cross-participation among groups was necessary and occurred:

Group 1 - Conductor
Co-Leaders: N. Mitchell (EC) & H. Tsuji (JA)
Participants: M. Nishi (JA)
J. Minervini (US)
W. Hassenzahl (US)
B. Green (JCT)

Group 2 - Model Coils
Leader: D.B. Montgomery (US)
Participants: A. Torossian (EC)
T. Ando (JA)
K. Okuno (JCT)
A. Ulbricht (EC)

Group 3 - Full Scale Coils & Design Integration
Leader: R.J. Thome (JCT)
Participants: K. Yoshida (JA)
P.H. Titus (US)
C.W. Bushnell (JCT)
F.M.G. Wong (JCT)
H. Nakajima (JA)
R. Reed (US)
F. Puhn (JCT)
S. Chicchio (EC)

A complete set of handouts from the meeting was sent to A. Kostenko, who was originally slated to lead Group 3 at the meeting, for distribution within the RF as necessary. In addition, a separate meeting with the RF has been scheduled for early March 1993, to discuss material from the January meeting, to review the contributions from the RF and to assure adequate communication of results among Parties.

The conductor group was able to agree on the specification for the ITER "Request for Proposals for the Supply of Nb_3Sn Strand". They also made considerable progress toward a conductor design guidelines document and an operating requirements document. In addition, they proposed reference cable designs for two grades of conductor for the central solenoid (CS) and three grades of conductor for the toroidal field (TF) coils. These will be used in the next round of analyses by the magnet design team.

The model Coil group reviewed three CS and six TF coil options for different test configurations. They were able to recommend one test configuration for each. The CS model coil option recommended is a two meter inner diameter coil with replaceable inserts that could model CS, TF and poloidal field (PF) conductor alternatives and operating conditions. The TF model coil would have a winding section representative of the full scale TF coil to provide realistic fabrication and assembly experience and realistic winding section mechanical behaviour.

Finite elements analyses of the full scale magnet system are currently underway by all Parties and were reviewed by Group 3. All Parties presented various models and cases of:

- 3D Global Models
- 2D Section Models
- 3D Component Models (e.g. Bucking Cylinder[BC], Shear Keys).

All Parties verified that a consistent PF scenario was employed for magnetic load determination. The main areas of interest in these analyses were:

- Shear between plates and strain in the winding pack
- Behaviour of the CS/TF interface
- CS/TF/BC load sharing
- Behaviour of the shear keys.

Tables were prepared to compare results among Parties, and areas for resolution and future study were identified. For each Group the major issues and conclusions have been outlined, and the homework has been defined.

The next Magnet Technical Meeting has been scheduled for June 1-4, 1993, at the Naka Co-Centre.

U.S. HOME TEAM NATIONAL MEETING - JANUARY 1993

by C.A. Flanagan, Deputy Home Team Leader

Two days of U.S. ITER technical meetings were held January 25-26, 1993, and were hosted by General Atomics (GA) at their facilities in San Diego. The keynote talk was given by the ITER Director, P.-H. Rebut, who provided an overview of the status of the ITER Engineering Design Activities (EDA) design. Rebut titled his presentation "ITER: A Reactor Core". He discussed his perspective of the importance of two key constraints associated with the technical objectives, namely, the need to limit the cost of the device consistent with the levels estimated in the Conceptual Design Activities, and the importance of safety to the design and operation of ITER. Rebut also discussed the physics basis, ignition and current drive considerations, some key aspects being focused on in the design, such as the toroidal field and poloidal field magnet designs, the plasma facing components (first wall and divertor), the blanket and shield, and the vacuum vessel. He briefly discussed the importance of communications to the EDA design process and some of the approaches being developed to assist the design and control process. Finally, he indicated his present thinking on the likely distribution of the technology research and development (R&D) credits, by major category.

Six technical overview presentations of U.S. ITER work were given during the opening plenary session and covered selected significant aspects of the design and R&D activities in the engineering and physics areas. The presentations covered work in the magnets, blanket and shield, vacuum vessel, poloidal field magnetics, safety, divertor and disruptions.

During the second day, parallel technical sessions were held in the physics, engineering, and fuel cycle areas. During these sessions, detailed U.S. ITER technical activities were summarized. The focus of much of these presentations was on the recent efforts to study critical aspects and issues related to the direction being taken by the international Joint Central Team (JCT) design activity. In the vacuum vessel area, the studies are on a double-walled, ball-filled, variable cross-section vacuum vessel. In the first wall, blanket, shield area, the studies are examining a wide variety of issues and concepts, including examination of coolants, structural materials, electromagnetic loads, configuration issues, operating temperatures, safety issues, thermal-hydraulics, compatibility issues, and fabrication issues. In the poloidal magnetics area, issues examined include determination of the range of plasma profile to be expected, alternate plasma shape constraints to reduce the peak coil currents, alternate poloidal field coil locations, and determination of effect of a close fitting conducting wall on plasma performance. Magnet design studies are proceeding in close co-operation with the JCT staff at the Naka Co-Centre, and these were described.

The physics session consisted of 29 presentations in seven areas; confinement and plasma performance, power and particle control, heating and current drive, disruptions, PF magnetics, diagnostics, and R&D co-ordination. In the confinement and plasma performance area, reports were presented on the status of the ITER H-mode database, transport simulation studies, and stability studies. The power and particle control reports were focused on the physics aspects of divertor designs and associated modeling efforts. The heating and current drive presentations were on scenarios for steady-state operations using current drive, various fast wave current drive scenarios, and application of electron cyclotron heating in ITER. The disruption talks reported on simulation and modeling studies of disruptions and materials behaviour during disruptions. Design considerations for the poloidal field systems were discussed. In the diagnostics area, reports were given on the overall status, on the progress in magnetic and divertor diagnostics, and on the progress on microwave diagnostics. Finally, a report was given on the co-ordination of the U.S. physics R&D programme.

A special session on fuel cycle programmes was held. In this session, eight presentations were made covering work in all aspects of the fuel cycle area. Included were talks on experiments being conducted at Los Alamos National Laboratory, parameters for fuel cycle, fueling studies including pellet injector activities, fuel cycle safety issues, modeling activities, vacuum development activities, and tritium activities at the Westinghouse Savannah River Company and their potential application to ITER.

Invited representatives from U.S. industries met in a special session on January 26, with members of the U.S. Home Team Management and Office of Fusion Energy Management, to review the overall programme for industry involvement in the U.S. ITER EDA. Contracts in five major areas (magnets, plasma facing components, blankets, remote handling, and vacuum vessel) are being negotiated with industry teams to participate in the U.S. ITER tasks. Each industry/laboratory team has undertaken initial tasks and in many instances significant effort is now being performed by the industry partner. A sixth request for proposal was issued at the end of 1992 for an award to industry in the design area. Responses were due in late February 1993.

The next U.S. Home Team National Meeting will be held in mid-May 1993, at the Princeton Plasma Physics Laboratory.

COMING EVENTS

- TAC meets in Garching, Germany, 15-17 March
- MAC meets in Garching, Germany, 24-26 March
- SWG-2 meets in Garching, Germany, 30 March-1 April
- Technical Meeting on Vacuum Vessel and Blanket, Garching, Germany, 29 March-7 April
- The ITER Council meets in Tokyo, Japan, 21-22 April
- Technical Meeting on Plasma Control, Naka, Japan, 26-28 April
- Technical Meeting on Remote Maintenance, Standards and Quality Assurance, San Diego, U.S., 24-28 May
- Technical Meeting on Magnets, Naka, Japan, 1-4 June

Items to be considered for inclusion in the ITER Newsletter should be submitted to B. Kouvchinnikov, ITER Office, IAEA, Wagramerstrasse 5, P.O. Box 100, A-1400 Vienna, Austria, or Facsimile: 43 222 237762 (phone 23606392).

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