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An overview of the ITER project

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Abstract

The ITER Project Team now coming together in Cadarache is currently being shaped from the old, preserving the legacy of technical know-how built up in the ITER Joint Central Team since 1992. It is particularly strong initially in the most urgent areas, related to long lead items – magnets, the main vessel and the buildings – as well as in work related to licensing. But it also incorporates new functional needs – financial, administrative, and procurement – and ties in the needs of future users during operation.

Since the bulk of the procurement for ITER will be provided in kind, efforts have been strengthened to define better the share of responsibilities with the Parties' Domestic Agencies. The procurement cost sharing is being transferred into realistic technical splitting of the work, with agreements between the Parties to demonstrate production of the necessary quality, and how to handle any shortcomings.

The design has evolved since originally conceived and valued 5 years ago. Design reviews of specific procurements will therefore start in September 2006 to ensure the current manufacturing and design assumptions continue to satisfy requirements.

This paper reviews the current status of development of the ITER project, covering organisational and technical issues.

Keywords: ITER; Reactor; Technology; Safety

1. Introduction

Following a protracted period of negotiations, and the proposal of four candidate sites for ITER construction, a site adjacent to the CEA Research Centre in Cadarache, France, was finally selected by the ITER Parties (Europe represented by Euratom, the People's Republic of China, India, Japan, the Republic of Korea, the Russian Federation, and the United States of America) in June 2005. Since then the inter-Party negotiations have concluded, and the Parties initialled the Joint Implementation Agreement for ITER Construction, Operation and Decommissioning in May 2006. This agreement is now expected to be signed in November 2006, and ratified in 2007. If this timetable is maintained, this will allow the ITER Organisation to begin provisional operation by the end of 2006, starting to employ its first staff and place its first contracts.

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This paper therefore reviews the planning and preparations being made for a swift ramp-up of activity towards ITER construction. It covers the appointment of senior staff and the establishment of the configuration of the future organisation, the planning of staff build up and the future budget profile, the project schedule and its implications for procurement timing, the evolution of procurement sharing taking account of technical realities, and the development of the relationship between the ITER Project Team and the Parties' Domestic Agencies. On the design front it describes the plans for design review, integration of test blanket modules and their supporting equipment, and the impact of licensing preparations.

2. ITER Organisation (IO)

In November 2005 Ambassador Kaname Ikeda was unanimously accepted by the Parties as Nominee Director General (DG), pending confirmation of his appointment by the first ITER Council, the governing body of the ITER Organisation. In March 2006 he took over from Yasuo Shimomura as Project Leader of the existing International Team, who then became his Senior Scientific Advisor. In November 2005 the search began in Europe for his Principal Deputy (PDDG), and following the screening of more than 400 applicants the author was appointed as Project Construction Leader in March 2006. On proposal from the Nominee DG and PDDG, the Parties confirmed the senior management structure and divisional responsibilities for the future organisation. The leaders of the main divisions, Deputy Director Generals (DDGs) chosen to achieve a balance between the Parties, were designated in July 2006. The organisation as currently conceived, is shown in Fig. 1, indicating the new senior management. As this organisation develops, there may be some modifications in the detail. With the appointment of the senior management team, further appointments only need to

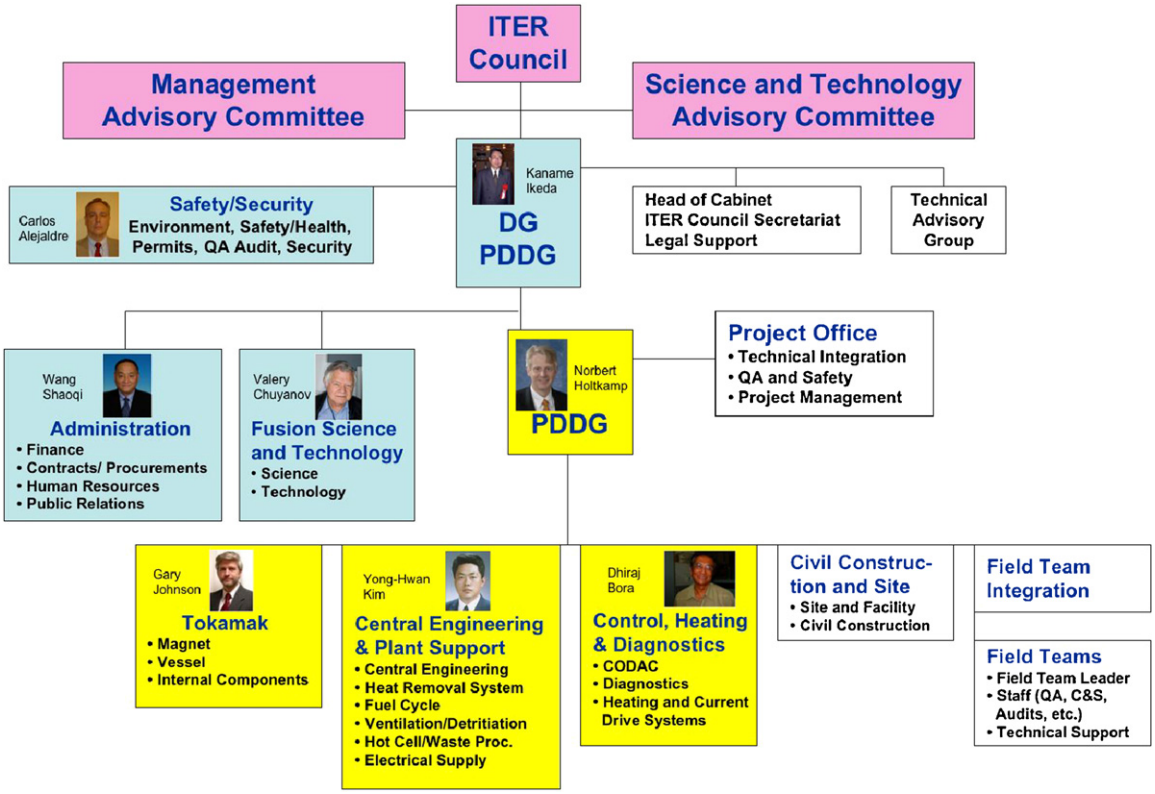

Fig. 1. ITER Organisation structure and senior management.

respect the overall balance of staff from the various Parties.

The IO can only be established after signature and ratification of the ITER Agreement, but nevertheless preparations are underway to facilitate its earliest start-up. These include the finalisation of Staff Regulations, with their implied employment conditions and staff salaries (establishment of pension and medical scheme cost deductions, for instance). They also include the writing of financial regulations and procedures, and the preparation of reporting and requesting of the budget for 2007, based on the Project Resource Management Rules. The details of the Site Support Agreement, between the IO and the European Host, and the Headquarters Agreement, between the IO and France, also have to be finalised. These documents all need to be approved by the first ITER Council, immediately after signature, to legitimise the operation of the IO.

3. Staffing

The above organisation is now being populated. To maintain the legacy of the design know-how, existing international team staff have been encouraged to move from the Garching and Naka Joint Work Sites to the Cadarache Joint Work Site as fast as possible. This is underway, as fast as the Parties and their staff are able, with major moves taking place in August/September, October/November, and at the end of 2006. The August/September move is being bolstered by the influx of DDGs and the PDDG, who can further help to specify the functions and jobs within their divisions.

In addition, 55 urgent positions have been identified, and the Parties have been asked to propose candidates so that 25 of these can be actively occupied well before the year-end. Under present arrangements, these staff can only come as secondees. It is hoped that, following signature of the ITER Agreement, contracts of employment between the (provisional) ITER Organisation and the first professional and support staff can be concluded before the end of 2006.

The planning of staff requirements has gone beyond 2006. This planning keeps to the integrated project schedule, and respects the budget envelope agreed in the ITER Technical Basis [1], namely 477 kIUA (1 IUA = US$ 1000 in 1989). This converts to ∼1800

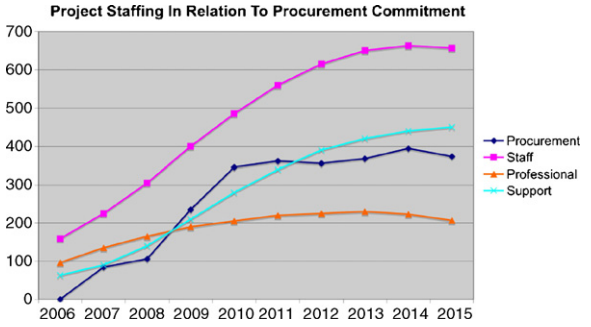

Fig. 2. Project staff build up during construction.

professional person years (PPY) and ∼2760 support person years (SPY) during the construction period. Further aims are to ensure a smooth transition of staff across different phases of the project, and to ensure an early start-up for the team building.

Assessments of the build up of project team staff during construction have been made (see Fig. 2). These show the ultimate number of team professionals rising to 220, with 410 support staff, allowing a smooth transition to the operational level which is of the same order. Fig. 2 also shows the relationship between the number of staff and the volume of procurement commitment at a given date, with a 1–2-year time buffer for professional staff and initial procurement specification, which continues as the procurements are further detailed by CAD support staff and tracked by technical support staff deployed in industry.

These figures show that by the end of 2007, the total number of professionals at Cadarache should reach 150, with 120 support staff.

It will be necessary to review the staffing requirement and staff costs in a few years, after the design review and when an agreed resource-loaded schedule has been developed. The original estimates in 2001 were based on 3 Parties. However this has now changed to 7 and many procurements are now split among Parties.

4. Expenditure

Expenditure estimates cover the scheduling of procurement, staff costs (counting both costs of directly employed staff of the ITER Organisation plus those of the Parties through seconded staff), and R&D during

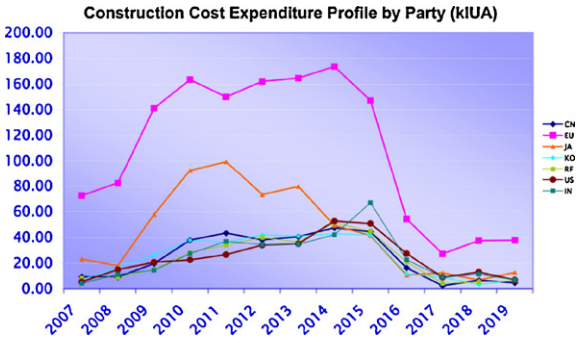

Fig. 3. Construction cost commitment profile.

construction. The current estimates are based on work done before 2001 on the scheduling of procurements, and thus need to be updated following the design review (see below). The schedule of procurements associated with construction also runs beyond the date of first plasma, for instance to cover costs for the DT phase fuel cycle systems.

Fig. 3 shows how these expenditures (in kIUA), which are mostly dominated by procurement, are shared by the Parties, assuming the agreed sharing of costs (5/11 Europe, 1/11 each other Party), and the current agreement on procurement splitting between the Parties, based on the ITER valuation in 2001. These predictions may therefore not reflect a Party's actual costs.

The above predictions will be revised as part of the design review, and verifying of the resource-loaded schedule.

5. Project schedule and work programme

The ITER project schedule is shown in Fig. 4, leading up to first plasma by the end of 2016. The current focus of technical work in the project is therefore grouped around six main activities:

- Site adaptation to take into account site-specific conditions and regulations, with a view to site preparation work starting at the beginning of 2007.
- Preparation of the Preliminary Safety Report with a view to its submission and the license application by the end of 2007, and with a public enquiry in mid 2008, leading to the granting of a construction license before the end of 2008.
- Preparation for design review, in particular of urgent items in the last quarter of 2006.
- Finalisation of the technical specifications for superconducting coils, vacuum vessel and the tokamak building complex.
- Memoranda of understanding for all procurement agreements need to be established to document the technical sharing of work.
- Development of a realistic resource-loaded schedule.

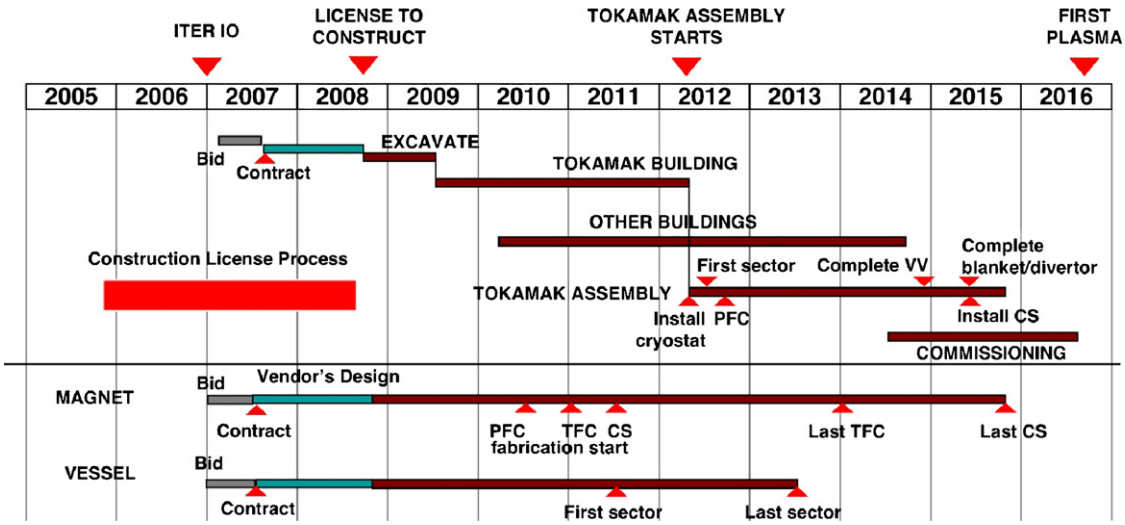

Fig. 4. ITER project schedule.

6. Procurement sharing

One of the main objectives of the Parties is to gain as much know-how out of ITER construction as possible, to put their industry on a firm footing when it ultimately comes to deployment of fusion power plants, and in the shorter term to involve them in the necessary cutting edge technologies. The sharing of the ITER procurements between the Parties, 90% of which they will provide "in kind", was therefore highly competitive. Nevertheless, it was possible to break up the work on an apparently reasonable technical basis, as part of the negotiations. The technical splitting of procurements now has to be developed more carefully in detail, and safeguards have to be built into the sharing to cover possible risks, such as the inability of a supplier in one Party to deliver in time sufficient high quality deliverables to meet the specifications.

The general procedure that has been developed for multiparty procurements envisages agreement of a Memorandum of Understanding (MoU) defining the general approach on how the procurement sharing amongst Parties could be adjusted to simplify the interfaces, identify the clear responsibility, and minimize the project risks. The MoUs have to be developed as soon as possible in order to prepare technical specifications efficiently in the IO and responsible Parties' Domestic Agencies. The MoUs will have to be accepted by the ITER Leaders Meeting (or its equivalent) and then endorsed by the ITER Council, since there can be financial implications which have to be settled by balancing values of contributions in several procurement packages.

A "Procurement Arrangement" normally documents the precise technical deliverables that will be delivered by each Party.

7. Relationship between IO and DAs

The general division of work between the ITER Project Team and the Domestic Agencies (DAs) should govern the skill set that is being hired in both areas. While the ITER Project Team is responsible for the overall design, integration, civil construction, installation and commissioning, the staff in the Domestic Agencies will execute detailed design, procurement, vendor oversight, testing and delivery. In addition, with the enormous amount of expertise available in each Party, much of the R&D that is still required, as well as much of the knowledge necessary to finalise the design, has to come from there.

The relationship between the ITER Organisation and the industrial suppliers is unusual in ITER, due to the preponderance of in-kind supply, funded by the Parties inside or outside of their own territories, for value credit in the overall project as agreed in the ITER Technical Basis. Thus although the ITER Organisation has responsibility for the overall integration of ITER, and its safe and successful operation, the financial leverage in contract operation is with the DAs of the Parties, which contribute the funds. The DAs therefore have procurement and technical expertise to follow the projects, and to be able to agree or negotiate with the IO about the financial implications of any changes that may occur.

From the IO side the relationship is governed by a FTL (Field Team Leader) for each Party, who is part of the IO, but spends significant time in the DA and surveying progress in their suppliers. The FTL

- can agree to field changes within cost and schedule contingency without consulting the IO up to an agreed upon amount;
- ensures that all relevant documents are transmitted to the DA from the ITER Organisation;
- ensures consistency of procurement packages, designs prepared by the DA, and ITER specifications;
- uses staff from the existing technical divisions in the IO, preferably those ultimately responsible for the installation, testing and operation of the component.

For its part, the DA

- delivers cost, schedule and performance information to the FTL;
- provides the FTL and staff with adequate office space.

The FTL submits cost, schedule and performance information each month to the IO project office (PO), reports all other necessary and useful information to the PO or the leadership team, communicates any schedule variance, scope changes, scope variances or potential issues and, guided by the PO, develops a risk matrix in which potential threats are tracked. Estimates of potential cost or schedule variances are given to the PO as

well as mitigation plans and strategies that the FTL develops in close collaboration with the DA.

With such a scheme, it should be possible to obtain early warning of problems, and to be able to compensate for them with minimum risk to the project costs and schedule deadlines.

8. Design review

At present, different procurement packages are defined to a different extent, primarily because the focus of the technical work since 2001 has been on packages requiring early procurement, and on those systems which interact most with them, or those which are most influential on licensing. The scope of the ITER design remains sufficiently defined so that the value of each procurement can be estimated, and so that changes in the earliest procurements do not have to be made overlooking the implications for later procurements.

A design review process is just being initiated driven by the International Team. This will be a continuous process over the next few years, focussing first on the earliest and most influential procurements to provide a frame for later ones. It is not intended that all Parties will participate in the discussion and express a view on all items, but the process will clearly need the involvement of experts from the Parties on specific issues. The review is being driven by the Project Office, and senior management decision making will be aided by a Technical Advisory Group (TAG).

The goal of the review is to resolve major open design questions in order to be able to prepare the procurement packages for the work breakdown structure (WBS) elements.

Each problem requiring resolution before a procurement package can be written merits an "issue card". Currently in ITER there are over 200 issue cards, and the number is growing as new staff join the project and as previously sidelined procurements receive renewed attention [2]. These vary from the fundamental to the trivial, and therefore have differing degrees of influence on the Project's risk of not reaching first plasma on time and on budget. The strategy for managing this risk at any time is documented in detail in the "Risk Management Strategy" of the Project, which is developed in conjunction with the procurement and construction schedules. This strategy therefore establishes the sequence and priority of the technical systems to be addressed, in conjunction with senior management. The issue cards and their rate of completion also provide a management tool to determine the progress and timely completion of the review.

8.1. Current work

The current technical work in the ITER Project Team is therefore orientated towards

- identifying all systems that are not designed yet or are still in the conceptual stage;
- starting from the technical basis [2], identifying all systems that have integration or technical issues which need to or should be resolved before a procurement specification can be assembled, documenting the issues, and planning a path forward for resolution;
- identifying areas, concepts and technical designs where recent R&D results indicate a possible performance problem or unacceptably high manufacturing cost, documenting issues, and planning a path for resolution;
- identifying areas, concepts and technical designs in which recent R&D results would benefit the design, schedule or cost;
- prioritising open issues with respect to their scope, schedule and cost impact, and identifying and implementing solutions in priority order.

A risk assessment document will be provided that will guide the design review in terms of scope, schedule and cost, and a priority number will be assigned.

8.2. Constrained change

In carrying out the design review, or generally finalising the design of specific procurements, or considering proposals for change in the design, since the overall ITER budget is fixed, changes which lead to cost increases, work or designs identified as not finished, or any other task that requires budget and was not foreseen before, needs to be offset against savings elsewhere. Each proposal for change therefore has to quantify the monetary, scope or schedule impact of the change, as well as the manpower needed for integration and who is supposed to provide them, clarify the impact on other WBS elements as precisely as possible,

and clarify whether the cost increase is a result of changes/conditions imposed by a Party. Any design change proposal has to be accompanied by proposed offsets in kind to keep the total project cost constant, proposed offsets in terms of scope (scope increase in one WBS versus scope decrease in another), and/or proposed offset using contingency. If caused by limitations from a particular Party, how additional costs can be covered needs to be discussed with that Party and any others affected.

8.3. Main review elements

The charge of the ongoing design review has certain major elements:

- Is the physics baseline established and documented well enough, and is the technical baseline consistent with it?
- Is the manpower sufficient for this stage of the project and distributed appropriately?
- Is the overall schedule consistent, sufficiently well established, and with enough contingency for this stage of the project?
- Is the organisation of ITER maturing and developing fast enough to be able to launch into construction when planned?
- Which parts of the organisation should be improved and how in order to support the construction project?
- Is the civil construction on track for construction start in 2009?
- Are the business systems in place to handle scope, schedule and cost of the ITER construction project?
- Are the safety and civil construction aspects properly addressed for this stage of the project?
- Where are the highest vulnerabilities?
- Is the design review process appropriate to address all technical, scope, schedule and cost aspects of the project?
- How can it be improved?

8.4. Technical advisory group

The Technical Advisory Group (TAG) reports to the DG and PDDG. Members are appointed by the DG for a 3-year term with the possibility of a 3-year extension. Members are expected to accompany the design review process and the build up of the IO. Their advice will cover technical, managerial and organisational aspects to help the DG and PDDG to successfully manage the project. There will be about 12–15 members and they will be recruited from the International Science Community. Reports of the TAG will be made public. TAG recommendations will be tracked and reported on in subsequent reviews. The TAG is expected to meet at least twice per year.

8.5. Design progress review

To assess the progress being made with the design review, it is proposed to hold a Design Progress Review meeting towards the end of 2006. This will address the following points:

- the status in each project division, reported by each DDG;
- the status of establishment and operation of DAs, reported by the Parties;
- the readiness of long lead procurements;
- the status of configuration management and internal design review;
- the status of development of planning, staffing and budget projections.

Parallel sessions will address high priority technical issues, planning, staffing and budget, QA, management and progress reporting, and safety.

9. Licensing

Licensing is currently on the critical path of ITER project construction. An English version of the draft preliminary safety report (RPrS) has been provided by the European Participant Team (EUPT) and is under review. Extensive work with a strong support of the EUPT and French (CEA) host is needed to submit the RPrS in the required form by the end of 2007. It will also be necessary to agree and finalise within the project those design characteristics which need to be written in the report, with a view to demonstrating before operation that the design constructed will limit environmental impact to set levels. At the same time these characteristics must leave sufficient scope for design change, and ensure that future operation and experimentation on ITER is not unduly cramped.

Support by experts with the knowledge of technical and administrative practice in construction is urgently needed for clarification of the implementation requirements.

10. Test blanket modules

All ITER Parties wish to take advantage of ITER to test high temperature coolant tritium breeding test blanket modules (TBMs). The existing development programmes for these items are outside the scope of ITER, and involve a considerable legacy of R&D, which due to its proprietary nature and implications for exploitation of fusion power has not up to now been completely freely exchanged between the Parties. Furthermore, each Party has their own design preferences, whereas there are only three ports available on the machine for testing. The Parties therefore have to decide how to work with each other, sharing ports and some information, and to discuss with ITER how to accommodate within the design and licensing constraints.

In July 2006 an ad hoc group on the TBM programme met for the first time. The Parties agreed to prepare qualification programmes, and to cooperate to finalise an optimised test programme for six TBMs. Each Party is also working now to clarify Party–ITER mutual obligations. In parallel a small technical task force of specialists from the Parties is working to consolidate the impact of all such testing on services and building design requirements.

11. Participation in ITER

ITER is perhaps the most challenging scientific endeavour being undertaken today. By necessity of that challenge, it is being undertaken internationally, with more than half the world's population funding its construction, and sharing in its benefits and risks. To be a success, it will need to attract the very best people, both from inside and outside the fusion community.

The structure that is developing shares the responsibility for success with the Domestic Agencies of the Parties by ensuring the joint aim of all is mutual success on time and within budget.

12. Conclusions

The ITER Organisation is imminent and final preparations are underway to make it effective at the earliest opportunity. The Parties are aware of their budget and staffing obligations and are making progress in satisfying them. The project team is coming together in Cadarache. A design review is about to begin which will strengthen the technical and financial commitment of all stakeholders, DAs and project team members. The challenges in realising ITER are hard but manageable, and, with the support of the fusion community, can be overcome.

Acknowledgements

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References

[1] ITER Technical Basis, ITER EDA Documentation Series No. 24, IAEA Vienna, 2002.
[2] S. Chiocchio, System Engineering and Configuration Control Management in ITER, this conference.