ITER Council Working Group on the Independent Review of the Updated Long-Term Schedule and Human Resources (ICRG)

Report

15 April 2016

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Executive Summary

Producing sustainable energy remains a key challenge for humanity. It is essential that all possible sustainable energy technologies with significant potential be explored. Fusion could provide a significant fraction of the world's base-load electricity if technical and economic viability can be demonstrated. The goal of ITER is to demonstrate the scientific and technical feasibility of fusion energy, building on six decades of worldwide magnetic confinement Tokamak research. ITER is not only at the frontier of technology, it is the world's largest and most complex energy research project. To meet this challenge an international collaboration of seven partners, the Members, has formed to build and operate ITER and to share the scientific results.

After years of project schedule delays, the ITER Council (IC) in 2015 appointed a new Director-General (DG), Dr Bernard Bigot, who has restructured the ITER Organization's (IO) senior management in a major way, with highly experienced senior managers leading the ITER Organization Central Team (IO-CT). This has led to a **substantial improvement in project performance**, a high degree of **motivation**, and **considerable progress during the past 12 months**.

The IO-CT has started to provide bimonthly **project performance reports** to the IC, including well-defined **milestones**, and is working towards implementing an Earned Value Management System (EVMS) to track progress and performance (schedule and cost). Presently, the IO-CT overall value-weighted estimate for construction project completion (First Plasma system) is reported to be approximately 40%. This includes all design work, IO-CT contributions, and considerable in-kind contributions from the DAs.

One of the first major priorities of the new management team was to develop, with the seven Domestic Agencies (DAs) of the Members, a realistic schedule and IO resource estimate plan. This was completed and presented to the IC's Seventeenth Meeting (IC-17) in November 2015, described as the Updated Long-Term Schedule (ULTS) and its associated resource estimate. The ULTS resulted in an increase of the requested IO-CT resources by 4.6 BEUR for the period up to 2025 over the current (2010) baseline, which did not fit within the known financial yearly constraints of the Members.

The ITER Council has charged the ITER Council Review Group (ICRG) to evaluate in detail the ULTS and its post IC-17 Update, which would reflect the known financial constraints of the Members. However, early in the review process, it became apparent that development of this "update" (called the "Iteration Modelling") would not be completed within the time frame of the ICRG review. Given the project's intense focus on achieving First Plasma (FP), the ICRG devoted most of its attention to that part of the **ULTS** and the associated resource estimates.

Assessment of the ULTS

The ICRG, after careful analysis of the documentation and information provided by the project's management team (both IO-CT and DAs), comes to the following **conclusions concerning the ULTS**:

- The **sequence and duration of future activities have been fully and logically mapped** in the **resource-loaded schedule**;
- The **methodology is rigorous** and was **applied systematically from the bottom** up; and as a consequence, the **schedule is complete,** with no significant omission.
- **The resource estimate is generally complete,** including scope that was previously missing, and provides a **credible estimate of cost and human resources**. DA activities are not resource-loaded but are tracked using key milestones.
- The ULTS results in a **December 2025 FP milestone, the earliest possible technically achievable date**. However, it does not presently have any **contingency**. Likewise, the resource estimate does not include any explicit contingency. Hence, the ULTS and its associated resource estimate cannot yet be considered to be reliable given that some risks will inevitably materialise.
- Under the new DG's leadership, **risk management** (i.e., project-wide systematic identification of risks and opportunities, development of response strategies and specific mitigation plans, and

estimation of the pre- and post-mitigation probabilities of occurrence) is now receiving senior management attention. As a consequence, the IO's risk management approach, organization, and processes are maturing at a good pace.

- At present the main determining factors for the critical path are the manufacturing and delivery of the sectors of the Vacuum Vessel, the on-time completion of the Tokamak Building, and Assembly and Commissioning. To address the matter of schedule reliability, the ICRG recommends that the IO determines a target date (milestone) for FP that includes a reasonable contingency once an initial quantitative risk analysis is performed. It would be desirable to have this incorporated in the IO-CT's new baseline proposal to the IC which is expected in November 2016.
- There seems to be no possibility to accelerate the delivery date of FP.
- The ICRG conducted detailed "drill-down" **reviews of a sample** (**7 major elements) of the ULTS resource estimate,** and this report makes a number of recommendations concerning their technical aspects, financial and human resources. The drill-downs confirmed that the resource-loading was done from the bottom up in a detailed and systematic manner and that no explicit contingency has been included in any of the estimates. The ICRG's observations and conclusions were checked by the IO-CT for factual accuracy. In general and based on the drill down samples, the ICRG concluded that the **resource estimates for IO-CT costs were within a reasonable range for this stage of the project** (i.e., not significantly over- or under-estimated).
- The ULTS assumes that the additional 4.6 BEUR required up to 2025 will be made available by the Members.

Assessment of the post IC-17 update of the ULTS (Iteration Modelling)

ITER Council has charged the IO-CT after the IC-17 to develop a revised ULTS, which would reflect the known yearly financial constraints of the Members. The IO-CT has started to develop such a plan, based on a **staged approach (Iteration Modelling)**, which makes full use of the work already invested in developing the ULTS. The Iteration Modelling keeps the date of FP fixed (2025), but foresees deferring components not needed for FP operation and allows for prolonged measurement campaigns in between, delaying the start of DT operation with respect to the ULTS. Initial results put this delay at about 3.5 years, corresponding to ~15% of the time, when calculated from today. The IO-CT and DAs are working to develop this Iteration Modelling further and expect to have an approach ready for the IC to consider in June 2016.

While recognizing that the Iteration Modelling is still a work in progress, the ICRG observes that although the staged approach delays the crucial burning plasma experiments by a few years, it has a number of benefits compared to the ULTS:

- All ITER Members can better focus on the successful achievement of FP;
- Overall project risk is reduced by addressing the technical challenges step by step;
- Funding requirements during the years 2017 to 2019, when some DAs face budgetary constraints, are reduced;
- There is better flexibility for accommodating delivery constraints of the DAs (and the IO-CT); and
- There is time to accommodate a longer research program between FP and the start of DT Operation, thereby preparing the crucial DT experiments more thoroughly.

All ITER Members need to join in fully elaborating and understanding the details as well as the consequences (advantages and disadvantages) of the Iteration Modelling approach.

General Recommendations:

- The joint IO-DA Project Teams are having a positive impact. But overall, the trust between the IO-CT and DAs is still not deep. Therefore, a continued strengthening of the project management culture at all levels of the organisation is needed and further integration is necessary.
- Subsequent iterations of the schedule should reduce the number of activities for earned-value reporting. The IO-CT may wish to consider collecting costs at Level 4 rather than at Level 5 (as currently being done) in order to reduce complexity.
- Right now, the guidelines for use of the Reserve Fund are very narrow; however, if the rules were broadened then the DG could use the Reserve Fund more effectively for the benefit of the project, for example to mitigate risks.

Human Resources

The approach taken by the ICRG was to review documentation, drill down into a sampling of departments and interview ITER staff members. As a result of this analysis, the ICRG comes to the following conclusions:

- The DG and his team are working successfully to create a project management culture at ITER. This work is appreciated by the ITER staff. In keeping with these changes, the ICRG encourages changes to the Human Resources Department and to the development of human resources policies and procedures that support that culture and the ultimate success of ITER. The primary goal should be the success of the ITER Project and the Human Resources Department has to serve as a support organization that helps to achieve this goal.
- IO management should consider restricting assignments, in general, to not more than two terms for staff other than operations. Exceptions to standard renewals should be possible, but they would need to be approved by the DG. The IO-CT must be careful not to automatically renew employment contracts. Contract renewal should be based on the needs of the IO and the performance history of the individual. The durations of the contracts should be defined according to the position and different phase of the project.
- The IO-CT should use its own staff for base or core functions but use contracted staff to address peak or more conventional requirements. Using a number of large, long-term labour contracts with a shared planning of project requirements would ensure that contracted labour could be obtained quickly and would be available as needed.
- The IO-CT needs to work with DAs to review staff requirements and encourage the DA's to send expert manpower to ITER.
- The Human Resources Department should conduct and maintain a skills/competency inventory and develop a knowledge management system.
- ITER management should seriously consider making changes within the Human Resources Department and to human resources policies and procedures to ensure that the organization is more flexible and supportive. The staff of the Human Resources Department needs to be more diverse and more in line with the diversity of the IO-CT member countries.

IO-CT and DA Integration

The culture of **collaboration between the IO-CT and the DAs** needs further strengthening, ITER must become the common project of all Members, and all priorities must be adjusted to meet the common goal: to make ITER and fusion a success.

- The success of ITER requires **efficient international cooperation**. It is therefore necessary for all ITER Members to strengthen their global cooperation in preparation for the operation of ITER. True international collaboration in any field of science depends on shared goals, experience in working together and mutual trust. These elements need to be further developed for ITER to ensure its efficient operation. **Joint operation experience by personnel from all**

ITER Members in the coming years, using available Tokamak facilities, would be an important step in that direction, especially by providing a training ground for ITER scientists and engineers.

1. Introduction

Producing sustainable energy remains a key challenge for humanity. It is essential that all possible sustainable energy technologies with significant potential be explored. Fusion could provide a significant fraction of the world's base-load electricity if technical and economic viability can be demonstrated. The goal of ITER is to demonstrate the scientific and technical feasibility of fusion energy, building on six decades of worldwide magnetic confinement research in Tokamaks. The key experimental targets are: to achieve the world's first burning DT plasma; to demonstrate steady-state fusion power production; to test essential fusion power reactor technologies and components; and to support the safety and environmental acceptability of fusion.

ITER is not only at the frontier of technology, it is the world's largest and most complex energy research project. To meet this challenge a worldwide collaboration of seven partners, the Members, has formed to build and operate ITER and to share the scientific results. Design, construction, integration, operation and exploitation of this large facility will provide the knowledge necessary to develop an industrial Fusion Demonstration Power Plant (DEMO) later in the century.

The ITER Project started in 1985. From 1988 to 1990 the Conceptual Design Activities took place, followed by the Engineering Design Activities (1992 to 2001). The ITER Organization (IO) was formally founded through an international agreement signed in November 2006.

The ITER Project has accumulated considerable delays and cost increases. The reasons for these have been analysed: the 2001 design was incomplete, the original schedule and budget did not take into account adequately the complexity of the project and the effects of the proposed dispersed organizational structure (Central Team (CT), Domestic Agencies (DAs)), and the way in which work was shared between parties. This led to inefficiencies, boundary problems, delays and cost increases. In contrast to most other large scale science and technology projects, the ITER Members decided not to place the project within a pre-existing organization with experience in successfully building complex scientific infrastructure. Thus the organization had to be built by recruiting experienced staff or by training – this requirement is not fully completed. In addition ITER is a unique nuclear facility, the nuclear safety aspects and requirements for fusion components, buildings, and operating needed to be developed from scratch.

In 2013, an external Management Assessment (MA) identified major problems in the management of the ITER project. As a consequence the ITER Council (IC) in 2015 appointed a new Director-General (DG), Dr Bernard Bigot, who has restructured the ITER Organization's (IO) senior management in a major way, with highly experienced senior managers leading the ITER Organization Central Team (IO-CT). This has led to a substantial improvement in project performance, a high degree of motivation, and considerable progress during the past 12 months. In addition, the DG proposed a number of measures to resolve the present difficulties, the most important one being that the ITER Project should be built by an integrated team of the IO-CT and the DAs under the leadership of the DG. The DA Heads, the DG and the Deputy DGs' form the Executive Project Board (EPB). The EPB supports the DG in taking all strategic decisions, in developing for the Project a new baseline (scope, cost and schedule) and in directing their implementation through the joint efforts of the integrated IO-CT and DA teams.

In addition a Reserve Fund was established, set up to mainly deal with additional costs resulting from design changes. The Reserve Fund, which is under the responsibility of the DG, has led to a significant acceleration of critical decisions.

One of the first major priorities of the new management team was to develop, with seven Domestic Agencies (DAs) of the Members, a realistic cost and schedule plan. This was completed and presented to the IC's Seventeenth Meeting (IC-17) in November 2015, described as the Updated Long-Term Schedule (ULTS), together with a request for additional staff and cash resources. In addition, the IO-CT has started to provide bimonthly project performance reports to the IC, including well-defined milestones, and is working toward implementing an Earned Value Management System (EVMS) to track progress (schedule and cost).

In response, the ITER Council established the ITER Council Working Group on the Independent Review (ICRG) [Appendix 1] to review the ULTS together with the associated existing staff and future Staffing Plan, and other required resources as well as the ITER Organization (IO) Human Resources organization and process/procedures.

2. Charge to and Approach taken by the ITER Council Review Group

The ITER Council (IC) charged the ICRG to perform an independent review [Document 1] of the

- Proposed *sequence and duration of activities* required to achieve FP and to subsequently operate the facility and complete the remaining systems and components for Deuterium-Tritium (D-T) operations;
- *Present and proposed resources* necessary by IO-CT to achieve the FP milestone, specifically the proposed staffing plan;
- IO's *structure*, its *Human Resources (HR) organization* necessary to support the envisaged activities;
- *Technical and financial assumptions* underlying the proposed ULTS (e.g. known financial constraints of the Members)

and to make recommendations that would improve the Schedule, IO-CT Staffing Plan, and HR effectiveness.

The ultimate goal of ITER is sustained fusion burning Deuterium-Tritium plasmas. The Project Requirements (PR) document (27ZRW8) of 2 April 2014 outlines the progressive start-up of ITER: At the end of the first construction period, an integrated commissioning of ITER systems shall be performed, to ensure correct functioning, and to assure readiness for plasma operations. The production of FP will occur at the end of the first integrated commissioning. Furthermore, first commissioning defines the transition of the project from construction to operation.

The IC and IO-CT agree that FP must be the first priority goal of the present phase of ITER and therefore the revised schedule and resource planning need to take this into account.

The ICRG had, according to its Terms of Reference, not only to "evaluate the proposed *sequence and duration of activities* required to achieve FP and to subsequently operate the facility and complete the remaining systems and components for Deuterium-Tritium (DT) operation", but also "to evaluate the post IC-17 update of the ULTS, together with its underlying assumptions, its associated IO-CT resources embodied in the IO-CT Staffing Plan". This post IC-17 update was not yet available at the time of the first on-site meeting in February 2016.

Therefore the ICRG decided to **first** study the details of the **Updated Long-Term Schedule** (**ULTS**) up to FP, the methodology of its generation, its credibility, the resource requirements etc. and, in a **second** step, to review the **post IC-17 update of the ULTS** as soon as it became available and to analyse it in comparison with the ULTS.

In its **first meeting** from 15 to 19 February 2016, the ICRG therefore focused on a general understanding of the ITER status, the schedule and resources [Document 3]. On 15 and 16 February 2016 the IO-CT presented very detailed data to the ICRG. In addition, the ICRG was able to form its own impression of the construction progress during a site visit. During the subsequent days, the management repeatedly met with the ICRG to receive and answer questions.

The ICRG interviewed the Heads of the Domestic Agencies and asked them a number of questions which are listed in [Appendix 2] together with a summary of the answers. The ICRG interviewed also the IC Heads of the Delegations (HoD) [Appendix 3].

The ICRG met in closed session to discuss the overall situation and then broke up into two sub-groups, one on Schedule and Resources, and the other on Human Resources. On Friday, 15 February 2016, both sub-groups reported their preliminary findings, formulated further requests and questions to the IO-CT and defined their next actions.

In particular the ICRG asked the IO-CT and DAs to address the following issues:

Overall status of procurement and construction progress: Gain a common understanding of the present status of procurement/construction activities, such as design, procurement, manufacturing, shipment, on-site installation, testing and commissioning of the specific work-packages.

IO Resource Needs: Some of DAs during their interviews with the ICRG raised questions concerning a further optimization of the IO-CT resource estimates (staffing and non-staffing, including non-labour costs). The ICRG requested the IO-CT and DAs to work together to clarify the IO-CT resource estimates and come to a common understanding.

Risk Study: The purpose of this study was to take an inventory of major technical risks and to understand the IO-CT's mitigation strategies and plans, and the impact on the schedule to FP if and when these risks materialise.

The IO-CT provided answers to those questions on 16 March 2016 in writing and on 18 March 2016 during a video presentation. At the same time the IO-CT presented a first iteration of the post IC-17 update of the ULTS, the so-called **1st Iteration Schedule**.

The ICRG, in interaction with the IO-CT staff, performed in-depth analyses of the resource estimates (both labour and non-labour) for several of the technical systems. The results of the technical analyses were sent on 24 March 2016 to the IO-CT and the DAs for fact checking. The results of the fact checking were provided to the ICRG in writing on 31 March 2016 and have been incorporated in the report.

In its **second on-site meeting** from 11 to 15 April 2016 [Document 4] the ICRG received from the IO-CT reports on the follow-up actions after the ICRG's first visit and the schedule development, the second iteration of the Scenario modelling, the most recent development of the Project Risk Management Process, the latest update on various aspects, as well as information on the Vacuum Vessel procurement.

The ICRG completed this report and agreed upon its content and the recommendations on 14 April 2016.

This ICRG report consists of an Executive Summary, eight Chapters, four Appendices and three accompanying documents (Terms of Reference and meeting schedules).

3. Analysis of the ULTS and Resource Estimates

3.1. Present Status of ITER

The changes in the ITER management, strategy, leadership and the DG's Action Plan have motivated the IO-CT team and are appreciated by all ITER Members. The management structure has been reorganized to reflect a construction project orientation and the senior management team is strengthened. An Executive Project Board (EPB) has been set up to take the needed decisions in due time for an effective global project management. Three Project Teams have been established in critical path areas: (1) Buildings, Site Infrastructure and Power Supplies Distribution; (2) Vacuum Vessel; and (3) Cryogenics, with leaders approved by the EPB.

The change in the decision making culture is appreciated at all levels and the impact of timely decisions is evident. The joint IO-CT/DA teams are having a positive impact, but the trust between IO-CT and DAs is still not deep. There was clear coordination between IO-CT and DAs on the ULTS, however the ICRG was disappointed in the degree of DAs involvement in the development of the resource estimates. Therefore, a further strengthening of the project management culture at all levels of the organisation is needed and further IO-CT DA integration is necessary.

A **Reserve Fund** has been set up under the DG's control to handle design changes rapidly in the best interests of the project. All decisions relative to using the Reserve Fund are discussed within the EPB.

A plan has been formulated to enhance knowledge and understanding of nuclear safety as a tool for improving the nuclear project culture in the Project.

The Quality Assurance Plan (QAP) is undergoing an update. The Project Management Plan (PMP) is currently in its final review stage to provide high-level principles and requirements.

Since the beginning of this year (2016), the ITER Council is receiving bi-monthly **Project Performance Reports**, focusing on technical and programmatic milestones. The first report was published in January 2016, the second in March. A comparison shows a clear progress: of the 25 Project Milestones for the years 2016 and 2017, 5 (in January the number was 4) have been completed, 17(14) are foreseen to achieve the IC milestone, and 2(7) are experiencing minor delays which are being closely followed. One milestone due in March is predicted to miss the forecast date (shipping of cooling pipes), however the delay is being addressed. Of the 4 programmatic milestones, one has been reached (the ICRG review). The other 3 are on time.

The ICRG has visited the construction site and noted that the progress is very impressive. There is a high level of activities, and the buildings, especially the Assembly Hall and the Tokamak Building are clearly taking shape.

Work under the Procurement Arrangements (91% of which have now been signed in terms of KIUA value credits) is progressing well and momentum is building. The IO-CT, together with the DAs, have analysed the global status of FP components in areas such as design, procurement, manufacturing, shipment, on-site installation, and testing and commissioning. This analysis is based on the Level 1 Schedule activities which represent the major ITER systems, but exclude Assembly and Installation. FP systems for the purposes of this analysis defined as: Buildings, Steady State Electrical Networks, Cable Trays, Vacuum Vessel, Gas Injection System, Magnets, Cryostat, Thermal Shield, Cooling Water, Vacuum System, Cryoplant and Distribution, Coil Power Supplies and distribution, CODAC, Central Interlock System, Central Safety System, ECRH, Diagnostics and Port Plugs, In-Vessel Viewing System, Access Control and Security Systems. The percentage completion (based on KIUA value credits) up to FP was estimated by the IO-CT to be:

Percentage complete through final design	89%
Percentage of manufacturing	24%

The percentage of manufacturing includes partial credit for components partially completed. The percentage completion for Non-FP components was also estimated to be:

Percentage complete through final design	71%
Percentage of manufacturing	11%

Presently, the IO-CT overall value-weighted estimate for First Plasma construction project completion (First Plasma system) is reported to be approximately 40%. This includes all design work, IO-CT contributions, and considerable in-kind contributions from the DAs.

3.2. Review of the ULTS and Resources

3.2.1. Resource-Loaded Schedule – General Analysis and Comments

In response to the charge given by the ITER Council, the IO-CT presented in November 2015 a resource-loaded ULTS through the start of Deuterium-Tritium (DT) operations. The ULTS was based on a comprehensive bottom-up planning exercise supplemented by a detailed IO-CT top-down internal review and challenge process. This schedule, which envisaged FP (FP) by the earliest technically achievable date of December 2025 assumed that the configuration for the ITER machine at the end of the first assembly phase (i.e. for FP) would be as defined through the baseline documents based on PCR-609, and that second phase assembly would begin immediately after cryostat closure in such a way that the FP earliest achievable date would not be affected. This schedule was the basis for presentations by the IO-CT to the ICRG in February 2016. This version of the ULTS is the one evaluated by the ICRG.

Methodology:

The ULTS is logically-linked and resource-loaded, consistent with a December 2025 FP milestone followed by a DT (Tritium Trace) milestone in 2032. The methodology was applied in a systematic and rigorous manner. The ULTS consists of roughly 250,000 activities at WBS Level 6 and lower, resources are estimated in 2015 EURs. The high level of detail in Level 6 makes it difficult to use to measure progress. The ULTS was developed from input from ~55 Responsible Officers (ROs) which provide the specific work activities and the needed resources. DA activities are tracked using key milestones. The ULTS is supported by a Project Controls group of approximately 20 staff. Costs are loaded at WBS level 6, but rolled up to WBSD Level 5, where charges are applied, at WBS Level 5.

Timeline and Critical Path:

The ULTS critical path to FP runs through the Vacuum Vessel (EU part), followed by installation and assembly, and integrated commissioning for FP. However the Tokamak Building lies close to the critical path and could easily slip. In the ULTS the FP milestone at 2025 is the earliest possible technically achievable date. The ICRG notes that this is a success-oriented schedule with no contingency. If any of the major risks that the IO-CT has identified materializes, then the FP date will almost certainly slip by some degree. There seems to be no realistic possibility to move the FP date forward.

The ULTS FP milestone is five years beyond the one specified in the 2010 Baseline schedule. The IO-CT cost estimate for the period up to 2025 is about 4.6 BEUR (100%) greater than the previous cost estimate. The project has stated the weaknesses of the 2010 Baseline schedule were missing scope, underestimate of installation and assembly activities and incomplete design.

The ULTS is vulnerable to schedule delays should DA deliverables be delayed beyond the "need by" dates or if problems arise during assembly and commissioning. This is particularly acute on critical path (or near critical path) deliverables such as the Vacuum Vessel and Tokamak Building. Meeting the ULTS critical path schedule is a shared risk by the IO-CT and the DAs. The IO-CT should continue to ensure adequate milestones are in place to provide early warning to critical path deliverables or assembly/commissioning risks.

3.2.2. Detailed Analysis of Critical Technical Sub-Systems (Drill-downs)

One outcome of the ULTS is a large increase in the size and costs for the IO-CT staff. This is due both to a more realistic estimate of the work to be done and to a major increase in the duration of the project. The resource estimate is based on 25 Cost Books, covering the major areas of the project. The ICRG has selected 7 of the critical technical sub-systems and conducted a detailed analysis, "drill-down", of the schedule and related resources The ICRG also took note of 7 additional detailed reviews conducted in the "Resource Optimization" sessions between the IO-CT and certain DA's.

The sub-systems were Diagnostics, FLM (Facilities, Logistics and Materials), Vacuum Vessel, Magnets, Heating and Current Drive, Installation and Assembly, and the Tritium complex. The key findings and recommendations are:

Diagnostics

This PBS consists of over 100 "projects" that represent individual diagnostic systems, their associated port plugs (where applicable), and the Port Plug Test Facility. These elements have a very large number of interfaces with a wide variety of ITER systems, requiring a great deal of integration. Many also require interactions with the Nuclear Regulator (ASN). A large number of the elements (about 70%) involve in-kind hardware covered by Procurement Arrangements (PAs), where the roles and responsibilities for the IO-CT and DAs are defined. Installation of most items falls under the Construction Department, so those costs are part of the Assembly estimate. The Diagnostics estimate does include acceptance tests, oversight of installation and commissioning as well as support for handling Non Conformance Requests, etc. There is an organizational interface with the Science & Operations Department, which has reviewed the estimate to confirm that there is no double-counting in cost estimates.

The resource estimate was developed through the IO-CT's standard project-wide bottom-up process, starting with loading the Level 6 Primavera schedule (~ 1200 work packages in this case). The schedule and cost were developed by personnel with direct experience of design, building, and operating similar systems on other fusion devices, however, ITER will be the first of its kind to require diagnostics capable of operating in a fully nuclear environment.

The estimated IO-CT resources to reach FP are about 390 MEUR (166 MEUR for labour + 224 MEUR for materials). Another 223 MEUR is estimated for the schedule between FP and the end of the Construction Phase (presumed to end in 2032), resulting in a total of 613 MEUR. It was reported that 173 MEUR (28% of the total) was included for items to be added (a list was provided). This scope addition is yet to be agreed, and not automatically assumed to be added. PCRs (Project Change Requests) for all systems follow the Project Change Procedure. The priority 1 diagnostics required for FP are included in the baseline. Almost all of the new proposed scope pertains to post FP diagnostics.

The IO-CT asserted that as much scope as possible has already been deferred to after FP. For the period after FP, the staffing profile remains at a peak steady-state level of 200+ FTEs. Under the ULTS, all staffing costs for diagnostics would be met out of the operations budget on the assumption that these would largely be used for operating diagnostics.

The design work over the past couple years has identified a number of missing items (included in the above-mentioned 173 MEUR PCR category). Almost all of the design work has progressed beyond a CDR (i.e., in Preliminary or Final Design), and deliveries of individual items will begin this year. Confidence was expressed in the current state of scope completeness, as diagnostics is not likely to be subject to significant scope changes due to regulatory issues.

For materials costs, it was reported that the estimates are up-to-date. A rough quantitative breakdown shows how much is prototypes (50%), external design input (13%), vendor contract prices and vendor

quotes (2%), historical/benchmark data (15%), and engineering judgment (19%). The IO-CT expressed high confidence in the overall quality of the materials cost estimate, however, there is no contingency.

The Division staff currently numbers 16 IO-CT employees, 2 matrixed CAD operators, 1 post-doc, with 6 more IO-CT positions to be hired this year. There are also a number of IO-CT support contractors working through deliverable-based contracts. By FP, the Division staff is planned to reach a total of 190 FTEs (P + G staff, CAD, and "flexible" – which could include staff seconded by the DAs) – approximately 15% of total IO-CT staff. Costs were calculated assuming that if DA personnel are seconded, costs will need to be reimbursed in most cases. There was both an internal IO-CT review of the resource estimate and another done by the previous IC Chair.

There are no specific regulatory hold points relating to diagnostics. The Diagnostics & Port Plugs schedule up to FP is driven to some extent by the need to complete design work to manufacture/deliver captive components required to assemble the tokamak. Some are near the critical path to FP. It was reported that risks have been identified and mitigation plans have been developed, all contained in a risk registry that is regularly updated. The IO-CT has shared preliminary data on the EVM pilot and their approach to the project wide EVM during the April ICRG visit.

The ICRG had concerns about the Diagnostic resource estimate. The assumed operational model was not made clear and therefore the justification of the large staff level during operations was also unclear.

Specific Recommendations:

- Continue IO-CT efforts to evaluate and optimize the staffing level for Diagnostics, especially for the period leading up to FP.
- Clarify the operations model and the expected interaction of diagnostic staff with member science and engineering staff.
- Keep IO-CT management attention focused on recruiting and retaining the best available diagnostic physicists, engineers, and technical staff (as either IO-CT employees or ITER Project Associates (IPAs) from the DAs) in a programme management matter. The ICRG encourages strong cooperation between IO-CT and DAs to fulfil staged diagnostic needs by different optimised approaches, such as construction and commissioning contacts, remote participants and operation service with major contributions from the DAs.

Facilities, Logistics, and Materials (FLM)

The FLM Division is responsible for: contributions to the building project team (BIPS); facilities management (FMM); and transportation of ITER components and materials management. The total division staff peaks at 32 and is at 23 currently. Staff tasks include the management of contracts, satisfying the management requirements of the nuclear regulator, the responsibility for all design reviews, as well as designing and building new infrastructure that has not been included in Procurement Arrangements (PAs). The IO-CT internal review trimmed the proposed staff by two. The majority of the cost in this area, greater than 500 MEUR in a total of approximately 575 MEUR (total amount between 2016 and 2032), is in industrial contracts for buildings and services.

Increases in costs in this area are largely due to the additional infrastructure that is not included in the PAs – for example the beryllium complex (19.2 MEUR), the additional storage warehouses (10 MEUR), other buildings (10.4 MEUR), workshops (17.85 MEUR), and building modifications after F4E "completion" (30 MEUR). The biggest element of cost for storage is due to facilities that were not originally envisaged and are now needed due to the slippage of the assembly schedule to store some deliveries from DAs. The same is true for logistics. Other additional items were never envisioned. For example the beryllium was assumed to be handled in the hot cell. In the absence of the hot cell in the schedule to FP, an alternative beryllium complex is required. The original schedule in 2010 assumed components would arrive ready for installation – it is now recognised that workshops will be needed to

make modifications to some items. The cost estimates of new buildings are not based on specific designs, but on estimated area and cost per square meter of comparable buildings at ITER. Although the project will aim to minimize the need to modify the buildings after construction, the Cost Book contains 49 MEUR contingency for such modifications if they turn out to be necessary.

Staff requirements for the division are based on the planned need and existing costs. They have been benchmarked for the building project team (BIPS-PT) against similar projects (the LHC at CERN, the JHR reactor at Cadarache, and Laser Megajoule) – summarized in Table 4 in the Cost Book. The staff requirements are comparable – given the first of a kind nature of ITER this indicates that staff numbers are certainly not overestimated. Similarly the staff requirement for the operational phase in site management and logistics is 23, which is about 70% of the comparable staff requirement of CEA Cadarache scaled by relative sizes of the total workforce. Again, this is a modest requirement.

Vacuum Vessel

The manufacturing of the Vacuum Vessel (VV) sectors defines the critical path until assembly. The vessel is being built in two places using two different engineering approaches, sectors 1 and 6 by Hyundai Heavy Industry (HHI) in Korea and the rest by a European consortium (AMW). The IO-CT, the EU, India, Russia and Korean DAs have formed a VV Project Team to coordinate work. Most of the common technical issues are being resolved using sector 6, under manufacturing at (HHI). The IO-CT expects that the vacuum vessel sectors contracted with HHI will be delivered on schedule with enough time before the assembly need date. The data from the real-sized mock-up fabrication test, such as for tolerance control during the machining and welding, are encouraging. The delay of VV sector 5, now being manufactured at a European consortium (AMW), is the most critical issue. The reason of the delay is technical and management issues at AMW. The IO-CT is of the opinion that the technical issues will be resolved using the HHI manufacturing experience as well as a tight control of each of the manufacturing procedures. There is at present zero float on delivery dates of VV sectors by AMW. Therefore the IO-CT is seriously concerned that this delivery date might not be met. This serious concern is being addressed by an ad-hoc working group at the highest level in order to find technical and legal solutions. The IO-CT believes this plan is the only possible risk mitigation measurement at this critical moment requiring prompt decisions involving all concerned parties and the IC. The ICRG strongly supports the action plan presented by the IO-CT.

The assembly is executed by the IO-CT. Each VV sector is equipped with its thermal shield and two TF coils on the sector sub assembly tool within the assembly hall. Following this, the sector is moved to the TKM pit where the sectors will be welded together. The welding of the VV sectors is managed by the IO-CT through a direct contract with ENSA.

The drill-down showed that the resource distribution has peaked workloads for each phase during the years 2016-2025. The corresponding FTEs are well matched to this resource plan. For example, the engineering and procurement work is planned to have the highest workload during 2016-2018 for procurement follow-up, due to many work packages, 9 VV sectors, 6,000 IWS components, and many equatorial and upper/lower ports. The plan assumes that there will be no further design changes, on time completion of engineering and manufacturing design, on time delivery, and no significant new technical issues. These assumptions were considered to be primary concerns because they are directly related to meeting the FP target schedule. But, design issues are not now primary concerns because manufacturing design is completed for all sectors by end of March 2016 (except minor adjustment for sectors 2 and 3 which doesn't limit the manufacturing progress in the two coming years).

The non-labour cost breakdown of the VV consists of In-Service Inspection (ISI), instrumentation, GS (Gravity Support), sealing flanges, neutral beam liners, ports, and sectors. These costs are about 16 MEUR from 2016 until 2026. ISI cost is nearer 30% of the total non-labour cost during the period 2016-2020. On the other hand, the FTE count is higher for the sector and port procurements than for ISI work. The resource plan shows that the design finalization for sequential sector and port procurements

for approval and validation still requires significant work before the assembly begins, with about 4 staff in the CAD team. The resource plan and work breakdown are reasonable under the assumption of focusing on FP at the end of 2025.

Magnets

The cost book, prepared by the IO-CT Magnet Division, describes the required work items and human resources in relatively great detail compared to the other Cost Books. Information provided during the drilldown on the Magnet systems is summarized below.

Total required manpower: The total manpower, the duration of the work, and FTEs for each system are (Total FTEs, total duration (years), FTE (calculated by dividing total manpower by total duration):

Magnet system	Total (FTE)	Total duration of work (y)	Average FTE (total/y)
TF coils	175	10	17.5
PF coils	87	10	8.7
CS coils	85	10	8.5
Correction coils	44	10	4.4
TF structure	21	10	2.1
Conductors	112	10	11.2
Feeders	150	10	15.0
Instrumentation/controls	235	10	23.5
In vacuum coils	73	10	7.3
Sum	982		**98**

These numbers indicate that from 2016 to 2025, i.e. for 10 years, around 100 FTEs are required for the ITER magnet construction. TF coil, Feeders, Conductor, and Instrumentation require the largest number of people.

It is instructive to compare the personnel in the IO-CT magnet team with the JADA magnet group, although the scope of the ITER magnet division is far wider than that of JADA (JADA cover only about 25% of the magnet procurement and do not have any of the design/integration issues). The IO-CT magnet group has a staff of 47 (compared with a staff requirement of 100). The major work packages for the IO-CT magnet group are: TFC, PFC, CSC, CC, Feeder, TF structures, conductors, instrumentation, and IVC, whereas the JADA magnet group has around 44 personnel engaged in the fabrication of the ITER conductors, TF coils, TF coil structures, conductor experiments and related systems. The current staff in the IO-CT Magnet Division is planned to double (to 100 FTEs) to support the overall magnet effort at the IO-CT through FP. Our analysis reveals no evidence of duplication. Where possible, the IO-CT and DAs share resources during procurement, depending on areas of expertise. There are examples given in the magnet top level design plan where the IO-CT provides experts and has carried out R&D to support the DAs. DAs also sometimes provide CAD and analysis assistance through Visiting Researchers (VRs) in TF coils, PF coils and feeders. The IO-CT has found no evidence of duplication of manpower.

The resource allocation over time and per work package during the assembly phase is also provided in the cost book. The number of staff needed for assembly exceeds the current staff number, especially for the feeders and the instrumentation. For the first 5 years the main focus is on fabrication and then they transition to installation of the magnets and support the Construction Department (CST). The staffing plan is consistent with such progress according to the phases of the project. Furthermore, the instrumentation is a direct procurement by the IO-CT Magnet Division which is ongoing. TFC, CSC, and Instrumentation require more than 10 FTEs each, and CSC will need almost 20 FTEs due to the short assembly time of only two years. In total, 57 FTEs will be needed for the assembly work, together with

installation supervision and quality control, which might need substantial resources for such a big installation. The DAs are expecting to contribute to this work.

The development of the manpower requirements for assembly and commissioning was presented in the drill-down meeting. At its peak, more than 60 FTEs are required for assembly in 2021 and 2022, respectively. Assembly manpower suddenly decreases after 2022. At that point, commissioning manpower quickly increases. The peak for commissioning manpower is 65.4 FTEs in 2025. However, the total manpower gradually decreases after 2022. This implies that some of the assembly manpower would shift to the commissioning effort. The IO-CT plans to redeploy staff to assembly work and commissioning work, subject to reorientation of skills and competencies.

Designers and engineers engaged in the fabrication of the magnet systems in each DA are interested in taking part in commissioning at the ITER site. This would assure appropriate transfer of knowledge and experience by cooperating in the commissioning and would be useful for both the IO-CT and DAs.

The analysis of the superconducting and thermo-hydraulic performance of the superconductors will require 72 FTEs for 10 years. The superconductors were already analysed for the original specification. However, IO-CT is asked to assess many new requirements. Examples are new plasma physics scenarios and significant changes to vertical stability control. For the period 2016-2025 there are 72 FTEs allocated for all aspects of magnet analysis which include thermo-hydraulics, AC loss, eddy current, superconductivity, and thermal radiation. Much of this work is critical for licensing. This work will also be very interesting for the DA's superconducting magnet scientists and engineers. The Members engaged in fabrication of the superconductors and magnets would like to obtain performance data that will be also useful for DEMO.

The DAs have started to provide information on the staff that they might make available to the IO-CT in due course (around 100 people across the project in the years until 2025). As this data has only just been received the IO-CT is still analysing the proposals and will discuss further with the DAs. The exact numbers and competencies (and fit to the IO-CT requirement) will be known only when we move closer to the completion of the component fabrication. The ICRG has some concerns about the level of IO-CT FTEs for these tasks – further optimisation with DAs is encouraged

Specific Recommendations:

- In order to efficiently handle the increasing and decreasing manpower needs for magnet assembly and commissioning, a staffing plan should be developed. Involvement of DA staff might be a particularly efficient way to meet resource needs. It would also facilitate effective knowledge transfer from the DAs to the IO-CT.
- Since DAs, collaborative institutes, and universities are interested in analysis of the ITER conductors and magnets, it will be useful to prepare a collaboration plan.

Heating and Current Drive Systems (HCD)

Heating and current drive systems are planned for staged installation and commissioning reaching 73MW source power by 2030. None of the HCD systems are considered to be on the critical path for FP. But a minimum 5 MW power (source power 8 MW) of Electron Cyclotron (EC) is essential for the breakdown for the FP. The overview of the schedules of all HCD systems shows similar milestones in the installation and commissioning and operation for the fastest technically achievable DT plasma. While the EC system has reached ITER technical requirements both the Ion Cyclotron (IC) and Neutral Beam (NBI) systems have yet to be fully developed.

Meeting the HCD schedule is challenging, it requires, for example, a 3rd shift for commissioning and the merging of electrical engineers into one team. The IO-CT staff requirements have been reviewed. The resource profile of each heating system has a similar distribution in each activity phase (design, manufacturing, installation & commissioning, operation) with installation and commissioning peaked

between 2025 and 2027, when the FP operation is planned. Currently the IO-CT staffing is about 15 FTEs (4.5 (EC) + 3.5 (IC) + 7 (NB)). The CAD team currently has 2 CAD designers for the design phase, working in collaboration with the design teams in the DA, then the number goes down to 1 designer for management of as-built drawings and drawing modifications.

The resource estimate in the installation phase is based on 2-shift (NBI, EC) and 1-shift (IC) installation with the work contracts being managed through the CMA. Most of the HCD team effort involves part-time oversight of the installation and 100% oversight for commissioning and operation. The operational resources assume 3-shift operation with support from external contributors, Visiting Researchers, DA staff, etc. Comparing the resources for HCD operation at ITER with existing tokamak machines, such as TCV and JET, shows that the ITER HCD operation resource estimate is smaller than that in TCV and JET for all EC, IC and NB heating systems.

Based on experience gained from existing tokamak machines, it is known that HCD systems are complex and technically challenging and they will play a key role in achieving DT burning plasmas. Therefore, the person count per Megawatt seems reasonable or a bit underestimated to achieve full performance of heating systems. The IO-CT plans the installation of all heating systems during the FP campaign to achieve the fastest technically achievable DT plasma.

Installation and Assembly

The review focused on the time frame from 2016 to FP, i.e. 2025. The current cost estimate for this area (all in 2015 currency) is: for Site Construction 1258 MEUR; IO-CT labour and support 100 MEUR; giving a total of 1358 MEUR.

It is noted that these figures have been updated in various areas since IC-17. The IO-CT staffing levels for 2016 and 2017 take into account the IC near term restrictions.

This overall estimate is up substantially from the ~440 MEUR in the 2010 ITER "baseline". The earlier figure was characterized as a rough, "top down" estimate that was further reduced by the Briscoe Panel and the IC. In 2014, the IC's Overall Management Performance Evaluation Working Group found that assembly planning and execution were seriously under-resourced.

The term "site construction" means plant installation and Tokamak assembly. It does not include civil works under the responsibility of F4E. Site construction also does not include the cost of assembly and installation where these are the responsibility of the DAs under procurement arrangements.

In the near term, (2016-2017) work consists of construction engineering, mock-ups and trials, design and procurement of tools, preparation and tendering of contracts, award & mobilization of CMA (Construction Manager-as Agent) and Construction Works Contractors, and early site construction.

For 2018 - 2025, the execution of construction work starts at components reception on-site, assembly and installation, testing, and turnover to Operations for Integrated Commissioning and Start-up to FP. It is noted that the ITER Project critical path flows through these activities after vacuum vessel components are received.

The site construction cost estimate is considered to be a Class 3 estimate, i.e. -10%/+30%. It is the result of a bottoms up, detailed and rigorous approach. Hands-on activity in the field is conducted primarily by three "works" contractors (Machine Assembly, Mechanical & Piping, and Electrical & Cabling) with detailed planning and supervision provided by the CMA.

Most of the staff resources are in the Construction Division, CST (Machine Assembly and Tokamak Complex) and the Plant Engineering Division, Plant Engineering Department (PED) (Plant Facilities). Staffing levels were based on a resource loaded schedule. It is recognized that the Tokamak assembly is much more complex than the Plant areas and will require much greater involvement of IO-CT experts; whereas the CMA can handle most tasks in the Plant areas. Current CST staffing is about 28, and will

grow to a peak of 78 in the 2020 – 2025 time frame. Many of the additional staff are expected to be transferred from design activities and other project areas. After including staff from PED and SCOD (Science and Operation Department) (for Controls work), the total staff manpower required is 163, although not all at the same time.

Many of the DAs have expressed willingness to provide support, but details have not been worked out. However, it should be noted that all such flexible staff are included in the individual PBS staffing plans, to be made available to CST through internal transfer. To the extent that DA's can supply staff with appropriate expertise, then these costs are included in the PBS estimates.

There are certainly many risks in the installation and assembly area, with need for repair or rework being major ones. The mitigation approach for these risks is an extensive provision of trials and mock-ups. It was reported that there are ~ 100-200 technical risks in the Risk Register, and it is updated as the design progresses; however, this review did not evaluate this. The team considers that the cost risk is covered by the Class 3 estimate, which has a confidence level of -10% to + 30%. However, there is no contingency in the current plan. While some cost increases might be covered by the Reserve Fund, present guidelines for the use of this fund are very restrictive.

Specific Recommendation:

- Develop with DAs a definitive plan for the participation of DAs in ITER installation and assembly, including technical, financial, and administrative arrangements.

Tritium

This drill-down session reviewed the Tritium Plant-TP (PBS32) and Radiological and Environmental Monitoring Systems-REMS (PBS64). The TP and REMS work packages consist of the Tritium Plant (Tokamak Exhaust Processing, Isotope Separation System, Storage and Delivery System, the Water Detritiation System and Analytical System), and also the REMS and related analytical systems.

The TP/REMS is currently in preliminary design, which needs to be complete at the end of 2018 to meet a key milestone, namely the submittal of the design safety report to ASN. The preliminary design effort will lead into final design (complete in 2021) which is then followed by procurement and fabrication (complete in 2024), installation and integration (complete in 2026) and finally commissioning (complete in 2031). In all phases, the IO-CT (DG) has Design Authority/Integration Responsibility.

Most TP/REMS deliverables are in-kind hardware covered by Procurement Arrangements, where the roles and responsibilities for the IO-CT and DAs are defined. The largest item is the Atmospheric Detritiation System, which is 50% IO-CT and 50% JA-DA under procurement arrangement.

The bottom-up resource estimate using the IO-CT's standard project-wide processes sums to 441 MEUR for the total TP/REMS lifecycle cost. The estimate to FP (December 2025) is 331 MEUR of which 53 MEUR is for labour expenses. The estimate beyond FP is 110 MEUR.

The schedule and cost resources were developed by TP/REMS staff with direct experience with design, building, and operating similar systems on other fusion devices, however, the scale and complexity of ITER is first of its kind. In addition, the time required for licensing analysis and testing for such a novel machine is not well understood and could take longer than planned. This is a concern and to avoid schedule delays, the IO-CT team should make every effort to ensure ASN is kept fully informed leading up to the submittal of the design safety report.

Staffing levels for the TP/REMS scope of work roughly average ~40 staff/year until the commissioning phase (2027-28) which ramps to ~65 staff/year, which then transitions to steady state operations of ~50 staff/year at the DT phase (2032).

The dominant element of the materials cost estimate, the Detritiation System (DS) was prepared in 2011 by an expert industrial partner (Kraftanlagen). The estimate is classified as a Class 2 – "Detailed Unit

Cost" approach with a design maturity considered "Advanced Preliminary Design". The accuracy of the estimate is considered -15% to +20%.

Since 2011, there have been several changes in the DS. During a follow-up session, the Section Leader went through the changes and expressed the opinion that in total, the plusses and minuses roughly balanced, and he believed it was a valid estimate for 2015. Other than the DS, the remainder of the materials estimates were either new estimates in 2015 or updated to 2015.

The Tritium management team believes there is a high confidence in meeting this schedule with the assigned resources since a more rigorous cost estimating process was applied than was used in the previous estimate, and that the estimating team is more experience and familiar with the scope of work. In addition, the estimate was benchmarked against other facilities (TSTA, Darlington), and it includes many "missing scope items" not included in previous resource-loaded iterations.

Specific Recommendation:

- Update the 2011 resource estimate of the tritium systems.

3.2.3. Cost Basis

The following comments concern only the IO-CT cost and not the in-kind contributions:

The IO-CT costs consist of staffing cost, materials and equipment costs. The IO-CT cost profile in the ULTS ranges from ~320 MEUR in 2016 to ~770 MEUR in 2024, including the Reserve Fund. The Reserve Fund is at present being used to primarily address critical scope additions and design changes that affect the DAs. The IO-CT staff cost estimate has undergone an internal review. From interviews with the DAs, it was clear that most DAs did not agree with the IO-CT resource estimates.

The 25 Cost Books also detail the basis for the contract labour, materials and equipment necessary to install and assemble ITER. As with the IO-CT staffing, the ICRG drill downs and the IO-CT/DA Resource Optimization sessions generally supported the reasonableness of those estimates. No major issues or evidence of systematic problems were identified. There is no provision for contingency. Since these are external costs for which IO-CT has only limited ability to control, there is high potential for cost growth, especially if the schedule slips for any reason.

3.2.4. Risk Analysis

Schedule and cost uncertainties in a large project are reduced as designs progress and systems/components begin to be manufactured by industry. Some uncertainties, however, remain related to possible design changes imposed by the Regulator, the various fabrication processes (especially for first-of-a-kind components), and tolerances for installation and assembly of those components.

Historically, the IO-CT has not devoted adequate attention to risk management (i.e., project-wide systematic identification of risks and opportunities, development of response strategies and specific mitigation plans, and estimation of the pre- and post-mitigation probabilities of occurrence). Under the new DG's leadership, this area is now receiving senior management attention and good progress is being made. The current IO-CT Risk Management Plan (RMP) was approved and issued in July 2015, and there is a subordinate Risk Management Procedure that was issued in February 2016. Looking ahead, the IO-CT intends to incorporate the contents of these two documents into the ITER Project Control Plan. Implementing the RMP and its associated Procedure are the responsibility of the Risk Management Officer (RMO) in the IO-CT's Project Control Office. Three additional staff are being assigned during 2016-17 to reinforce the RMO's capability to carry out those duties. The RMP and its associated Procedure are beginning to be implemented in a systematic manner through the monthly Departmental Performance Review meetings, where risks and issues (i.e., risks that have materialized) are being reviewed and managed together with project schedule and cost performance.

There is a separate and complementary Risk Analysis, Prevention and Management Committee that was established in mid-2015 "to identify, prevent and manage potential threats to the ITER project not related to the baseline, in order to avoid crisis that might hinder operations, image and reputation of the ITER Project." This group is coordinated by the DG's Cabinet Head and strongly linked to the IO-CT's Internal Control process. It addresses risks to the IO-CT's corporate functions, whereas the RMO's risk management function is concerned with technical risks in delivering the ITER Project.

Just recently, the DG has created a Project Risk Management Committee (PRMC) that provides for a 3-level framework to enforce management oversight of the technical risk management process within the IO-CT. The PRMC's Terms of Reference were presented to the ICRG. The three levels (parallel to Project Change Request management) in ascending order are: (1) the Level 3 Configuration Control Board; (2) the Level 2 Configuration Control Board; and (3) the Executive Project Board. The PRMC also is charged with performing risk modelling and proposing a procedure to cover the costs of risk prevention and mitigation actions by the IO-CT and DAs.

The RMP establishes the roles and responsibilities (both for the IO-CT and the DA Heads) for technical risk management, defines what constitutes a technical Project Risk, and requires that a Project Risk Register of all technical Project Risks be developed and maintained through periodic review and updating (at least quarterly). The owner of the Register is the RMO, who is responsible for institutionalizing the technical risk management process and supporting the DG and DA Heads, Organizational Unit Managers and TROs in its implementation.

The Risk Management Procedure specifies a protocol for risk prioritization based on likelihood of occurrence and severity of technical, schedule, and cost impact(s). It also specifies criteria that determine whether a risk must be reported to the Executive Project Board. It does not yet reflect the monthly risk and issue management workflow with the three Levels that the IO-CT has just recently adopted.

It is noteworthy that the Procedure requires the uncertainties in the task durations and cost estimates to be assessed in the resource-loaded schedule by the task owner in the form of Probability Density Function. Using the collected risk and uncertainty data, the IO-CT Project Control Office is supposed to perform risk modelling in order to calculate the appropriate amount of time and cost contingency that the project should have. However, the DG has made a conscious decision to defer doing this based on the different attitudes among the ITER Members regarding contingency.

As required by the RMP and its implementing Procedure, the Project Risk Registry was initially developed, starting in late 2014, based on inputs from organizational elements within the IO-CT as well as from the DAs. It was reviewed and updated during the process of developing the ULTS, and further updating efforts have been recently been made, and there are plans for a systematic follow-up.

The ICRG was provided with a detailed paper that describes what the senior IO-CT management considers to be the project's ten most important technical risk families along with three key management risks. These risks have been analyzed in considerable detail along with their schedule impacts, and mitigation strategies have been developed to minimize the likelihood of occurrence. Some of the potential impacts, even after mitigation, could be quite serious (many months of schedule delays) if the risks were realized. Thus, IO-CT senior management is highly focused on preventing their occurrence. The analyses and mitigation strategies/plans are generally well thought out and mature in their stage of development. As of yet, there has not been any quantification of the probabilities of these risks occurring either before or after implementation of the identified mitigation measures. The IO-CT reported that some of the cost of the mitigation strategies had been included in their resource estimates. However, no data was presented that would allow the ICRG to verify this.

The IO-CT's risk management approach, organization, and processes are maturing at a good pace, and the ICRG encourages the IO-CT senior management to sustain that momentum.

The IO-CT is presently handling non-technical project risks separately via the Risk Analysis, Prevention and Management Committee, and technical project risks through the RMP process. The newly created

PRMC has added another element to IO-CT risk management that seems to complicate the picture for risk management roles and responsibilities. The DG is considering that instead of this "stovepipe" approach, it may be better to somehow integrate these groups and their functions into a single comprehensive project risk management program with one owner. The ICRG believes that this would make sense. The RMP (or Project Control Plan) should be updated accordingly to comprehensively define the roles, responsibilities, and processes for systematic risk/issue management within the IO-CT.

The IO-CT expressed confidence that the Project Risk Registry has comprehensively captured all known significant Project-level risks. The ICRG believes that the top priority risks are included. In addition to the risks that have thus far been identified, the IO-CT senior management is well aware that there are "unknown unknowns," that is, unforeseeable risks that could emerge in the future. Of course, these can only be addressed once such a thing occurs.

Without any quantification of the probabilities of these risks occurring, either before or after mitigation, it is not possible to use the project's risk analysis in a meaningful way to quantify the reliability of the ULTS. Since there is no float in the ULTS critical path to FP, the impact of any of the major risks occurring would be quite substantial in terms of delays and costs. Hence, it is not possible to claim that the ULTS will reliably predict that FP will be achieved in December 2025. Without even a rough quantification of post-mitigation risk occurrence probabilities, there is no way to assign a confidence factor to the ULTS.

The Risk Management Procedure provides for probabilistic (i.e., Monte Carlo) risk analyses to be performed that would enable the IO-CT to estimate an appropriate amount of schedule contingency (float) to be built into the ULTS. It would also enable an estimation of cost contingency needed to address risks that will inevitably materialize during the Construction Phase. Through the Procedure, schedule and cost contingency are controlled by the DG as a "senior management tool to maintain schedule and overall cost boundaries where risks are realized." This would support the notion that the DG should be able to more flexibly apply the Reserve Fund as cost contingency to address risks.

Specific Recommendations concerning the Risk Management:

- Proceed to fully implement the Risk Management Procedure throughout the ITER Project to systematically identify, frequently review/update, and determine prioritization of Project Risks based on post-mitigation probabilities of occurrence and severity of impacts, and quantify needed cost contingency as a DG management tool for risk management.
- Expand the present scope for the use of the Reserve Fund by the DG to also address risks.

3.2.5. Milestones

The IO-CT has presented a list of milestones for the years 2016 and 2017 (which were approved at the IC-17) and the status of their completion. This close oversight of project performance and progress by the IC and the senior IO-CT management needs to be continued. When looking at the major assembly milestones which start in 2017 and are scheduled to end in 2024, the density of activities and interrelated milestones presents a major challenge.

Specific Recommendation concerning Milestones:

- Adequate milestones similar to those for the years 2016 and 2017 should be defined for the coming years, and closely monitored to provide early warning to critical path deliverables or assembly risks.

3.3. Conclusions concerning the ULTS and Resources

The **ULTS** calls for completing construction for FP at the end of 2024, followed by integrated commissioning, resulting in FP at the end of 2025. The schedule for DT was developed as a technically achievable date. Deuterium and trace Tritium operations would begin after completion of the pre-nuclear shutdown at the end of 2032 with full DT at the end of 2033.

The critical path for FP goes through Vacuum Vessel sector fabrication, followed by Installation, Assembly, and Commissioning. However the Tokamak Building lies close to the critical path. The ICRG reviewed this critical path schedule in depth. It was logical and very detailed. The ULTS would be a sound basis for a working schedule to measure progress against, i.e. a baseline.

The ICRG comes to the conclusion that FP in December 2025 as first major milestone is the earliest possible technically achievable date. However, it does not have any contingency, and with a machine as complex as this, problems that delay the schedule are bound to occur.

Some of the DAs and ITER Member representatives told the ICRG that they consider the ULTS staffing plan and resource estimates to be much larger than necessary. The ICRG therefore asked the IO-CT and DAs to reach a common understanding on the IO-CT staffing plan and resource estimates, focusing on the schedule up to FP.

The DAs' concerns about the IO-CT resource estimates can be generalized as:

- Unclear roles and responsibilities between the IO-CT and DAs leading to potential duplication of efforts;
- Potential duplication between the IO-CT Engineering and Construction Departments;
- The IO-CT not accounting for the evolution of its organization during construction;
- Possible excessive planning/estimation for shift work and related shift work assumptions during construction, integrated commissioning, and operations.

Subsequently, the IO-CT worked with the DAs to review the resource estimates, starting on 22 February 2016. The objective was to share the basis of estimate including process and method used to develop the resource estimate for the IO-CT. The analyses focused on the process used, and the technical basis of the cost estimate so as to develop a common understanding between IO-CT and DAs in the areas where some of DAs expressed their concern about overestimation during the ICRG meeting. Several conference meetings were held over a period of ten days, with all of the DAs except for the US attending some of the meetings. All agreed to the meeting objective.

The IO-DA joint sessions covered specific items (e.g., Magnets, Vacuum Vessel, and Assembly) as a representative sample of the overall project resource estimate. The DAs reached a common understanding with the IO-CT in some areas and improved their understanding in others, however, some generic concerns still remain. In order to address those, it was agreed that the information exchange needs to continue and further discussions should occur as a follow-up action. Also as part of this follow-up, the ICRG encourages the active participation of all seven DAs.

IO-CT also conducted an analysis of the shift work assumption and cost boundaries at work pachkage level by PBS and different phase, and informed the DAs that the IO-CT resource estimate is consistent with the project assumptions applied to ULTS although further optimization was needed for shift work assumptions in some PBS. This is consistent what the IO-CT presented to ICRG.

4. Analysis of the post IC-17 update of the ULTS as presented to the ICRG in March and April 2016 (Iteration Modelling)

4.1. Background

The IO-CT presented the ULTS to IC-17 in November 2015. The resulting payments budget for the IO-CT would have been (for 2016-2025) 5156 MEUR (excluding the Reserve Fund contributions) and the resulting IO-CT manpower during 2016-2025 would have amounted to a cumulated total of 12332 FTE-years.

In response, the IC stated that the IO-CT is limited to 301 MEUR for 2016, including the Reserve Fund. For 2017 no budget was yet approved by the IC, but the Interim Draft Payments Budget was 411 MEUR; the IO-manpower was capped at 736 positions for 2016 and 796 positions for 2017. The projected IO-CT staff FTEs for 2017 was 977 (i.e. 181 posts higher).

The IC requested the IO-CT to propose adjustments, by iteration, of the resource loaded schedule which fits the known financial constraints of the Members.

4.2. Status of the Iteration Modelling

The planning is based on deferring elements not necessary for FP to reduce the IO-CT in-cash and staff yearly requirements between 2017 and 2025, particularly before 2020. The IO-CT (with input from several DAs) has started to study different models for staged scenarios which reduces the budgetary and staff needs for the period 2016-2025 until FP (with particular focus on the period 2016-20). The staged approach generates a delay for DT Operation and adds longer periods for research programs between FP and the start of DT Operation. The resulting schedules vary somewhat, depending on the assumptions. The Iteration Modelling makes full use of the elements of the ULTS. The Iteration Modelling is "**work in progress**" and is a high-level modelling exercise based on the same work packages as the ULTS.

The **Iteration Modelling** envisages multiple assembly phases and is therefore a **staged approach**. Its key features are:

- There is no shift in date (and design requirements) for FP. It remains as given in the ULTS, presented at IC-17.
- The schedules (and associated resources/costs) of components/systems not required for FP have been shifted into the future.
- Reducing the components for FP enhances the likelihood of achieving the milestone.
- The new Research Plan envisages, besides FP and DT Operation, two extended plasma campaigns (L Mode Plasma – elongated, and H Mode Plasma – full heating and current drive) before the start of DT Operation (equivalent to a Fourth Plasma campaign).
- It reduces project risks by addressing the technical and scientific challenges step by step.
- This schedule attempts to accommodate the known financial constraints of some of the ITER Members.
- The multiple phases provide flexibility for accommodating the placed contracts in different DAs (and the IO-CT).
- The present modelling does not yet consider "placed contract" constraints and the costs or schedule impact of demobilisation/remobilisation. Further work is needed to quantify the full extent of these constraints and impacts in order for IO-CT senior management and the ITER Council to make well-informed decisions on the best course of action.

The ICRG was presented with a 1st iteration of the modelling in March 2016 and a 2nd iteration in the on-site meeting in April. The IO-CT plan is to provide an up-date of the Iteration Modelling to the IC-18 for approval and prepare a baseline cost and schedule for consideration by IC in November 2016.

The 2nd iteration included first feedback from the DAs. Six DAs (except EU-DA) intend to deliver their in-kind contributions as in the ULTS. The IO-CT costs associated with the design and delivery of non-FP systems by DAs (except EU-DA) have not been postponed. For the EU-DA deliveries for non-FP systems (and also associated IO-CT in-cash procurements), a "stretch model" has been adopted for associated costs. In effect, this implies that IO-CT will continue the design efforts for non-FP systems, so as to ensure that, at the minimum, interfaces are correctly reflected. Costs of transversal IO-CT activities, affecting both IO-CT and DAs, have been prorated. As a next step the transition costs (including extra storage for early non-FP components, demobilisation and remobilisation costs, and any contractual specificities) will be evaluated.

4.3. Schedule and Cost

The following discussion is based on the 2nd iteration presented in April.

Schedule

In the Iteration Modelling the schedule until FP remains the same as given in the ULTS, but with a reduced number of components. The possible schedule from the 2nd iteration for the years until DT operation is shown in the following schematic diagram [Fig 4.1]:

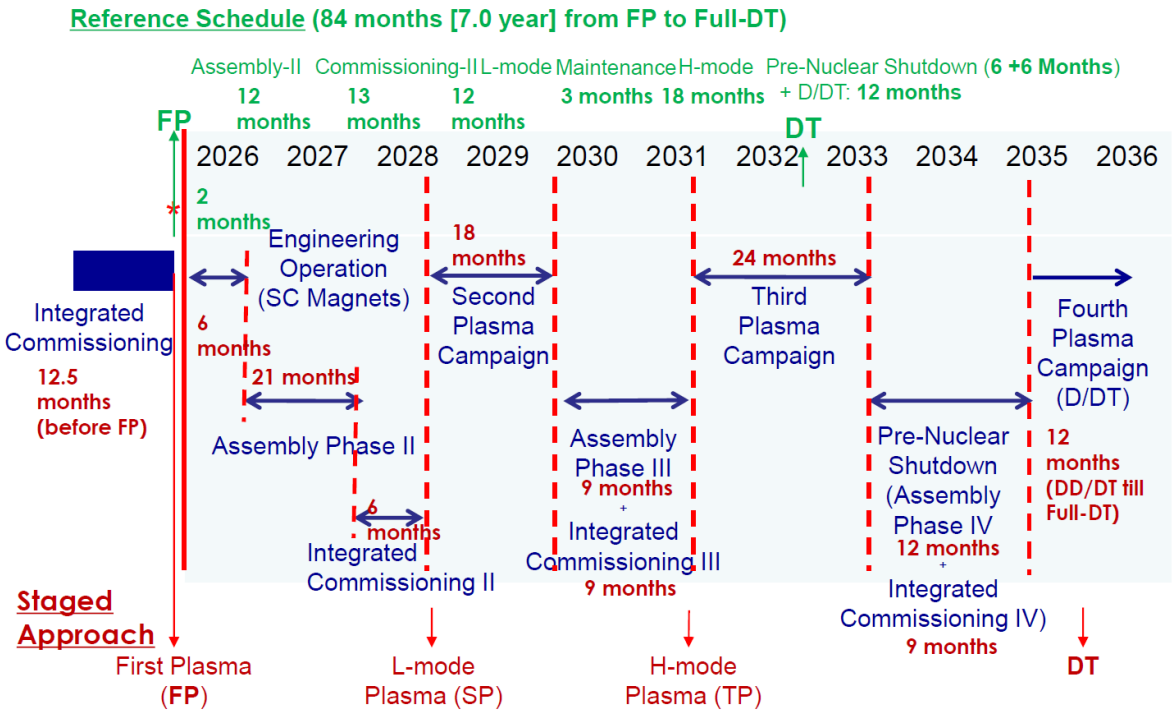


Figure 4.1 Schematic schedule from FP to full DT operation (2nd Iteration, for stage model)

The key parameters and goals about the four experimental campaigns are:

FP: **nominally 100 kA/ 100 ms** consistent with needs to achieve and diagnose breakdown, to sustain plasma current of ~1 MA/ 3s and to complete engineering tests including full SC magnet systems (with circular plasma with VVPS).

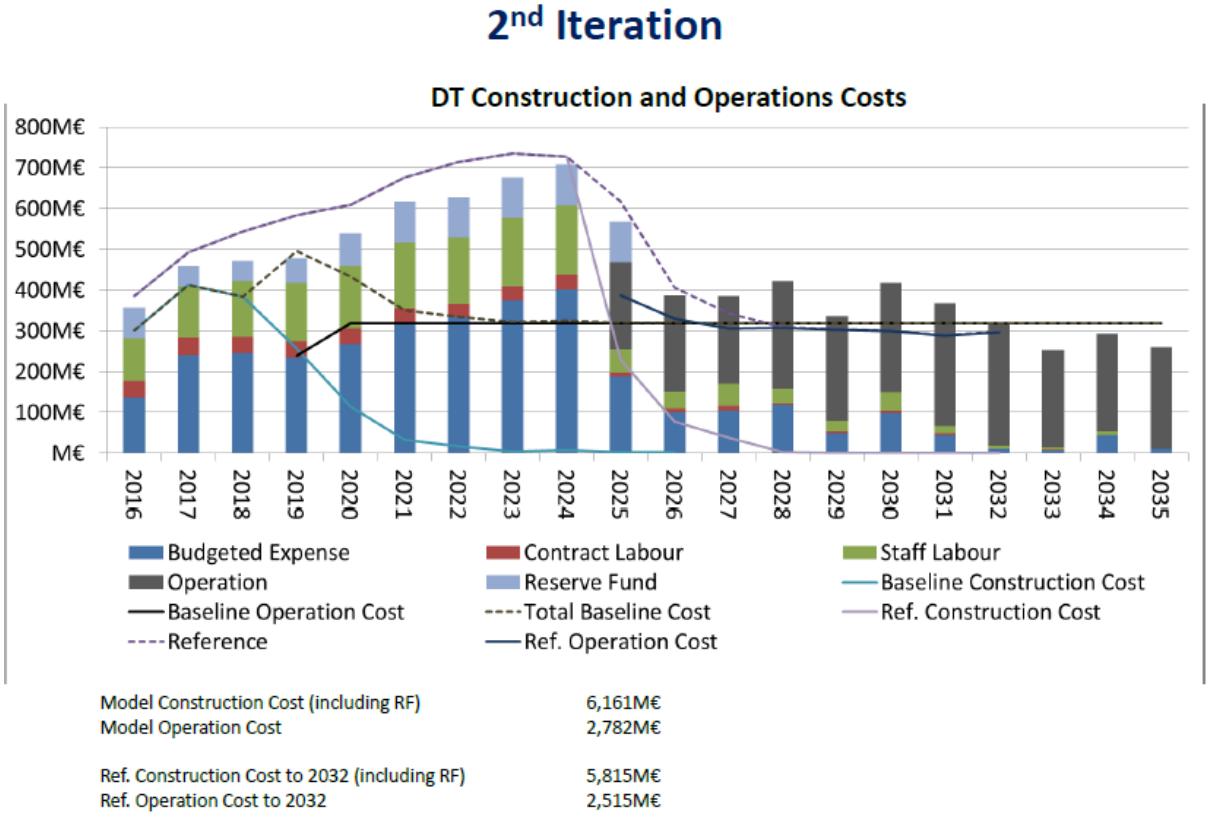
Second Plasma (non-active H/He): up to 7.5 MA L-mode operation with priorities derived from commissioning with full tokamak plasma, investment protection and plasma control and operation goals (with diverted and shaped plasma, full in-vessel systems).

Third Plasma (non-active H/He): up 7.5 MA H-mode operation and 15 MA L-mode operation with more advanced systems required for H-mode studies and auxiliary system commissioning in advance of nuclear phase (full H&CD, and Diagnostics), disruption mitigation and licencing.

Fourth Plasma (nuclear D/DT): 15 MA DT-operation, with all systems required for nuclear operation and tritium handling available and ready for final commissioning (full Remote-handling)

Cost and Staffing Profiles

The annual construction and operation budget in MEUR for IO-CT for DT, together with the ULTS (Reference), is shown in [Figure 4.2]. A plot for the necessary FTEs is given in [Figure 4.3].



Model Construction Cost (including RF)	6,161M€
Model Operation Cost	2,782M€
Ref. Construction Cost to 2032 (including RF)	5,815M€
Ref. Operation Cost to 2032	2,515M€

Figure 4.2: The 2nd Iteration **Annual IO-CT Construction and Operation Budgets** (in Millions of EUR) for the different Schedules. The Operation Cost estimates have been calculated in 2015. The costs were not reviewed however by the ICRG. Decommissioning cost is not included.

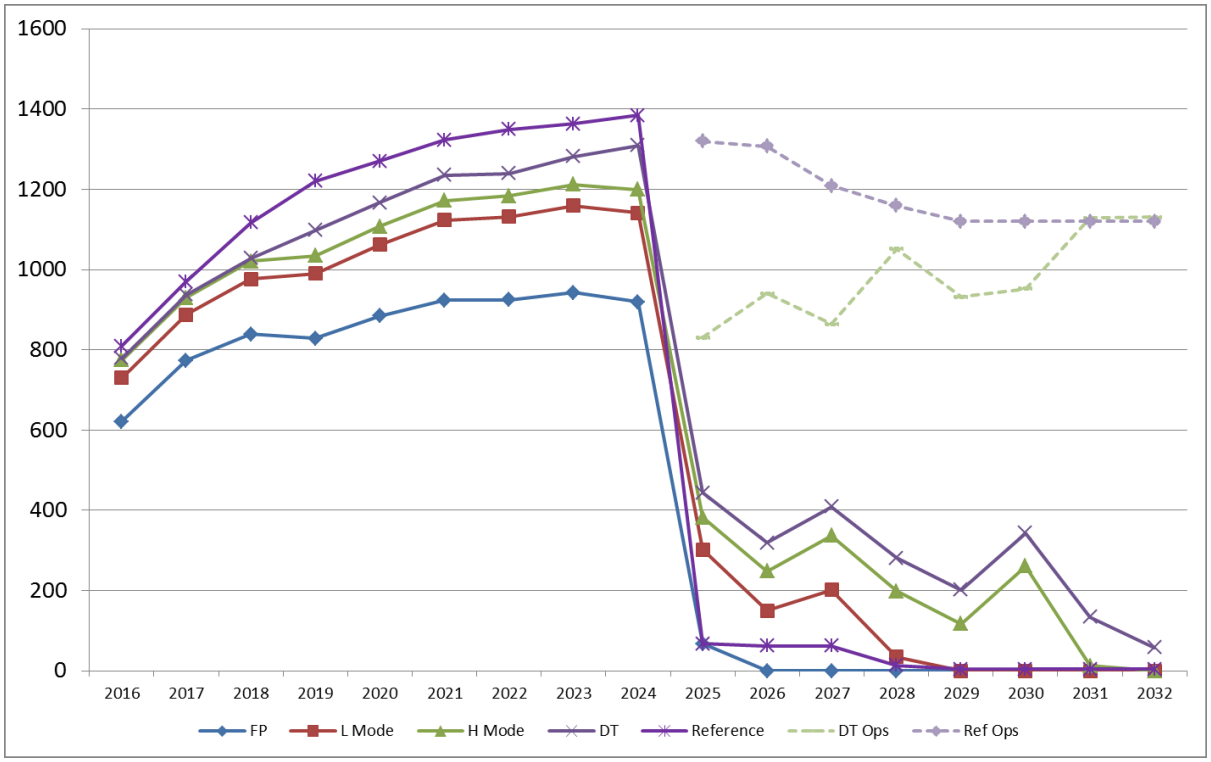


Figure 4.3 The 2nd Iteration Annual **manpower** (for **Construction and Operation**) for the different Schedules (in FTEs).

The profile of the **staffing** follows the same trend as that of the Budget.

5. Comparison of the ULTS and the 2nd Iteration Modelling Schedule

Figure 5.1 shows a cost profile comparison between the current construction baseline, the ULTS construction and the 2nd Iteration construction budgets:

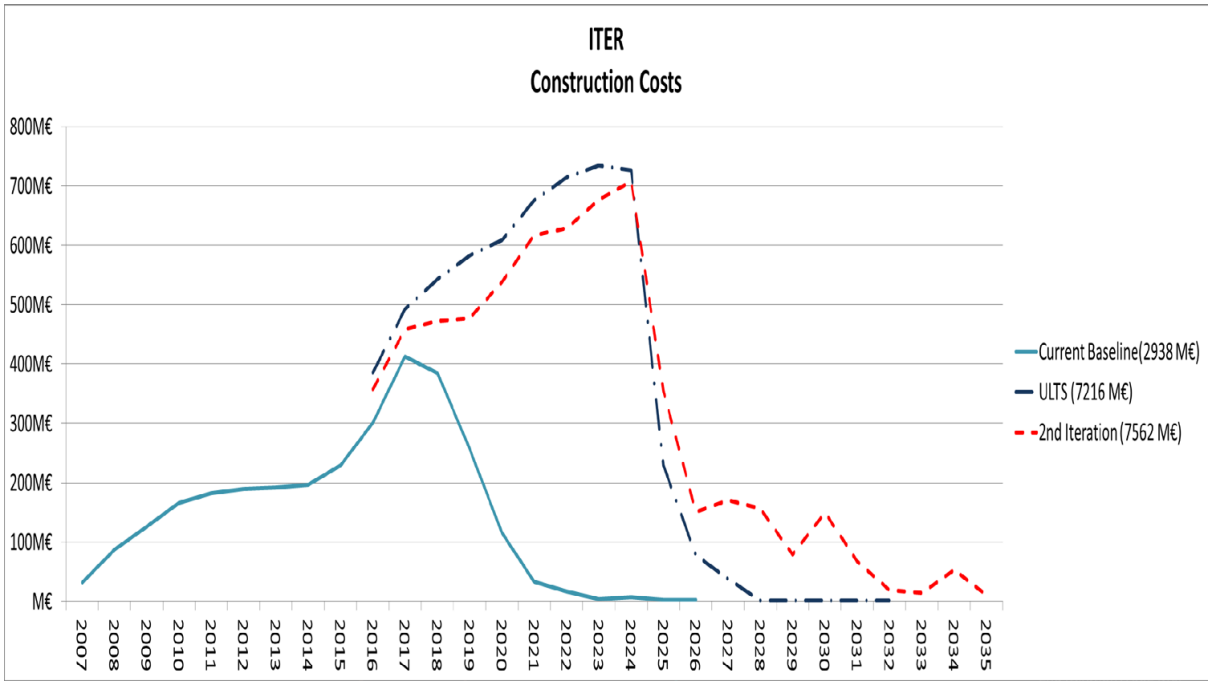


Figure 5.1 The annual IO-CT In-cash Construction Cost

The following Table 5.1 shows a comparison of the times scheduled for the activities from FP to DT Operation:

Comparison of times for activities in the two schedules	ULTS (months)	2nd Iteration (months)
Assembly and Installation	18	42
Commissioning	22	24
Operation	44	60
Sum	84	126

Table 5.1 Comparison of time lines in the Reference and Iteration Schedules

Having analysed both, the ULTS and the Iteration Schedule, the ICRG concludes:

While the Iteration Schedule delays the crucial burning plasma experiments by a few years, it has a number of benefits compared to the ULTS:

- It allows all ITER Members to focus on the successful achievement of FP.
- It reduces the project risks by addressing the technical challenges step by step.
- It reduces the budget in the years 2017 to 2019, when some DAs face budgetary constraints.
- It provides flexibility for accommodating the placed contracts in different DAs (and the IO-CT).

One important strength of the Iteration Schedule while waiting for the delivery duration of the 2nd and 3rd assembly components lies in its possibility to accommodate a longer research program between FP and the start of DT Operation. The success of ITER (like all large facilities) depends on its reliable operation, the reduction of operating risks, and therefore a full understanding of all components, of the diagnostic elements, and of all measurements. This requires a well-established collaboration of all partners in the operating teams, experience in jointly operating such a complex facility, and mutual understanding. Developing all of this needs time, training and common experience.

It is worth noting that the time difference to reach DT Operation in the two Schedules, when calculated from today, is ~15%, or ~3.5 years.

The ICRG is aware that the Iteration Modelling results as presented to the ICRG in March 2016 and updated in April 2016 is only the first step in the full development of this approach. It is so far a high-level modelling exercise based on the same work packages as the ULTS; however, the ULTS is a detailed and comprehensive schedule. For the Iteration Modelling to be converted, subject to the endorsement by the ITER Members, into a full schedule and resource baseline, a considerable amount of detailed analysis and optimization work will need to be undertaken in the coming months.

Specific Recommendation:

- The ICRG encourages the IO-CT and all ITER Members to fully develop the Iteration Modelling and to analyse the plan also for its implications for the DAs. The Iteration Modelling does so far not consider "placed contract" constraints, either for contracts placed by the IO-CT or the DAs; this will have to be refined in further iteration cycles. Furthermore, it does not consider the costs or schedule impact of demobilization (e.g. premature close-out of contracts, costs associated with staff redeployment, time required etc.) and the subsequent schedule and cost impact of re-mobilization (lead times for remobilisation, procurement schedule etc.). These aspects need to be refined once there is greater clarity and commonality amongst IC Members as to their vision of the post-FP ITER Schedule.

General Recommendations concerning the both Schedules and their Resources

- The joint IO-CT/DA teams are having a positive impact, but overall, the trust between and DAs is still not deep. Therefore, a continued strengthening of the project management culture at all levels of the organisation is needed and further integration necessary.
- Subsequent iterations of the schedule should reduce the number of activities for earned-value reporting. The project may wish to consider collecting costs at Level 4 rather than its current Level 5 to reduce complexity.
- Right now, the guidelines for use of the Reserve Fund are very narrow; however, if the rules were broadened then the DG could use the Reserve Fund in any way necessary for the benefit of the project, for example to mitigate risks.

6. Human Resources Analysis

6.1. Introduction

The ICRG was charged to review IO-CT's Human Resources (HR) organization (HR Department and other related departments) and the processes and procedures necessary to support the envisaged activities; more specifically all human resources functions, such as recruiting, orientation and placement, training, performance evaluation, remunerations and retention.

The ICRG is aware that there is no perfect solution to human resources management in large-scale projects like ITER. The goal in reviewing the ITER Project was to use the varied backgrounds, expertise, and experience of the ICRG members to respond to the questions posed and not to be overly prescriptive.

6.2. Present Status of HR

The facts related to human resources were provided to the ICRG during the opening plenary session and through the submission of information as requested by the review team [Appendix 4].

6.3. Approach to the HR review

The ICRG reviewed the available information prior to the on-site meeting and also:

1. Examined qualification norms of staff and staffing levels within drill down areas;
2. Reviewed the details of the Human Resources Process and Procedures Handbook, Version 2.0, dated January 2016;
3. Examined staff regulations and IO-CT internal circulars;
4. Reviewed other HR-related documents that were made available.
5. Interviewed Francoise Cazenave-Pendaries, Head of Human Resources Department
6. Interviewed 28 IO-CT staff members that were selected from the IO-CT Organization Chart by the Human Resources Sub-group members. The interviewees included individuals from different departments/divisions/offices within the ITER Organization, individuals at different levels within the organization, and individuals from different member countries. The questions asked of the interviewees and their responses are given in [Appendix 4].
7. Interviewed the Chair and Deputy Chair of the Staff Committee
8. Conducted follow-up interviews with other IO-CT staff members and management as necessary to gain additional information
9. Corresponded with IO-CT staff after the on-site visit to gain additional information and to get clarification on outstanding issues.

The interviews played a critical role in identifying areas that required follow up or further explanation. The review followed the questions given in the Terms of Reference. The review did not focus on the staff numbers related with the work packages as they were reviewed during the drilldowns, in the context of analysing the schedule and related resources.

6.4. Results of the Review of the Human Resources Department and Response to Charge Questions

The international collaboration that joined together to design, construct and operate ITER adds complexity on many levels. In order for ITER to be successful, that complexity needs to be managed, monitored, and possibly adjusted as ITER matures. The HR Department plays an important role in supporting the DG in this regard.

Terms of Reference Topic #1: IO-CT Current Structure and Staffing Associated to the Schedule

A. Assessment and HR Audit of the current organizational structure and set-up of the IO-CT, of its Departments and Divisions, and its adequacy to ensure maximum effectiveness and efficiency for construction and assembly phase, i.e. determine efficacy and justification of the present staff vis-à-vis the organizational needs of today in the near term

In order to understand the organization better, drill-downs were conducted in a number of areas to review and analyse the requirements to meet the project needs. The following areas were selected for review:

- **CAD Staffing**: In reviewing the CAD engineers, the ICRG learned that CAD staffing currently support the work of ITER with 65% of those resources working fully toward FP as defined in the ULTS. It was also noted that there have been cases where design changes have been so significant that a large portion of the CAD models and drawings, in those cases, do not have relevance today. A number of lessons learned are being incorporated for better utilization, including annual CAD work plans (not existing until 2014), clear definition of deliverables, and mandatory design inputs available prior to the start of CAD work. It should be feasible to reduce total CAD staffing (ITER plus contractors) once the well-defined structure as planned now is fully implemented.

  Staff interviewed expressed frustration with the difficulty in finding qualified CAD staff from outside the local region, meaning that it has been difficult for them to keep the Member diversity in line within their division.

  The ICRG also notes that the decision to hire 54 CAD staff in June, 2015 for 3 to 5 years was over-simplified by absorbing 51 staff from their own external contractors, though normal recruitment processes were followed. Given the nature of the job and the fact that CAD staff would normally be front loaded on a project during the design phase, it was surprising that moving from a contracting to an employee arrangement was appropriate. During ICRG's discussions with the IO-CT team, they voiced concern regarding having contractors and employees working together and the fact that the current contracting mechanisms require full scope descriptions prior to contracting work. Given the nature of designing, especially in an R&D environment, the IO-CT team requires the ability to make modifications and be flexible. Under the current contracting arrangement, this is not possible.

- **Schedulers**: In the review of scheduling, it was stated that ULTS is comprised of a very large number of activities (close to 250,000) and it integrates the activities associated with the detailed work schedules of the seven DA's plus the activities of the IO-CT. The scheduling activities are being carried out by mix of IO-CT staff and contracted personnel. The ICRG has strong views that the number of activities in the schedule be reduced given that the detailed scheduling of activities under DA's scope is being carried out by them. (The IO-CT management group has a plan to develop the Earned Value Management (EVM) to track project performance. It will be a very difficult and time consuming job with over 250,000 schedule activities.) A gradation system in scheduling for the components, structures, and systems in critical path activities compared to non-critical path activities might be in order. Also, there is a perception among many that schedule development is getting much more attention than implementation. The IO-CT is open to streamlining the scheduling process, but they do not agree that, even with reduced monitoring of activities, they would be in position to shift any schedulers to other activities in view of the limited number of staff.

- **Magnet Division:** The ICRG picked up "Magnet" as another HR drill-down area, since it covers large portion (1/3) of total ITER procurement and significantly influences ITER's overall headcount. Within Magnet system, TF (Toroidal Field) is the largest sub-set that occupies over 50% of procurement value of Magnet as shown below.

Procurement Value Break-down of "Magnet"

Magnet total procurement value	812 kIUA
FT (Toroidal Field)	481 kIUA
PF (Poloidal Field)	128 kIUA
CS (Center Solenoid)	140 kIUA
Others	63 kIUA

According to data that IO provided to the ICRG, design of Magnet system has been almost completed and manufacturing has been progressed roughly by 50%. Detailed data is shown below.

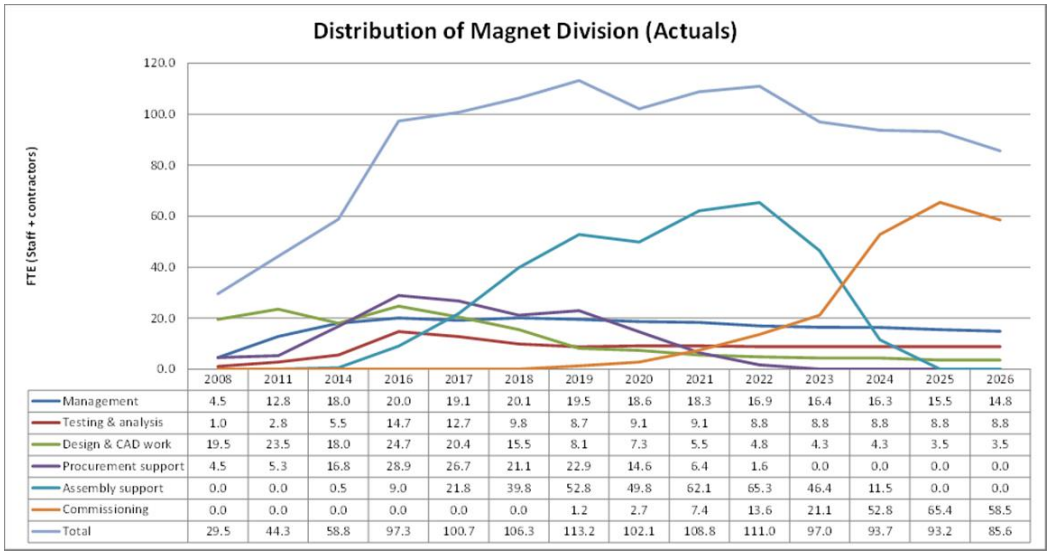
Design and Manufacturing Progress of "Magnet"

Components		kIUA	Design	Manufacturing
TF	Conductor	53.78	Completed	Completed
		43.39	Completed	Completed
		41.54	Completed	Completed
		43.39	Completed	Completed
		16.16	Completed	Completed
		16.81	Completed	50% completed
	Magnet Winding	89.74	Completed	20% completed
		86.39	Completed	10% completed
	Magnet Structure	90.11	Completed	10% completed
PF	Conductor	52.71	Completed	50% completed
		11.23	Completed	50% completed
		16.96	Completed	50% completed
	Magnet	40.86	Completed	Not started
		6.80	Dummy done	Not started
CS	Conductor	90.00	Completed	50% completed
	Magnet	49.84	Completed	10% completed
Others	CC (Corrections Coils)	5.51	Completed	Started
	Magnet support	22.86	Prototype done	Not started
	Conductor for CC and Feeder	2.13	Completed	Completed
	Pre commission ring	0.60	Prototype done	Not started
	Feeder	31.98	prototype done	Not started

Note: It is assumed that design are completed for those that started production / manufacturing.

Given above, it is natural to assume that Magnet Division has passed the peak of design engineering resource demand (resource demand of design engineering should have been decreasing), while manufacturing/assembly related resource demand is increasing.

However, according to FTE (full time equivalent) data (past actual and future plan) shown below, resource/workload for Design & CAD works was not largely changed in this 8 years, although the division has moved from design phase to manufacturing phase in 2009 - 2010.



	2008	2011	2014	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Management	4.5	12.8	18.0	20.0	19.1	20.1	19.5	18.6	18.3	16.9	16.4	16.3	15.5	14.8
Testing & analysis	1.0	2.8	5.5	14.7	12.7	9.8	8.7	9.1	9.1	8.8	8.8	8.8	8.8	8.8
Design & CAD work	19.5	23.5	18.0	24.7	20.4	15.5	8.1	7.3	5.5	4.8	4.3	4.3	3.5	3.5
Procurement support	4.5	5.3	16.8	28.9	26.7	21.1	22.9	14.6	6.4	1.6	0.0	0.0	0.0	0.0
Assembly support	0.0	0.0	0.5	9.0	21.8	39.8	52.8	49.8	62.1	65.3	46.4	11.5	0.0	0.0
Commissioning	0.0	0.0	0.0	0.0	0.0	0.0	1.2	2.7	7.4	13.6	21.1	52.8	65.4	58.5
Total	29.5	44.3	58.8	97.3	100.7	106.3	113.2	102.1	108.8	111.0	97.0	93.7	93.2	85.6

Note: It is assumed that Design & CAD Work is resource for system/equipment/component requirement development and design. When design staff moves to DA's procurement support work, it is counted as Procurement Support FTE.

This may indicate that Magnet Division is slow in transforming staff competency/skill balance, or design is still incomplete, while starting manufacturing, and sizable design engineering resource is still needed.

Overall, there is some concern that the IO-CT should ensure that the different units work well in an integrated project approach. Working in silos could mean that effort is being duplicated over a number of different areas. Also, as the project matures and the manpower requirements change, continued review of this possibility needs to be examined. The IO-CT management should continue the effort to ensure that the project organization is working well together. The ICRG does believe that implementation of Project Teams (on as needed basis) is an excellent way to bring the resources from various areas of the organization together. This should be continued and strengthened as the project matures.

A number of changes could be made in recruiting to help to increase member diversity among the ITER staff. Background requirements should be appropriate for the type of staff required, positions should be advertised outside of the Fusion Community in instances where the position does not require a fusion background and the DAs should work to increase the number of nominated well-qualified applicants. In addition to the ITYRER job website, the main tool used by IO-CT for advertising vacant position externally to the Fusion Community is 'LinkedIn'.

Benchmarking against other organizations was conducted by the ICRG. The benchmarking exercise showed that the number of staff at the IO-CT seems somewhat higher compared to other, similar, projects. The ICRG does, however, acknowledge the added complexity of the ITER Project. Without having detailed information about the makeup of staff (employees, contractors, seconded staff) in other benchmarked organizations, it is difficult to ascertain or compare accurately. The ICRG notes here that IO-CT staff should make up the base staff for each phase of the project and that contractors should be used to handle peak or temporary requirements.

Given the complex nature of the ITER Project, the ICRG believes that, overall, the size of the organization is reasonable and that the requests for staff are, for the most part, warranted.

Terms of Reference Topic #1: IO-CT Current Structure and Staffing Associated to the Schedule

B. Verification of the effectiveness of the current staff distribution and of the appropriateness of the present IO-CT staff for their given assignment.

As an international joint investment project, the ITER Project includes a majority of investments supplied by Members in the form of in-kind contributions. As such, the role of IO-CT and of the overall organizational strategies are keys to the success of the ITER Project. Here, the role of the IO-CT includes a program management function (overseeing the planning, adjusting and monitoring of Member projects) and a project management function (for the areas for which the IO-CT has scope responsibility).

While there is no perfect organizational structure, the ICRG believes that there should be some flexibility in the ITER Organization to allow it to adapt to new management and business strategies and to adjust itself according to the project phase, including the current change from a focus on design to a focus on construction.

Roles and responsibilities should be regularly reviewed and refined if necessary. This might mean having to reassign or retrain staff that are currently under 5-year contractual agreements. Given that necessity, it seems that the HR organization is not geared and ready for such a change since they have self-reported that they are understaffed and have had to reprioritize their activities and reassign staff.

The ITER Agreement, Article 7.11, reads: "The Staff shall be appointed on the basis of their qualifications, taking into account an adequate distribution of posts among the Members in relation to their contributions". The DG's Action Plan that was submitted to the IC states "In matter of recruitment, excellence should be the rule; the adequate distribution of posts among the members in relation to their contribution should remain a subsidiary criterion for an individual recruitment compared to his qualifications." Overall, the ICRG strongly supports giving the DG the flexibility that he needs to deliver the ITER Project.

At the same time, the ICRG encourages ITER to consider member diversity among staff when candidates have equal qualifications. Increasing the member diversity among the candidate pool is important and encouraging the DA's to nominate many well-qualified candidates is critical also.

The IO management should consider restricting assignments, in general, to not more than two terms for staff other than operations. Exceptions to standard renewals should be possible, but they would need to be approved by the DG. The IO-CT must be careful not to automatically renew employment contracts. Contract renewal should be based on the needs of the IO-CT and the performance history of the individual. The durations of the contracts could be defined according to the skill requirements and phases of the project, distinguishing the manufacturing period and the operations period and taking into account individuals in key positions.

Terms of Reference Topic #2: Review the different aspects of the IO-CT HR Organization

A. Assess the resources and qualifications of an HR Department staff responsible for executing the staffing plan;

The Human Resources Department staff stated that they are understaffed and as a result, they handle predominantly administrative work rather than acting as business partners to the ITER Organization. They believe that the current mix of Professional "P" and General "G" staff is not ideal and that they want to make the organization more professional.

The ICRG did note that the Human Resources Department might benefit from having a more diverse mix of Human Resources staff. Ideally the Human Resources staff should be international in nature to allow for more understanding of the unique set of challenges that new international staff and their families face when they join the ITER Project.

A consistent message that came from all levels of the organization suggests that the current Human Resources Department approach is not flexible enough. While the rules and regulations are robust, the

Human Resources Department should look to make themselves more adaptable in order to provide the best Human Resources support possible to the ITER team. The staff want the HR team to help them sort through issues and work hard to find resolution, not just establish and enforce rules.

A benchmarking against other international organizations might be a good start to a self-assessment that should be conducted of the current HR policies and procedures.

Terms of Reference Topic #2: Review the different aspects of the IO-CT HR Organization

B. Review the capability of the IO-CT HR organization to recruit and retain the resources considered by the IO-CT as necessary to carry out the activities of the proposed schedule in their specified time duration;

In general, employees feel that the Human Resources Department policies do not work well to retain them. This has led to unhappiness among the staff and uncertainty about their future. This could lead to higher than anticipated turnover and low morale.

Current HR recruiting staff would not be able to handle recruiting the number of additional staff required by the current IO-CT plan and the turnover of existing staff. The IO-CT should analyse the staffing requirements and work with the DAs to fill vacancies where DA expertise would be critical.

A skills/competency management tool is needed. There are currently existing staff with the skills necessary to support other roles and the organization currently has no way to know where those competencies exist. The HR Department Head knows that this is an issue, but does not currently have the resources to develop and implement a solution for this problem.

Terms of Reference Topic #2: Review the different aspects of the IO-CT HR Organization

C. Assess the adequacy of the structure of the HR Department and of HR policies and procedures to implement the Staffing Plan within the required time, with focus on identification of qualified candidates, interview selection and recruitment processes (including preparation and review of job descriptions and appropriate qualification/experience required, orientation and assignments, training and development); staff retention processes (including remuneration, motivation and morale, welfare and social security, safety and health aspects), and resulting staff distribution, and assessment of whether such processes are in line with the spirit and intent of the ITER Agreement.

Technical staff often want as few rules and regulations as possible and Human Resources and other support functions are sometimes viewed as obstructing progress. The ICRG was aware of this fact and has taken that into account in the assessment. However, a large amount of feedback stressed that the Human Resources Department and their policies and procedures need to be more flexible.

The IO-CT Human Resources Department is not viewed favourably among many ITER staff. The perception among the staff is that they feel that the Human Resources policies are not applied fairly and equitably across the organization and this has led to their distrust and fear.

It is suggested that the DG define what is expected of the Human Resources Department and define the targets to the head of Human Resources Department. The perception currently is that the Human Resources Department is responsible for setting the rules and regulations, enforcing them and then rewarding those that conform.

The Human Resources Department is very focused on administrative tasks. It should be strengthened to include a change management component and support for the skills policy.

Training opportunities need further improvement in line with future challenges. Training is currently focused on compliance and not on development.

Terms of Reference Topic #2: Review the different aspects of the IO-CT HR Organization

D. Review the state of participative management and communication among staff, within and outside of the hierarchy. (The IC Review Group may also make observations on multicultural aspects of the project).

Staff are overwhelmingly supportive of the new top management group and support the more rigorous project management culture that is being implemented. The Project Team concept is positive. Most staff members interviewed felt that they had the opportunity to contribute to decisions.

There are some concerns among the staff (and the ICRG) that multi-cultural human resources issues exist. The ICRG members were concerned that the percentage of overall staff does not more closely align with the member contributions. The diversity of selection board members was reviewed for a few samples and shows that there is a need to have fair representation from multiple member states. An adjustment on the wording of the job descriptions to encourage individuals meeting the qualification requirements and not encouraging over-qualified individuals would be of value. This could help to increase the diversity among the applicants and ultimately bring the diversity of staff more in line with the member contributions. Additional efforts should also be made by the DAs to ensure that additional qualified applicants are approved.

Terms of Reference Topic #2: Review the different aspects of the IO-CT HR Organization

E. Comment on general industrial relations, trade unionism, disputes and their resolution as practiced in the IO-CT.

As of March 2016, the number of Staff Committee is 10 full members and 2 alternates, They are elected annually among the IO-CT staff. The committee meets with IO-CT administration representatives every month, proposes agendas and keeps minutes. The committee also meets regularly with the DG. The Human Resources Department consults with the Staff Committee on staff welfare and staff administration. With respect to staff regulations, the Staff Committee ensures dialogue between staff and the DG. It is not a requirement to have committee members from all representative ITER Members, but that is something that the ITER Project might want to consider.

Disputes and resolution of disputes are handled per the staff regulations. If someone disagrees with a DG employment decision there can be an appeal. It has to be made within 40 working days of the decision. The DG has 20 days to reply. If they still disagree with the issue it could be brought to a mediator. The mediator is nominated by IC for a three-year term and is a judge who is external to the ITER organization. The mediator will provide a recommendation to the DG, but it is not binding on the DG. If staff still are unhappy, they can appeal to the ILOAT. There were seven such appeals in 2015, seven in 2014, and eight in 2013. Currently, there are seven cases pending in the ILOAT. Most of those concern the termination of a contract for lack of performance.

Terms of Reference Topic #2: Review the different aspects of the IO-CT HR Organization

F. Identification of collaborative ways of working that can optimize the use of existing staff from both the IO-CT and the DAs, and suggestions about how they can be practically implemented (e.g. how IO-CT can progressively absorb DA's staff on site).

The IO-CT is encouraged to use DA expertise to the extent possible to minimize the learning curve, transfer DA expertise, and allow transition from construction to commissioning and operations.

ITER Project Associates are considered a good and useful tool in this context.

Utilizing DA expertise is another useful tool and the DAs are encouraged to send experienced personnel to support the IO-CT. DA expertise could be used more extensively provided that there are clear and detailed plans developed to deploy them and there is an agreement established between the IO-CT and the DAs. For DA expertise, there should be a tie to specific work outlined in the WBS work scope.

DAs could take on some of the work currently planned for IO-CT Assembly.

The choice between using the internal employees (or DA) and the contracted staff is always complex. The contracting is flexible but currently requires a perfect definition of the tasks. The cohabitation of IO-CT employees and contractors must be framed. The difficulty is in specifying well the domain where the design still evolves; if it is uncertain, it is necessary to use IO-CT or DA employees. Some engineers

could have difficulty in specifying exactly what needs to be done and would prefer to direct the contractors on a daily basis. The contractors need to have high technical skills and are not interchangeable. Contractors, in general, will be more effectively on conventional work. The issue related to contractors need to be reviewed in comparison to other international projects to be sure that the IO-CT is not being overly restrictive. The IO-CT should consider using a number of large, long-term staffing contracts to ensure that contracted staff can be obtained quickly and are available as needed. Training could be provided to ensure that the contracted staff have and maintain the appropriate skill sets.

6.5. Summary and Recommendations:

In summary, the ICRG would like to make the following recommendations as a result of the review of Human Resource aspects:

- The DG and his team are working successfully to create a project management culture at ITER. This work is appreciated by the ITER staff. In keeping with these changes, the ICRG encourages changes to the Human Resources Department and to the development of human resources policies and procedures that support that culture and the ultimate success of ITER. The primary goal should be the success of the ITER Project and the Human Resources Department has to serve as a support organization that helps to achieve this goal.
- IO management should consider restricting assignments, in general, to not more than two terms for staff other than operations. Exceptions to standard renewals should be possible, but they would need to be approved by the DG. The IO-CT must be careful not to automatically renew employment contracts. Contract renewal should be based on the needs of the IO-CT and the performance history of the individual. The durations of the contracts should be defined according to the position and different phase of the project.
- The IO should use IO-CT staff for base or core functions but use contracted staff to address peak or more conventional requirements. Using a number of large, long-term staffing contracts with a shared planning of project requirements would ensure that contracted staff could be obtained quickly and would be available as needed.
- The IO-CT needs to work with DAs to review staff requirements and encourage the DAs to send expert manpower to ITER.
- The Human Resources Department should conduct and maintain a skills/competency inventory and develop a knowledge management system.
- ITER management should seriously consider making changes within the Human Resources Department and to human resources policies and procedures to ensure that the organization is more flexible and supportive. The staff of the Human Resources Department needs to be more diverse and more in line with the diversity of the IO-CT member countries.

7. Commissioning, Protection, and Operation

An integrated commissioning plan is being developed for ITER's FP. The high-level plan is complete, logical and the duration of tasks and staffing seems reasonable. The detailed processes are, however, not yet fully defined. There is little apparent contingency in the plan and it is therefore "success oriented." The ICRG encourages further development of the plan and the risk strategy for commissioning.

ITER is protected by a two-layer machine protection system: a conventional control system (Control and Data Acquisition (CODAC) and Plasma Control System); and Interlock Systems (the Central Interlock System (CIS) and Plant Interlock Systems). The conventional system provides the first line of protection and ensures the interlock system is rarely used. In addition to the machine protection system the Safety Systems ensure safety of personnel.

By FP, almost all the CIS hardware must be in place. Similarly the plasma control system and CODAC must be operational and linked to the CIS. However, as new plant systems come online after FP, further linkage will be established. A contract for the CIS is in place and the final design review took place in late March 2016. The IO-CT consulted extensively with CERN and fusion experts on the design of the CIS. After the CIS is developed it will be tested on KSTAR in 2017-2018 and installed at ITER in 2019. The commissioning of the machine protection systems starts in 2022 and culminates in FP. The ICRG considers the machine protection system to be progressing well and is impressed by the systematic development plan.

Joint operation experience by all ITER Members in the coming years using available Tokamak facilities would be an important step in that direction, especially by providing a training ground for ITER scientist and engineers. Strengthening the role of the existing frame of the International Tokamak Physics Activity (ITPA), which has operated on tokamak physics R&D activities and joint experiments in available tokamak facilities for many years by members of ITER mainly focusing on ITER-relevant scientific and technical (S&T) issues, would be a good way for joint operation experience. The ICRG encourages an IO-CT/DA Joint Team to work together with ITPA for simulating of future critical ITER S&T issues.

8. Conclusion

First, the ICRG presents its findings concerning the charge given by the ITER Council to perform an independent review of the following elements:

- *Proposed sequence and duration of activities required to complete the design and fabrication of the various components; the design and construction of the buildings; the installation and assembly of the systems/equipment/components necessary for FP; commissioning necessary for FP to be achieved; and subsequently operate the facility and complete the installation/assembly and commissioning of the remaining systems and components for Deuterium-Tritium (D-T) operations.*

The proposed sequence and duration of future activities have been fully mapped in the resource-loaded schedule. The ULTS is logically-linked and resource-loaded, consistent with a December 2025 FP milestone, the earliest possible technically achievable date, followed by a DT (Tritium Trace) milestone in 2034. The applied methodology is rigorous. The ULTS critical path to FP runs through the Vacuum Vessel (EU part), followed by installation and assembly, and integrated commissioning for FP. However the Tokamak Building lies close to the critical path and could easily slip. In the ULTS the FP milestone at 2025 is the earliest possible technically achievable date. The ICRG notes that this is a success-oriented schedule with no contingency. If any major risk that the IO-CT has identified should materialize, then the FP date will almost certainly slip by some degree. There seems to be no realistic possibility to move the FP date forward.

Presently the IO-CT overall value weighted estimate for construction project completion (First Plasma system) is approximately 40%. This includes all design work, IO-CT contributions, and considerable in-kind contributions from the DAs.

- *IO present and proposed resources necessary to achieve the FP milestone, i.e. to carry out the activities in their specified sequence and duration; and specifically the proposed staffing plan, (taking into account the availability of current framework agreements and proposal for hiring a Construction Management Agent).*

The proposed resources (financial and human) necessary to achieve the FP milestone have been derived directly from the resource-loaded schedule. A detailed analysis of some of the sub-systems has in general confirmed that the assumptions concerning manpower and funding needs are reasonable.

One area of great interest is the extent to which DA involvement might reduce the number of IO-CT staff. There are obvious advantages in having DA personnel with expertise in their in-kind hardware be involved with its installation. All DA's have expressed interest in supporting ITER in this way, but in varying degrees. The ULTS costing did not assume any specific level of DA participation, but described methods by which it could be done, e.g. the ITER Project Associate (IPA) concept. It seems that most DAs would require that the IO-CT pay those costs either directly or by credit, and the IO-CT's resource estimates assumed that DA personnel cost would be reimbursed by the IO-CT. Thus, the DA involvement does not represent a significant cost reduction to the ITER Project but is beneficial for the reasons stated above. The ICRG recommends that IO-CT and DAs develop further plans before assembly begins.

- *IO's structure (the efficacy and justification of the Organization's present staff vis-à-vis the Organizational needs of today and in near term), Human Resources (HR) organization (HR Department and other related departments) and process/procedures necessary to support the envisaged activities; more specifically all HR functions e.g., recruiting, orientation and placement, training, performance evaluation, remunerations, retention, etc..*

The major conclusions and recommendations related to **Human Resources** are:

The DG and his team are working successfully to create a project management culture at ITER. This work is appreciated by the ITER staff. IO-CT management should consider restricting assignments, in

general, to not more than two terms for staff other than operations. Exceptions to standard renewals should be possible, but they would need to be approved by the DG. The IO-CT must be careful not to automatically renew employment contracts. Contract renewal should be based on the needs of the IO-CT and the performance history of the individual. The durations of the contracts should be defined according to the key responsibilities and different phase of the project.

In an effort to ensure that the most technically qualified individuals are performing work for ITER, the IO should use IO-CT staff for base or core functions (or functions that have a long duration) but use non-IO (contracted) staff to address peak or more conventional requirements. Having the flexibility to hire staff or contract support is important and should be used as appropriate to serve the needs of ITER. There are current restrictions associated with using contracts and this should be re-examined to ensure that ITER is being as flexible as possible in that regard. Additionally, the IO-CT needs to work with DAs to review staff requirements and use expert staff from the DAs. Finally, the Human Resources Department should conduct and maintain a skills/competency inventory and develop a knowledge management system that can be used throughout the life of ITER. Without having those tools, expertise may exist but may not be known to managers and the loss of key knowledge or skills may occur as contracts expire and are not renewed.

ITER management should seriously consider making changes within the Human Resources Department and to human resources policies and procedures to ensure that the organization is more flexible and supportive. Having international human resources experience and more member country diversity within the Human Resources Department is important to ensuring the empathy that the ITER staff expect.

- *Technical and financial assumptions underlying the proposed ULTS (e.g. known financial constraints of the Members).*

The ULTS was developed as a bottom-up resource loaded schedule. The resource estimates therefore did not include financial constraints, but included the delivery dates provided by the DAs. The development of the staged approach with different iterative models takes the known financial boundary conditions of some of the Members into account.

Second, the ICRG judges that the schedule to FP (December 2025) in both the ULTS and the staged approach (Iteration Modelling) is the earliest possible technically achievable date, with no contingency (float) included. At present the main determining factors for the critical path are the manufacturing and delivery of the sectors of the Vacuum Vessel, the on-time completion of the Tokamak Building, and the assembly and commissioning. The ICRG recommends that the IO-CT determines a target date (milestone) for FP that includes a reasonable contingency once the outcome of the present steps to mitigate these risks are known and a first quantitative risk analysis is performed. It would be desirable to have this information together with the new baseline expected in November 2016.

Third, the ICRG encourages IO-CT and DAs to develop a deeper understanding of the staged approach and to analyse its implications. In the opinion of the ICRG the most important strengths of the staged approach, beside meeting the financial boundary conditions, lies in i) a more focused, staged assembly and commissioning and ii) its possibility to accommodate extended periods for research program between FP and the start of DT Operation.

Acknowledgement

The ICRG would like to thank the members of the IO-CT for having prepared, with the input from the Domestic Agencies, a very complete documentation and the constant availability to respond to questions.

Thanks go also to the Heads of the Domestic Agencies, the IC Heads of Delegation, and the IC Chair for sharing with the ICRG their point of view.

Very special thanks go to Sachiko Ishizaka, the IC Secretary, and her team for a very efficient support and great help during all phases of the review.

ITER Council Working Group on the Independent Review of the Updated Long-Term Schedule and Human Resources

Appendices and Documents

Appendix 1: ICRG members and their sub-group membership

Members of the ITER Council Review Group and their Subgroup* Membership

***SR: Subgroup on Schedule & Resources**

HR: Subgroup on Human Resources

Chairman:	
Albrecht Wagner (SR)	Former Chairman of the Board of Directors, Deutsches Elektronen-Synchrotron DESY, Hamburg
Vice-Chair:	
Boris Kuteev (SR)	Deputy Head, Tokamak Dept. Kurchatov Nuclear Technology Complex, NRC Kurchatov Institute
Members:	
Young-soon Bae (SR)	Plasma Scientist, Plasma Modelling Team, KSTAR Science Center, National Fusion Research Institute
Chetal Subhash Chander (HR)	Former Director IGCAR and PM for Indian Fast Breeder Program
Steven Cowley (SR Chair)	Chief Executive of the UK Atomic Energy Authority (UKAEA), Head of EURATOM/CCFE Fusion Association
Diane Hatton (HR Chair)	Director, Planning, Performance and Quality Management Office, Brookhaven National Laboratory (BNL)
Jeffrey Hoy (SR)	President, Trident Services, LLC
Takashi Kato (SR)	Director, Japan Advanced Technology Co. Ltd.
Bok Nam Lee (HR)	Professor, Seoul National University
Jiangang Li (SR)	Professor/ Former Director of ASIPP, Member of CAE
Masahiro Ozaki (HR)	Partner, PricewaterhouseCoopers Consulting LLC
Lester Price (SR)	DOE retired, Federal Project Director, Spallation Neutron Source
Mark Reichanadter (SR)	Project Manager, Linac Coherent Light Source-II (LCLS-II), SLAC National Accelerator Laboratory
Philippe Sansy (HR)	HR Director, CEA Atomic and Alternative Energies Commission

Appendix 2: Questions to the DAs and their answers

The ICRG interviewed the Heads of the Domestic Agencies (DAs) and asked them a number of questions:

1) Do you support the 2025 FP Schedule? Are you committed to deliver both in-kind contribution and the in-cash contribution as requested by the IO-CT?
2) Do you support the DG's strategy and process for the IO-CT/DA iteration for the revision of the Updated Long-Term Schedule?
3) How do you see the difference/credibility of the on-going exercise for the updating of the baseline (Cost & Schedule) compared to the previous ones?
4) DA views on specific risks. How do you see the "success-oriented & no contingency" strategy?
5) Are there better ways for IO-CT/DA collaboration? What about the possibility for DAs to second their staff to the IO-CT (as "secondment" or "IPA")
6) Your assessment of the HR needs estimated by the IO.
7) How is the current status of the IO-CT/DA Integration?
8) Your views on IO-CT's HR management.
9) DA's impression/views of changes in the IO-CT management. How it affected your work? Some changes in terms of IO-CT's responsiveness, efficiencies etc.?

The synopsis of their answers at the February meeting provided a consistent picture:

The DAs support the 2025 schedule to FP for the in-kind contributions, while additional cash contributions are considered too high and need to be negotiated with governments. The schedule is based on Detailed Work Schedules submitted by all DAs, and therefore it is not a political, but a technical achievable schedule.

The basis for the schedule is much better than previous ones, believable, and credible. But it is very optimistic. The reliability of the Schedule has improved through the Schedule Task Force and the Review Group exercise since October 2015. The schedule is based on industry input and the review process has involved all DAs. But the iteration between the IO-CT and DAs regarding the staff and resource estimates is still considered insufficient.

For at least one Member the highest risk element is the (national) Budget. For ITER itself the IO-CT part of the cost is the biggest risk.

Concerning IO-CT staff all DA Heads see the present estimate as too high. The IO-CT should focus on the central integration and management. At the same time the DAs are eager to second staff to the ITER site, as the project progresses. There seems a need to better define the role and responsibilities of the IO-CT. The HR management needs improvement. The IO-CT is seen to have too many engineering people rather than construction people.

Concerning the handling of risks a clear cultural difference becomes apparent, where in some countries no explicit contingencies are foreseen (and also not considered necessary) while other countries operate with relatively large contingencies.

Essential changes have occurred in the IO-CT management under the new management. IO-CT/DA integration has clearly improved. But further improvements seem possible through reviewing the roles and responsibilities of the IO-CT and DAs. At a senior level, a project culture and the spirit of "one team" has been generated, but it has not yet reached the entire IO-CT staff.

Concerning the strategy to focus only on FP while deferring DT related activities to later, one country said that one should agree on the best technically achievable schedule (towards DT) and not defer it. The FP is an important political milestone and one therefore should do the best to reach FP as soon as possible, but in parallel one should do the best for the DT as well.

Appendix 3: Questions to the IC Heads of Delegation and their answers

The ICRG also interviewed the IC Heads of Delegation and asked them where they saw the **three biggest risks** and how the evaluated the priorities of FP versus DT Operation. The answers reflected a very consistent picture: The three biggest concerns are schedule, cost and project management.

All Members stressed that the future of ITER is crucially dependent on a credible schedule until FP. Although the mission of ITER is the demonstration of DT burning with an output fusion power of 500 MW, the focus of the schedule, the priorities and resources must be the achievement of FP. There must be a clear definition of this scope (an agreed definition of FP and its Key Performance Parameters). The schedule should take into account major risks.

The additional cost and human resources should be kept at a minimum. The possibilities for improvement of the staff resource management need to be explored, e.g. the necessary skill mix in the coming years.

The management must further strengthen the IO-DA integrated teams and their progress must be accelerated further.

Appendix 4: Summary of Facts related to HR

The following findings of fact related to human resources were provided to the ICRG during the opening plenary session and through the submission of information as requested by the review team.

The Human Resources Department is divided into two main sections – Talent & Competencies Development and Remuneration, Performance and Employment. The structure of the Department is shown in Figure A4.1.

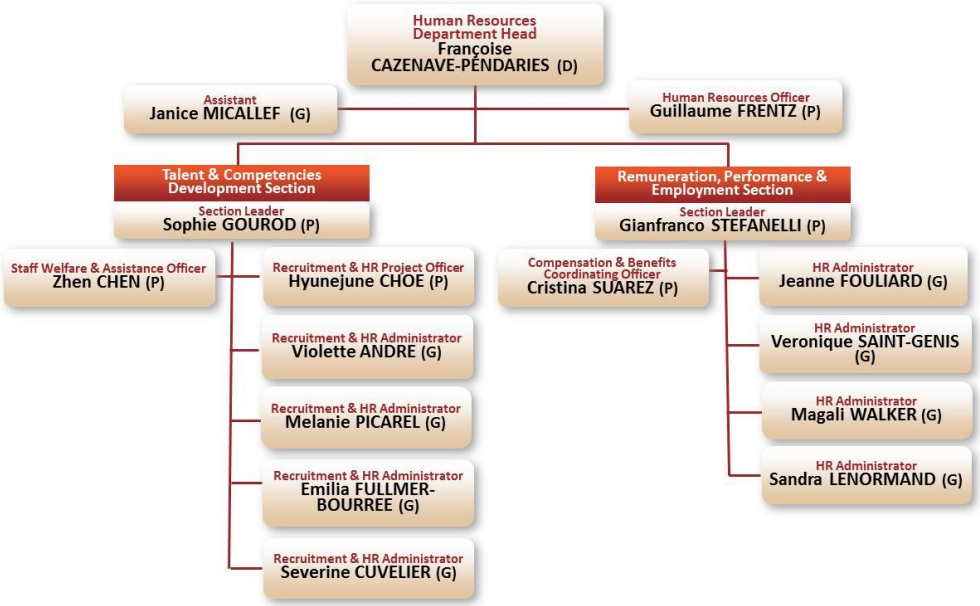


Figure A4.1

The diversity of the IO-CT Human Resources Department staff is as follows:

Nationality				Int, Exp	Int. Exp in Int. Org. before ITER	Number of contracts		
EU	KO	CH	US			1	2	?
13	1	1	1	7	2	5	10	1
81,25%	6,25%	6,25%	6,25%	43,75%	12,50%	31,25%	62,50%	6,25%

Processes and procedures are captured in the ITER Human Resources Processes and Procedures Handbook which was made available to the review team. The document contains information in the following areas:

1. Recruitment and Employment;
2. Remuneration and Benefits;
3. Employee Development;
4. HR Governance and Tools; and
5. Non-IO Staff information

Additionally, the Staff Regulations and IO-CT Internal Administrative Circulars (IAC) were also examined.

Staffing Plan and Staffing Figures for the ULTS were presented as shown in Figure A4.2 for the period 2009 - 2015 with a forecast for 2016:

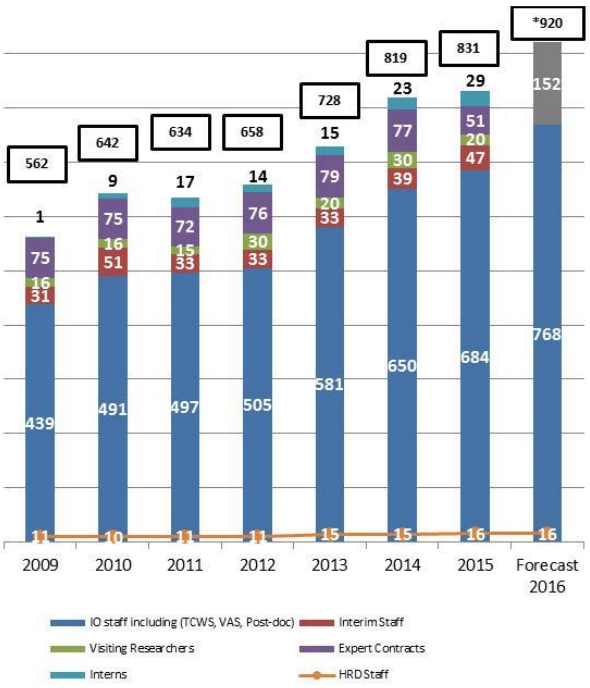


Fig A4.2

The distribution of member contributions against the distribution of ITER staff by Member was given to the review team as:

	Member Financial Contribution % (During Construction)	% of Professional Staff (P)	% of General Staff (G)	Total Staff	Total Staff %
EU	45.46%	66.58%	73.51%	446	69.47%
India	9.09%	4.28%	2.24%	22	3.43%
Japan	9.09%	5.08%	2.24%	25	3.89%
China	9.09%	7.49%	10.07%	55	8.57%
Korea	9.09%	6.95%	2.24%	32	4.98%
US	9.09%	4.28%	5.97%	32	4.98%
Russia	9.09%	5.35%	3.73%	30	4.67%

In 2015 there were 42 departures with 12 coming out of the "G-General" category and 30 out of the "P-Professional" category. 22 of those were resignations, 19 resulted from the end of a contract period and 1 came from the end of a probationary period.

Nominations by the DAs are summarized in the Table below:

2015 *(ITER source)*	CN	EU	IN	JA	KO	RF	US	TOTAL
(1) Number of applications	363	2096	162	25	12	81	256	**2995**
(2) Number of nominated applications*	237	1857	37	25	12	52	193	**2413**
(3) Ratio of nominations by DA	***65.3%***	***88.6%***	***22.8%***	***100.0%***	***100%***	***64.2%***	***75.4%***	***80.6%***
(4) Breakdown of nominations	***9.8%***	***77.0%***	***2.3%***	***1.0%***	***0.5%***	***2.2%***	***8.0%***	-
(5) Shortlisted applications	56	235	17	8	8	14	35	**373**
(6) Number of staff who took up duty	***9***	***52***	***6***	***2***	***1***	***1***	***3***	***74***
(7) Breakdown of 2015 appointments	***12.2%***	70.3%	***8.1%***	2.7%	1.4%	1.4%	4.1%	-
(8) Pre-selection rate = (5) / (2)	23.6%	12.7%	***45.9%***	32.0%	***66.7%***	26.9%	18.1%	**15.5%**
(9) Selection rate = (6) / (2)	***3.8%***	***2.8%***	***16.2%***	***8.0%***	***8.3%***	***1.9%***	***1.6%***	**3.1%**

** The approach to nomination differs from one Member to another*

The staffing plan associated with the ULTS was developed using the bottom up estimation process based on activities and work packages. Technical and management reviews were held to ensure that the estimate was appropriate. That exercise resulted in the need for staff as shown in Figure A4.3 below:

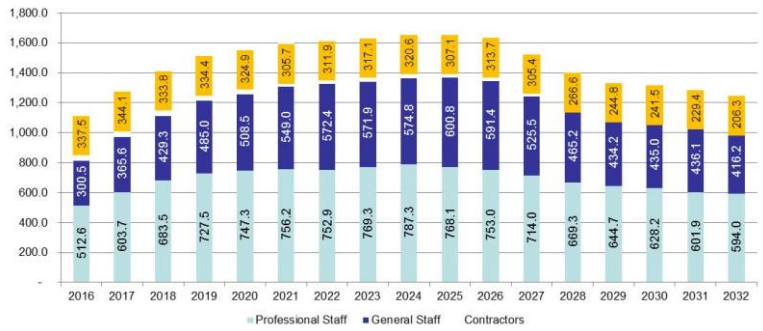


Figure A4.3

In keeping with the ITER Agreement, all employment contracts are made for a time period not to exceed five (5) years, but they can be renewed. Staff have to be notified of the decision concerning renewal or non-renewal of their employment contract at least six (6) months before the end of the contract. This renewal process has meant that Human Resources and the concerned IO-CT technical departments have many contracts to renew each year (153 in 2017 and 187 in 2018). Since the 5th of March, 2015, the DG has terminated six (6) staff for professional inadequacy while none were terminated in previous years.
In addition, the IO-CT must balance the staff to fill positions to bring them in line with the distribution of member contributions. Article 7.11 of the ITER Agreement states "The staff shall be appointed on the basis of their qualifications, taking into account an adequate distribution of posts among the Members in relation to their contributions." The DG's March 2015 Action Plan that was submitted to the IC states " In matter of recruitment, excellence should be the rule; the "adequate distribution of posts among the

members in relation to their contribution" (art. 7.11 of the ITER Agreement) should remain a subsidiary criterion for an individual recruitment compared to his qualifications"

In 2015 there were 88 job openings, with 2,400 applications nominated through the Domestic Agencies (DAs). 370 interviews were organized and 74 positions were filled, including three new department heads, the DG, 2 DDGs and Head of Cabinet positions. The Head of HR stated in the opening session that the HR Department is understaffed and that they have had to prioritize their activities and reassign staff internally in order to keep up with recruitment plans and staff management.

The IO-CT defines five job families which include groups of roles with homogeneous levels. Each family is defined according to its purpose within the ITER Project. Those job families are:

- Line management
- Scientific Coordinator
- Project Engineering
- Organizational Support
- Assistant

Twenty-nine roles within the ITER Project are divided among those families as follows:

		LINE MANAGEMENT	SCIENTIFIC COORDINATION	PROJECT ENGINEERING	ORGANIZATIONAL SUPPORT	ASSISTANTS
DDG D2 D1		Director of Department Director of Office				
D1	P6	Head of Division*				
	P5	Section Leader	Scientific Expert	Expert Engineer (ex system engineer 3)	Expert Officer (ex Org Support Domain Officer 2)	
	P4		Coordinating Scientist (ex- scientist coordinator)	Coordinating Engineer (ex system engineer 2)	Coordinating Officer (ex Org Support Domain Officer 1)	
G7	P3		Scientist - 2	Engineer - 2 (ex system engineer 1)	Functional Officer - 2 (ex Org Support Officer 2)	
G6	P2		Scientist - 1	Engineer - 1	Functional Officer - 1 (ex Org Support Officer 1)	
G5	P1			Coordinating Technician Engineer - Early Career (ex experienced technician 2)	Functional Assistant - 3 (ex experienced functional support 3)	
G4			Technician - 3 (ex experienced technician)	Technician - 3 (ex experienced technician 1)	Functional Assistant - 2 (ex experienced functional support 2)	
G3			Technician - 2 (ex technician)	Technician - 2	Functional Assistant - 1 (ex experienced functional support 1)	Assistant
G2				Technician - 1	Clerical Support (ex functional support)	Secretary
G1						

* Division Heads are D staff

Notes:
1- Specific positions are not included in this mapping
2- Roles in parentheses correspond to the names of the previous global mappings

The recruitment process has been streamlined to include the publishing of one unique standard job description for multiple similar openings, the use of rostered applications from previous competitions, the use of a second round of interviews (in case the right candidates were not found during the initial interviews), a limit of two to four members on each selection board (including one HR member), etc.

When new staff are brought on board, the first eight months is a probationary period during which staff are monitored through training, regular feedback meetings, and formal reporting by line managers at periodic intervals.

Within the framework of the annual performance appraisal, a Performance Improvement Plan is implemented when the level of performance has been assessed as not meeting the job requirements.

Beyond IO-CT staff, additional non-IO staff categories include:

- **Visiting Researcher:** In accordance with Article 7.12 of the ITER Agreement the Members may send VRs to the IO-CT. During the stay at the IO-CT, the VR remains an employee of his/her Employer. ITER currently has 20 Visiting Researchers.
- **External Expert:** External experts are used to cover specific tasks or peak workload by signing contracts on a personal basis. ITER currently has ~51 External Expert Contracts
- **Intern:** An internship program has been established to receive undergraduate and postgraduate students with different academic backgrounds. ITER currently has ~29 Interns.
- **Interim Staff:** Interim staff are hired through an interim company to provide assistance to IO-CT staff for a specific fixed-term limited mission. ITER currently has ~47 Interim Staff.
- **ITER Emeritus Fellows**: Honorary status for individuals (former staff or qualified experts) who continue supporting the IO-CT activities. These individuals are appointed by DG. ITER currently has ~13 ITER Emeritus Fellows.
- **ITER Project Associate (IPA):** IPAs are a new position created in 2016 and are selected through a contract of association to support the IO-CT, for a fixed period of time, and to provide professional expertise, skills and knowledge in a particular field. Only candidates whose Home Institution is part of an ITER Member are eligible to be an IPA.

There was a priority given in 2016 to recruitment, so the current training program is limited to mandatory, corporate, and already committed training courses.

The Staff Committee is a nine-member team that is elected annually among the ITER staff. The committee meets with IO-CT administration representatives every month, proposes agendas and keeps minutes. The committee also meets regularly with the DG. From 2016, staff committee representatives have been increased to 12.

The high-level Organization Chart for the ITER Organization is shown as Figure A 4.4.

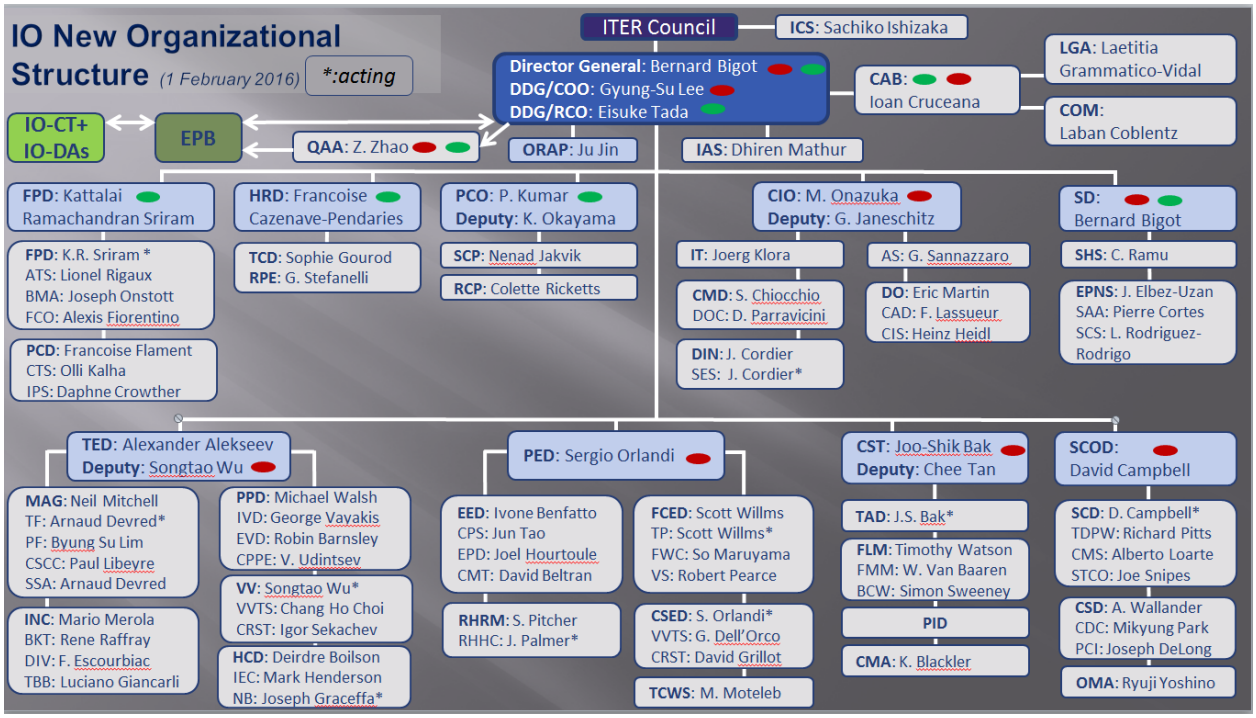


Figure A4.4

Questions to IO Staff and their answers

Twenty-eight ITER staff members were interviewed as part of the work of the Human Resources Sub-Team. The questions asked to those individuals were:

a) Tell us about yourself
b) Are you satisfied with your work at ITER?
c) If you want or need to switch your job within ITER, is there training to allow for that?
d) A new DG recently took over. Do you think the organization is transforming in the right way?
e) Do you contribute to the decision making process at ITER?
f) How is your current workload/work burden?
g) Do you feel that the ITER organization is appropriately staffed?
h) Does your current experience with ITER match your initial expectations?
i) Is the HR organization helpful in recruitment and retention?
    i. Any areas for improvement?
    ii. Any complaints?
    iii. Anything else you would like to tell us about?

The responses are summarized below.

Interview Summary

Interviewee #	Satisfied with your work at ITER?	Your Workload too high?	ITER approp. Staffed?	Positive about HR Organ?	Supportive of new Mgmt?	If you want or need to switch jobs, is their training?	Do you contribute to decision making at ITER?
1	N	Y	Y	N	Y	N	N
2	N	N	Y	-	-	N	Y
3	Y	Y	Y	Y	Y	Partial	Y
4	Y	N	Y	Y	Y	Partial	Y
5	Y	Y	Y	-	Y	N	-
6	N	N	N	N	Y	N	N
7	Y	Y	N	N	Y	-	Y
8	N	Y	N	N	Y	Y	Y
9	Y	Y	N	-	Y	N	Y
10	Y	Y	N	N	Y	-	Y
11	Y	Y	Y	Y	Y	N	Y
12	Y	N	Y	-	Y	N	N
13	Y	Y	N	Y	Y	N	Y
14	Y	N	Y	-	Y	N	Y
15	Y	Y	N	Y	Y	N	Y
16	Y	Y	N	Y	Y	-	Y
17	Y	Y	-	Y	Y	-	-
18	Y	Y	-	Y	Y	-	Y
19	Y	Y	-	Y	Y	-	Y
20	Y	Y	-	Y	Y	-	Y
21	Y	-	N	N	Y	-	Y
22	Y	-	N	N	Y	-	Y
23	Y	-	N	Y	Y	-	Y
24	Y	Y	N	Y	Y	-	Y
25	Y	Y	N	N	Y	N	Y
26	-	-	N	N	Y	N	Y
27	Y	-	N	N	Y	N	Y
28	Y	-	-	N	Y	N	Y
Positive Responses	85%	76%	35%	52%	100%	7%	88%
Negative Responses	15%	24%	65%	48%	0%	93%	12%

Document 1: Terms of Reference for ICRG

Terms of Reference for

the ITER Council Working Group on Independent Review of the Updated Long-Term Schedule and Human Resources

The ITER Council at its Seventeenth Meeting (IC-17) held on 18-19 November, 2015 established the ITER Council Working Group on Independent Review (hereafter the IC Review Group) of the Updated Long-Term Schedule (ULTS) together with the associated existing staff and future Staffing Plan, and other required resources as well as the ITER Organization (IO) Human Resources organization and process/procedures, comprised of independent experts (nominated by the Members), working under the leadership of a Chair designated by the ITER Council.

Objectives

At its Seventeenth meeting, the ITER Council has recognized that in order to take future decision on the Updated Long-Term Schedule (ULTS) proposed by the ITER Organization, there is a need to perform an independent review of the:

- Proposed sequence and duration of activities required to complete the design and fabrication of the various components; the design and construction of the buildings; the installation and assembly of the systems/equipment/components necessary for FP; commissioning necessary for FP to be achieved; and subsequently operate the facility and complete the installation/assembly and commissioning of the remaining systems and components for Deuterium-Tritium (D-T) operations;
- IO present and proposed resources necessary to achieve the FP milestone, i.e. to carry out the activities in their specified sequence and duration; and specifically the proposed staffing plan, (taking into account the availability of current framework agreements and proposal for hiring a Construction Management Agent);
- IO's structure (the efficacy and justification of the Organization's present staff vis-à-vis the Organizational needs of today and in near term), Human Resources (HR) organization (HR Department and other related departments) and process/procedures necessary to support the envisaged activities; more specifically all HR functions e.g., recruiting, orientation and placement, training, performance evaluation, remunerations, retention, etc.;
- Technical and financial assumptions underlying the proposed ULTS (e.g. known financial constraints of the Members).

To this end, the ITER Council has decided to establish the IC Review Group to:

- Evaluate the post IC-17 update of the ULTS, together with its underlying assumptions, its associated IO-CT resources embodied in the IO-CT Staffing Plan;
- Assess the reliability and credibility of the proposed schedule, identify assumptions and accompanying resources and their compatibility with the spirit of the ITER Agreement. Known financial constraints of the Members (e.g. the capped budget for the EU

contribution until 2020) should be taken into account [Note 1] and the IC Review Group is expected to ascertain this assumption and provide their considered opinion;

- Assess the capability and reliability of the IO-CT's HR organization and processes in relation to the implementation of the Staffing Plan provided by the ITER Organization;
- Make recommendations that would improve the Schedule, IO-CT Staffing Plan, and HR effectiveness.

The IC Review Group should report to the Council by the end of April 2016 at the latest on the IO-CT Staffing Plan implementation credibility, on the Schedule/assumptions/Resources reliability and credibility, on the risks and opportunities associated with the execution of the ULTS and the IO-CT Staffing Plan, and on recommendations for changes, if any, that would enhance the reliability of the Schedule and facilitate its implementation and the implementation of the IO-CT Staffing Plan.

Scope of Work

The IC Review Group shall develop its plan for the evaluation in accordance with these terms of reference. The IC Review Group shall present its plan to the ITER Council for approval within 15 days after its membership is agreed upon by the Council.

Pursuant to the approved plan and these terms of reference the review shall gain a full understanding of the schedule and its resource loading, and of the IO-CT's ability to execute the schedule, and evaluate if the proposed Staffing Plan is optimum to meet the objectives of the Project, focusing on schedule/resources, staffing associated to the schedule, and IO-CT current structure and staff as detailed below, and shall use a combination of the judgment of the experts from their own experience and/or sampling of specific activities, whenever the IC Review Group determines that a more in depth assessment may be appropriate.

<u>Schedule/Resources</u>

- Assessment of ULTS reliability and credibility;
- Assessment of technical (for instance, assess the assumptions made in the schedule which could present a particular risk to the project and the obstacles that would be possible impediments to performance, e.g. regulatory requirements)and financial assumptions made in the schedule and their impact in terms of reliability of the proposal;

[Note 1] *Concerns have been expressed that if considerations are to be given for individual Members, then the project will take a long time to complete, and therefore the Schedule review should be on the basis of 'technically achievable schedule'. Members are then required to ensure availability of resources in a timely manner. It would not be realistic to proceed in that manner, because the Council requested the schedule to be "realistic" and: (a) we already know that there are financial constraints which cannot be ignored and (b) one of the main purposes of the review is to determine whether it is possible to meet the technically achievable FP date with those known financial constraints. The two (technically achievable and financially constrained) are not necessary incompatible with each other.*

- Verification that the RFE dates for Buildings, delivery dates for tools, components and systems are supported by the responsible Domestic Agencies [Note 2] ; and sequence/duration of major activities that the schedule assumes are realistic, have properly considered time contingencies and possible impediments to performance, and are based, as applicable, on
  - prior industrial experience with similar work;
  - data acquired via use of mock-up of the activity;
  - scaling based on related activities in other tokamak or similar facilities;
  - time and motion studies performed utilizing industrial data for each motion;
  - direct input from contractor(s) already selected to perform the work or hired to provide an estimate of the work;
- Verification that the sequence and duration of the installation/assembly of the systems/components are appropriately assigned to the construction and assembly planning, considering receipt inspection, storage of components, etc.;
- Review that the resources assigned to the performance of each of the major activities are justified for the duration assumed for that activity;
- Assess the reasonableness of the overall costs for executing to the schedule, and compliance with known and fixed constraints of the Members;
- Suggest exemplary alternatives in any of the above areas where the ICRG considers appropriate.

Human Resources

IO current structure and Staffing associated to the schedule

- Assessment and HR Audit of the current organizational structure and set-up of the IO-CT, of its Departments and Divisions, and its adequacy to ensure maximum effectiveness and efficiency for the construction and assembly phase, i.e. determine efficacy and justification of the present staff vis-a-vis the organizational needs of today and in near term;
- Verification of the effectiveness of the current staff distribution and of the appropriateness of the present IO-CT staff for their given assignment.

IO HR Organization

- Assess the resources and qualifications of an HR Department staff responsible for executing the Staffing Plan;
- Review the capability of the IO-CT HR organization to recruit and retain the resources considered by the IO-CT as necessary to carry out the activities of the proposed schedule in their specified time duration;

[Note 2] *It is not the responsibility of the IC Review Group to verify the DAs' commitment to delivery dates, but the Group must verify that the ULTS properly integrates the input of the DAs (via their Detailed Work Schedules (DWS)) and the IO-CT has not altered the DAs delivery dates without the DAs' approval.*

- Assess the adequacy of the structure of the HR, Department and of HR policies and procedures to implement the Staffing Plan within the required time, with focus on identification of qualified candidates, interview selection and recruitment processes (including preparation and review of job descriptions and appropriate qualification/experience required, orientation and assignments, training and development); staff retention processes (including remuneration, motivation and morale, welfare and social security, safety and health aspects), and resulting staff distribution, and assessment of whether such processes are in line with the spirit and intent of the ITER Agreement;
- Review the state of participative management and communication among staff, within and outside the hierarchy. (The IC Review Group may also make observations on multicultural aspects of the project);
- Comment on general industrial relations, trade unionism, disputes and their resolution as practiced in the IO-CT;
- Identification of collaborative ways of working that can optimize the use of existing staff from both the IO-CT and the DAs, and suggestions about how they can be practically implemented (e.g. how IO-CT can progressively absorb DAs' staff on site).

Process of Work

The IC Review Group shall rely initially and principally on the documents provided by the ITER Organization and available via IDM. These documents should include the Integrated Schedule established by the IO-CT and DAs submitted to IC-17, the updated Target Schedule, and ULTS to be produced by the IO-CT in consultation with the DAs following the decisions and comments made at IC-17 – notably the need to focus the scope to FP - , the Basis of Estimates documents, the Staffing Plan, and existing HR policies and procedures, and other relevant information.

The group may also decide to conduct a sample survey among the IO-CT staff regarding the matters within the scope related to the staff. The sample size chosen in that case should be reasonably small.

Any requests for additional information from the ITER Organization should be addressed to the Director-General, who shall then make his appropriate staff available for this purpose. Specific questions from the IC Review Group should be communicated (e-mail is an acceptable method) to these staff members in sufficient advance of requested delivery.

Time Frame of the Review

The IC Review Group will complete its review in time and submit its report to the IC by the end of April 2016 at the latest. The report shall contain the Review Group's assessment and possible recommendations, if any, to enhance the reliability of the schedule and to improve the IO-CT's organizational structure and HR processes.

In case they are put forward by the IC Review Group, recommendation should be straightforward and easily implementable by the IO-CT and DAs. As such, they should be reflected in a revised proposal of the ULTS and associated resources, which should be submitted

in time for the Eighteenth Meeting of the ITER Council (IC-18) for the Council to take effective decision on it.

The report of the IC Review Group shall not be subject to IO-CT management or staff review or approval prior to its submission to the Council.

While the Council hopes for a well-documented consensus view, the Council understands that consensus is not always achievable and asks the IC Review Group to work in good faith to present a balanced and accurate review.

Leader and Members

The IC Review Group comprises an "independent" group of up to 15 experts nominated by the ITER Members. The IC Review Group experts will represent a cross-section of skills in the areas of, among others: project and resource management and planning, technical system integration, construction, and human resources. The experts shall work under the chairmanship of the IC Review Group Chair, designated by the IC.

The selection of the IC Review Group membership will be done by the IC Chair in consultation with the Members' Heads of Delegation or their representatives. The IC Chair's proposal for the membership of the IC Review Group and its Chair shall be submitted to the Council for approval via written procedure no later than the third week of December 2015.

Representation of each ITER Member in the IC Review Group is not necessary (but is strongly encouraged). The membership of the IC Review Group will be approved by the ITER Council through written procedure.

The Review Group should include experts who have prior ITER project knowledge or familiarity, but not have been or be directly involved in the present ITER project, or participated in the development of the Updated Long- Term Schedule and the Staffing Plan. They shall be informed of the IO-CT Central Team and its arrangements with the Members' Domestic Agencies. Their expertise should be such as enabling reliable judgment of the durations and resources required of the major schedule activities without conducting an assessment of each detailed sub-activity. Some of the IC Review Group members should have experience in large projects' HR organizations, and desirably in those of international projects.

All IC Review Group members shall be barred from pursuing or obtaining an employment position with the IO-CT for a three-year period following formal submission of the IC Review Group report to the ITER Council.

The IC Review Group Chair shall decide on the assignment of the members of the IC Review Group to review parts of the scope of the review. In doing so, the Chair shall ensure that the personnel assigned will not have a conflict of interest with the segment of the review to which the person is assigned.

Resources

The ITER Organization will provide administrative services to the IC Review Group, including secretarial support, meeting facility and communication among the members. Travelling cost of the Chair and the members shall be borne by the respective Members.

Document 2: Agenda of the First Meeting of the ICRG (15-19 February 2016)

DAY 1 (Monday, 15 February)

Time	Item	Location	Participants (*Presenter)
08:00 – 08:45	Transportation	Aix→ HQ	
08:45 – 09:15	Administrative arrangements	HQ Reception	ICS
9:15 – 10:45	Closed session for ICRG	DG Meeting Room	**ICRG members only**
10:45 – 11:00	Break		
11:00 – 11:45	Welcome and overall status and progress of the ITER project • Introduction of IO management • Overall status and progress in accordance with DG Action Plan • Focusing on the 1st Plasma	IC Chamber	**DG***, DDGs, DAs, CTMB members
11:45 – 12:45	Outline of updated Long-Term Schedule development and resource estimate • Updated resource-loaded schedule • Improved monitoring and control of project performance • Overview of input material for the review	IC Chamber	DG, **RCO***, COO, DAs, CTMB members, PCO
13:00 – 14:00	Lunch (with DG and IO Management)	Canteen	
14:00 – 15:00	Project achievement and major technical and engineering challenges • Progress of all major PBS • Technical integration and control • Main technical challenges • Assembly and installation approach	IC Chamber	DG, RCO, **COO***, DAs, CTMB members, CIO
15:00 – 16:00	Site Visit & Virtual Tour for IC Review Group Members	Construction Site & Virtual Reality Room	DG, DDGs, DAs
16:00 – 16:15	Break		
16:15 – 17:00	Schedule presentation • Resource Loaded Schedule • Basis of schedule • Performance monitoring and reporting including KPI and EVM • Assumptions and constraints	IC Chamber	DG, DDGs, DAs, **Dir/PCO***, Dir/FPD, Katsumi Okayama, PCO
17:00 – 18:00	Closed session for ICRG	DG MTG Room	**ICRG only**
18:00 – 18:30	Meeting with the IO	DG MTG Room	DG, DDGs, Dir/PCO, Dir/FPD
18:30	Departure for Aix		ICS

DAY 2 (Tuesday, 16 February)

Time	Item	Location	Participants (*presenter)
7:30 – 8:15	Transportation	Aix→ HQ	
8:30 – 9:15	Resource and cost estimate presentation • Summary of resource and cost estimate up to First Plasma • Cost book and basis of estimates • Assumptions and constraints; ongoing iterations	IC Chamber	DG, DDGs, DAs, Dir/FPD, Joe Onstott, PCO
9:15 – 10:00	HR presentation • Current staffing profile in IO • HR processes and procedures • HR policy and strategy	IC Chamber	DG, DDGs, DAs, **Dir/HR***, Dir /FPD, CAB, PCO
10:00 – 10:15	Break		
10:15 – 11:30	Closed session for ICRG	DG MTG room	**ICRG only**
11:30 – 12:00	Meeting with IO (questions)	DG MTG room	DG, DDGs, DAs, CAB
12:00 – 13:00	Lunch break	Canteen	
13:00 – 15:00	Sub-group break-out sessions	5048 & DG MTG room	Selected depending on the subject
15:00 – 15:15	Break		
15:15 – 16:45	Sub-group break-out sessions		Selected depending on the subject
16:45 – 17:30	Closed session for ICRG	DG MTG room	**ICRG only**
17:30	Departure for Aix	HQ → Aix	

DAY 3 (Wednesday, 17 February)

Time	Item	Location	Participants
07:30 – 08:15	Transportation	Aix→ HQ	
08:30 – 09:00	Closed ICRG meeting	DG MTG room	**ICRG only**
09:00 – 10:30	Sub-group break-out sessions	5103 & DG MTG room	Selected depending on the subject
10:30 – 10:45	Break		
10:45 – 12:15	Sub-group break-out sessions	5103 & DG MTG room	Selected depending on the subject
12:15 – 13:30	Lunch break	Canteen	
13:30 – 16:45	Sub-group break-out sessions	5103 & DG MTG room	Selected depending on the subject
16:45 – 18:30	Closed session for ICRG	DG MTG room	**ICRG only**
18:30	Departure for Aix	HQ → Aix	
19:30 – 21:30	Dinner	Restaurant in Aix	DG, DDGs, ICS, CAB, DAs etc.

DAY 4 (Thursday, 18 February)

Time	Item	Location	Participants
07:30 – 08:15	Transportation	Aix→ HQ	
08:30 – 09:00	Plenary meeting ICRG with the IO	DG MTG room	DG, DDGs
09:00-09:50	VC with JADA Head*	DG MTG room	*Yoshinori Kusama
10:00-10:50	VC with CN DA Head* & HoD Representative*	DG MTG room	*Delong Luo
10:50-11:00	Break		
11:00-11:50	VC with RF DA Head*	DG MTG room	* Anatoli Krasilnikov
11:50-12:45	Lunch break	Canteen	
12:45-13:30	In Person meeting with IN DA Head*	DG MTG Room	*Shishir Deshpande
13:30-16:00	Sub-group breakout sessions		
16:10 -17:00	VC with US HoD, Mr Adam Cohen Deputy Undersecretary for Science and Energy, DOE	DG MTG room	
17:00-17:45	Breakout Sessions		
17:45- 18:30	Closed session for ICRG	DG MTG Room	ICRG Only
18:30	Departure for Aix	HQ → Aix	

DAY 5 (Friday, 19 February)

Time	Item	Location	IO Required staff (*presenter)
07:30 – 08:15	Transportation	Aix→ HQ	
08:30-09:10	VC with Representative of **KO HoD*** * Ms Hyunsook Cho,Director for Fusion R&D Support Team, MSIP (since the DG is new)	DG MTG room	
09:10-09:40	Closed session for ICRG	DG MTG room	
09:40-10:20	VC with **JA HoD**, Mr Todani, Vice-Minister of MEXT	DG MTG room	
10:20-10:30	Break		
10:30-11:00	Teleconference with **IN HoD**, Mr Grover	DG MTG Room	
11:00-11:45	VC with **EU HoD**, Mr Ristori, DG Energy, EC	DG MTG Room	
11:45 – 13:00	Presentation from the Schedule Subgroup	DG MTG room	**ICRG only**
13:15– 13:40	Lunch	Canteen	
13:45 – 14:30	Presentation from HR Subgroup	DG MTG room	**ICRG only**
14:30-15:30	Closed session for ICRG	DG MTG room	**ICRG only**
15:30-15:45	Break		
15:45– 16:30	Closed meeting ICRG	DG MTG room	**ICRG only**
16:30-17:15	Meeting with the IO Staff	Lecture Room	IO staff (Section Leaders and above)
17:15– 18:00	Plenary meeting ICRG with the IO management	IC Chamber	DG, DDGs, DA Heads et al.
18:00	Departure for Aix	HQ → Aix	

Note

CTMB: Central Team Management Board of the ITER Organization

RCO: Relations Coordinating Officer/DDG

COO: Chief Operating Officer/DDG

PCO: Project Control Office

FPD: Finance & Procurement Department

HR: Human Resources Department

CAB: Cabinet of the Director-General

Document 3: Agenda of the Third Meeting (Second Visit) of the ICRG

(11-15 April 2016)

IC Chamber (VC capable)

DG Meeting Room (5034): (VC capable, 22 people)

Meeting Room 5103 (VC capable, 10 people)

DAY 1 (Monday, 11 April)

Time	Item	Location	Participants (*presenter)
08:00 – 08:45	Transportation	Aix→ HQ	
08:45 – 09:00	Administrative arrangements	HQ Reception	
09:00 – 10:15	ICRG Closed Session • Progress Report • Meeting strategy & planning	DG Meeting Room	**ICRG members only**
10:15 – 10:30	Break		
10:30 -- 10:45	Opening • Opening Remarks by the ICRG Chair • Additional Comments from the IO and the ICRG Members	DG Meeting Room	ICRG, DG, DDGs et al. DA Heads (optional)
10:45-12:30	Update on the Iteration Modeling Exercise and Revision of the ULST & IO Answers to other ICRG Questions • Presentations by the IO • Q & A and Discussion		ICRG, DG*, DDGs* et al. DA Heads (optional)
12:30-13:30	Lunch Break	Canteen	
13:30-14:30	Plenary Discussion (ICRG Closed Session)	DG Meeting Room	**ICRG members only**
14:30-17:30 (including a break at around 16:00)	Subgroup Sessions and/or Report Drafting	DG Meeting Room/5103	**ICRG members only**
17:30	Departure for Aix		

DAY 2 (Tuesday, 12 April)

Time	Item	Location	Participants
08:00-08:45	Transportation	Aix→ HQ	
08:45-09:30	ICRG Closed Session (Plenary Discussion)	DG Meeting Room	**ICRG members only**
09:30-12:30 (including a break at around 10:30)	Subgroup Sessions/Report Drafting	DG Meeting Room/5103	**ICRG members only**
12:30 – 13:30	Lunch Break	Canteen	
13:30 – 17:30 (including a break at around 15:30)	Subgroup Sessions/Report Drafting	DG Meeting Room/5103	**ICRG members only**
17:30	Departure for Aix	HQ → Aix	

DAY 3 (Wednesday, 13 April)

Time	Item	Location	Participants
08:00-08:45	Transportation	Aix→ HQ	
08:45-09:30	ICRG Closed Session (Plenary Discussion)	DG Meeting Room	**ICRG members only**
09:30-12:30 (including a break at around 10:30)	Subgroup Sessions/Report Drafting	DG Meeting Room/5103	**ICRG members only**
12:30 – 13:30	Lunch Break	Canteen	
13:30 – 17:30 (including a break at around 15:30)	All ICRG Report Drafting	DG Meeting Room	**ICRG members only**
17:30	Departure for Aix	HQ → Aix	

DAY 4 (Thursday, 14 April)

Time	Item	Location	Participants
08:00-08:45	Transportation	Aix→ HQ	
08:45-12:30 (including a break at around 10:30)	All ICRG Report Drafting	DG Meeting Room	**ICRG members only**
12:30 – 13:30	Lunch Break	Canteen	
13:30 – 17:30 (including a break at around 15:30)	Finalization of the Report	DG Meeting Room	**ICRG members only**
17:30	Departure for Aix	HQ → Aix	

DAY 5 (Friday, 15 April)

Time	Item	Location	Participants
08:00-08:45	Transportation	Aix→ HQ	
08:45-12:00 (including a break at around 10:30)	Preparation of Presentation of Report	DG Meeting Room	**ICRG members only**
12:00 – 13:00	Lunch Break	Canteen	
13:00-14:00	Meeting with the IO-CT Senior Managers and DA Heads • Briefing on the Report by the ICRG Chair (and Subgroup Chairs)	IC Chamber	DG, DDGs, CTMB Members, DA Heads, ICRG members
14:30-15:00	Break		
15:00-16:00	Meeting with IO Staff • Briefing on the Report by the ICRG Chair	Lecture Room (Ground Floor)	DG, DDGs, IO managers (Section Leaders & above), ICRG members
16:30	Departure for Aix	HQ → Aix	
19:30-21:30	Dinner hosted by the DG	Aix	