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FUSION FOR ENERGY

2014-2015 Progress Report to the Council of the European Union

1 August 2014 – 30 November 2015

Fusion for Energy

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Executive Summary

During the period covered by this report there have been some important changes at the ITER International Organization (IO) and the European Domestic Agency (DA) for ITER, Fusion for Energy (F4E). In November 2014 F4E's Director resigned and F4E's Governing Board (GB) appointed Pietro Barabaschi as F4E's Acting Director who took up his duties on 1 March 2015. In March 2015 the ITER Council appointed a new Director General (DG) of the IO (Bernard Bigot) and endorsed an Action Plan which had been prepared in response, among other things, to the findings of ITER's 2013 Management Assessment. In parallel F4E's Acting Director drew up an Action Plan which was endorsed by F4E's Governing Board in March 2015. The ITER and F4E Action Plans triggered several important initiatives to improve the performance of the ITER Project by putting into place a new organisation characterised by a profound integration of the DAs and the IO, in particular:

- Creating an **Executive Project Board (EPB)** composed of the IO DG and the Domestic Agencies (DAs) including F4E to facilitate more rapid decision-making and is functioning well (e.g. for the implementation of the Reserve Fund);
- Setting up common **Project Teams (PTs)** of managers and staff from the IO and DAs for specific areas and facilitating greater exchange and mobility of staff. The new PT for the Buildings, Infrastructure and Power Supplies (BIPS) is the first example;
- Establishing a **Reserve Fund** to compensate DAs for cost increases incurred due to changes which are driven by the IO and have cost impacts. The terms of reference for the Fund were approved and decisions allocating the Fund have been taken by the EPB.

As well as launching these new initiatives the IO, together with F4E and the other six DAs worked together to prepare the first version of an Updated ITER Long Term Schedule. This was presented by IO to the 17th meeting of the ITER Council (IC) on 18-19 November together with revised resource estimates from IO. The IC, where the European Commission represents Euratom, asked for an independent review of the Updated Schedule and the resources requested by the IO needed by June 2016.

In addition to the above, F4E made substantial progress in a major exercise for the revision of its own cost Estimate at Completion (EAC). A presentation of the EAC was made to the F4E Governing Board of 1-2 December 2015. While F4E now has reasonable confidence that the resources required to provide F4E's in-kind contributions to achieve First Plasma are compatible with the present Euratom Multiannual Financial Perspectives MFF of 6.6 B€, it is mindful that very substantial additional time and resources, after 2020, will be necessary to complete the construction of the ITER Project.

In spite of the very substantial changes in both the IO and F4E as well as the efforts that had to be directed towards the improvement of the ITER Project, the development of the Updated ITER Schedule and F4E's cost EAC, there has been substantial progress in a number of areas that testify to the strength of the partnership between F4E, the IO and European industries which are described in more detail in this report.

Concerning the ITER Buildings, the design activities for the Tokamak Complex continued to be disturbed during 2014 due to (a) late delivery of input data to F4E from the IO and (b) frequent design changes issued by the IO to F4E. In June 2015 the new IO DG decided to block any changes that impact on the design of the buildings and in the second half of 2015 F4E has been able to finalize the design of the three first levels of the Tokamak Complex, and to approve the design of the fourth level. Another important development was the creation of the BIPS PT, which brings together 64 members of staff from F4E and the IO under one roof and aims at allowing for more efficient cooperation.

Despite the challenges described above, there has been much visible progress on the ITER construction during the reporting period. In 2014 the foundation slab of the Tokamak Complex was completed which used 14,000 m^3 of concrete and contains over 3,500 tons of reinforcement bars. All the walls of the Diagnostic Building, level B2, and almost all the walls of the Tokamak Building are complete. In May 2015 the reinforcement works of the first level of the bioshield started and are close to completion. Finally, the steel structure of the Assembly Building was completed and the roof was lifted into place.

Many of the main components for the superconducting Toroidal Field (TF) magnets have entered into series production and the more than 35 Winding Packs have been produced which is enough for five entire TF coils. Work continues on the fabrication of the seven 500 ton sectors of ITER's Vacuum Vessel (VV) and there has been a major improvement in the collaboration with the supplier. A PT for the VV has also been created and work is underway to create joint optimised processes between F4E and the IO.

Concerning other ITER systems under development by F4E, for radio frequency heating there have been promising experiments with a short-pulse gyrotron where a power of over 1 MW of 170 GHz microwaves, meeting the ITER requirements except for the pulse duration. For the neutral beam heating systems, the construction of a new testing facility in Italy continued apace with the buildings almost completed and major components under manufacture.

Moving to the Broader Approach (BA), excellent progress was made during 2014 and that the overall level of progress measured by a comparison of earned and planned credit remained at 90%. For the Satellite Tokamak Programme (JT-60SA project) the production of the TF coils progressed very well. The assembly in Japan advanced and the VV is close to completion. Likewise good progress was also achieved in the IFMIF/EVEDA project were installation and commissioning of parts of the prototype accelerator is taking place in Japan.

To deliver on F4E's commitments, F4E awarded 61 operational contracts and 7 grants to industries, laboratories and other organisations in 2014 for a total value of just over 400 M€ million bringing the total value of contracts and grants awarded to over 3.25 B€. At the same time, 86 new procurement or grant procedures were launched. In relation to F4E's internal functioning, emphasis continues to be placed on project management and control with the creation (in July 2015) of a new "Project Management Infrastructure and Control" Department.

Moving to resources, in 2014 F4E implemented a budget of just under 900 M€ in commitment appropriations and 502 M€ in payment appropriations, corresponding to 100 % and 89 % of the final budgets. In 2015 F4E has, with the support of the Commission, reduced its commitment budget in line with what can be realistically implemented by some 500 M€ (to be returned to F4E in 2018-2020). At the same time F4E has continued to recruit personnel throughout 2014 and 2015 and by mid-November there were 410 staff in post and the vacancy rate stood at 6.1 %. Finally, during the reporting period F4E has made substantial progress in the implementation of actions in response to internal audits and F4E has implemented >90 % of actions and >90 % of recommendations from the outstanding six internal audits.

1. Introduction

In 2006, by signing the ITER Agreement, seven Parties (Europe, China, Japan, Korea, India, Russia and the United States) agreed to set up the ITER International Organization (IO) in Cadarache, France with the objective of building and operating the ITER device. ITER will be by far the largest fusion experiment in the world and has many high-tech “first-of-a-kind” components (e.g. the largest superconducting magnets ever constructed). ITER is also treated as a nuclear installation under French law which means that strict safety and quality assurance requirements have to be adhered to.

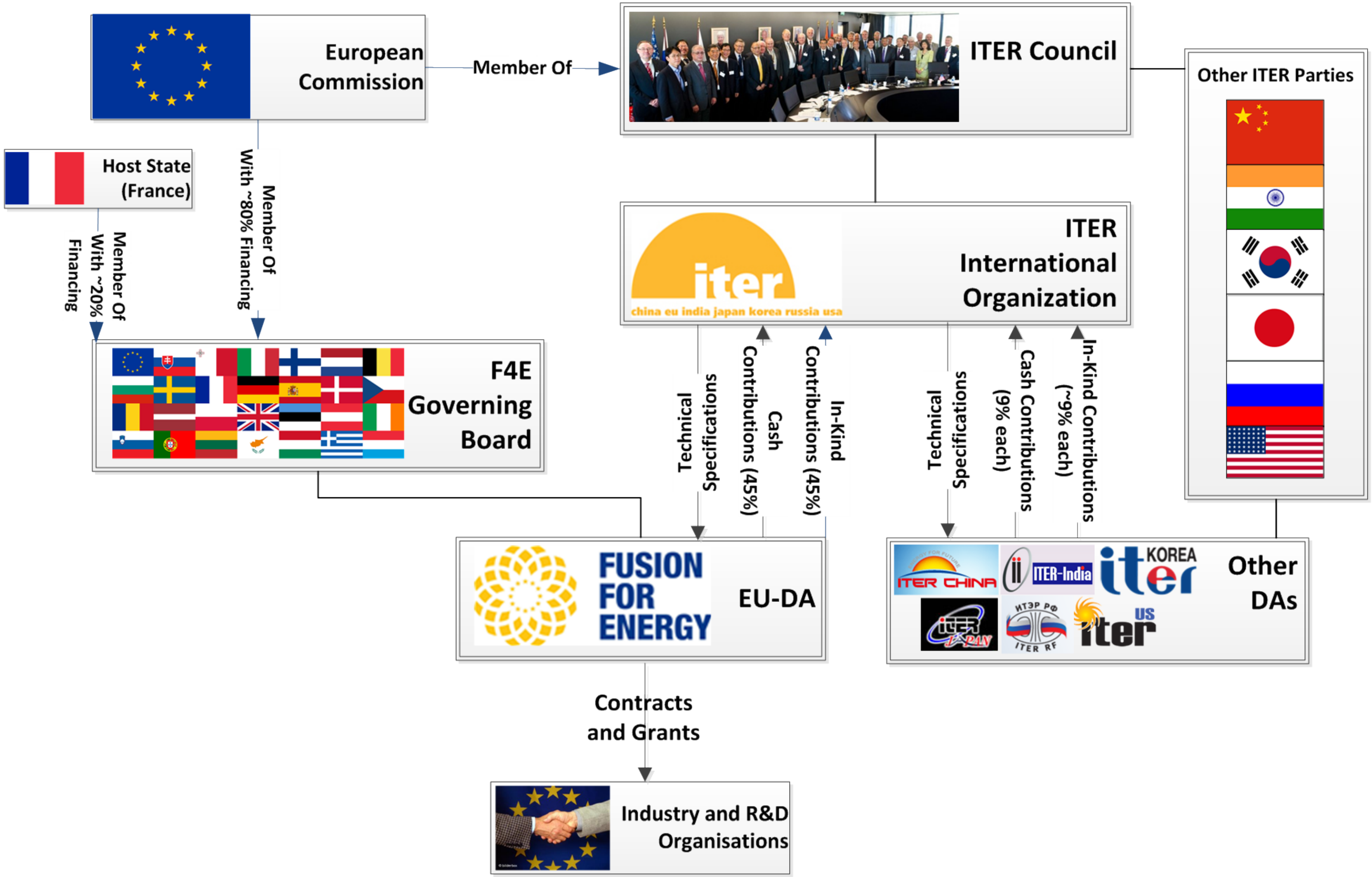
Unlike most comparable construction projects, only 10 % of the resources needed to build for ITER are being provided “in cash” by the seven Parties. Instead, the Parties decided to divide up the components of ITER among them (Europe, as host with 45 % and the other Parties ~9 % each) and have them made by their industries in order to provide them to the IO as “in kind” contributions. Each Party has nominated a “Domestic Agency” (DA) to provide such in-kind contributions to the Project.

In spite of the fact that the IO is neither responsible nor accountable for the budget required for the in kind contributions, it is responsible to define the technical specifications of all components to be procured by each DA. In addition, up until to only recently, there has been no adequate mechanism requiring the IO to compensate the DAs for any design changes that cause extra costs.

Fusion for Energy (F4E) is the European DA. F4E receives and negotiates technical specifications with the IO, then contracts out work to industries and research organisations, mostly in Europe. F4E is responsible and accountable for its budget expenditure to its Governing Board, to the Council of European Union, as well as to the Discharge Authority – the European Parliament.

The governance of ITER and F4E is shown schematically below. The European Commission represents Euratom in the ITER Council where, with the other six ITER Parties, approves IO’s annual budget, 45 % of which is provided via F4E’s budget as “in cash” contributions to the IO.

Cost clearly depends on work scope (i.e. design), and even more so when alterations are required during construction phase. The fact that the latter is largely under the control of IO and its governance, and the former of F4E, clearly shows a misalignment of responsibilities. This is indeed one of the most challenging aspects of the ITER project, as well identified in the European Parliament’s 2013 study on cost effectiveness of the ITER project by Ernst and Young. Indeed the headings of the executive summary of this study state that “*Cost increases have largely emanated from the project-level and are outside of the direct control of F4E*” and “*F4E is a sui generis organisation operating in a complex environment, which constrains the possibilities for cost-efficiency*”. In short, due to the very set up of the Agreement and its instruments, a significant fraction of the costs which F4E has to absorb are not under its direct control.



Schematic showing the Governance Structure of the ITER Project (Note that DA stands for Domestic Agency)

2. Status of the ITER Project

2.1 Introduction

ITER is being constructed at Cadarache in the south of France. Europe as the Host Party and France, as Host State, have special responsibilities for the success of the Project. Europe supports 45 % of the construction cost and 34 % of the cost of operation, deactivation and decommissioning of the facility as well as preparing the site. Around 90 % of the ITER project is built by in-kind contributions. F4E, in its role as the European Domestic Agency (DA) for ITER, provides components to ITER that amount to five-elevenths of the overall value of the project.

Europe has budgeted 6.6 B€ (in 2008 values) for its contribution to ITER until 2020 according to the July 2010 decision of the Council of which approximately 4 B€ is earmarked for the contracts and grants that are required to be placed by F4E with industries, SMEs and research laboratories for ITER construction. In 2014 F4E awarded 61 operational contracts and 7 grants to industries, laboratories and other organisations for a total value of just over 400 M€ bringing the total value of contracts and grants awarded to 3.2 B€. At the same time, 86 new procurement or grant procedures were launched.

2.3 Overall Schedule Performance

In spite of the schedule revisions, the performance of the overall ITER project against the 2010 reference schedule (in terms of milestones achieved) continued to slip and was in the range of ~60% for most of the period 2011-2014. As a knock-on effect this has created difficulties for F4E to implement its budget as it has not been possible to sign contracts according to the foreseen schedule which have damaged F4E's reputation and has been disheartening for the staff involved. The 2013 independent ITER Management Assessment recognised several causes of the schedule delays:

- None of the schedules approved by the ITER Council were based upon a realistic assessment of the capability of the ITER Organization (IO) and DAs to deliver and have instead been driven by a political desire to end ITER construction on a given date;
- Governance structures that take decisions in the IO often require consensus to be reached among the seven Parties – such arrangements are not suitable for a first-of-a-kind project like ITER where rapid decisions are needed;
- The IO was not considered to be an efficient or effective organisation for the management of projects and that systems engineering and configuration management are weak (which has led to slow finalisation of designs and requirements that F4E needs);
- Divergence of the responsibility between the IO and the DAs has slowed down decision-making and that relatively small problems have taken an inordinate amount of time and energy to solve.

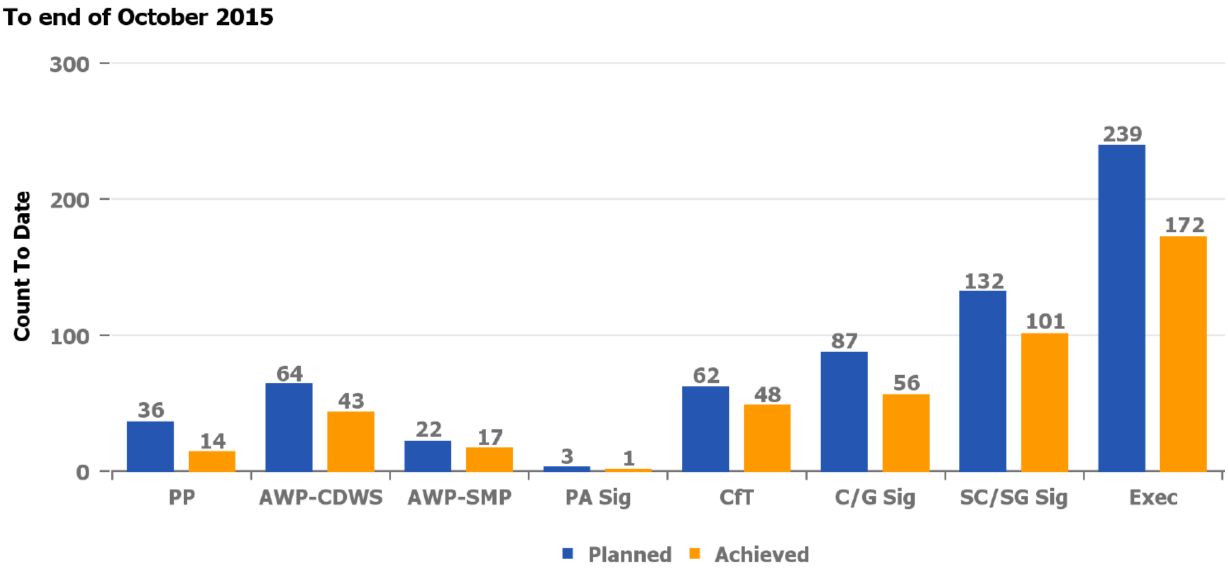
As a consequence, F4E has suffered delays in some areas under its responsibility (of up to around 45 months), in particular for the buildings for which a detailed analysis of the causes and the lessons learned was present to F4E's Governing Board in December 2014. It has been shown that delays in the delivery of input data and continuous change requests by the IO slowed down the progress of work by F4E and led to countless deviations. It should be noted that the ITER buildings are the subject of two independent assessments (separate to the Annual Assessment of F4E provided to the Council and European Parliament) which will be completed by the end of the 2015.

During the reporting period the IO, together with F4E and the other six DAs worked together to prepare the first version of an **Updated ITER Long Term Schedule** which was presented to the 17th meeting of the ITER Council (IC) on 18-19 November. The IO also presented the IC with revised estimates (financial and human) which it requires. The Updated Schedule, which is intended to be realistic, foresees a substantial delay for ITER's "First Plasma". The IC, where the European Commission represents Euratom, approved the Updated ITER Schedule as far as the milestones for 2016 and 2017 is concerned and asked for an independent review of the overall Updated Schedule and the resources requested by the IO needed. This review should be completed by June 2016

2.4 Quantitative Performance Assessment (Milestones)

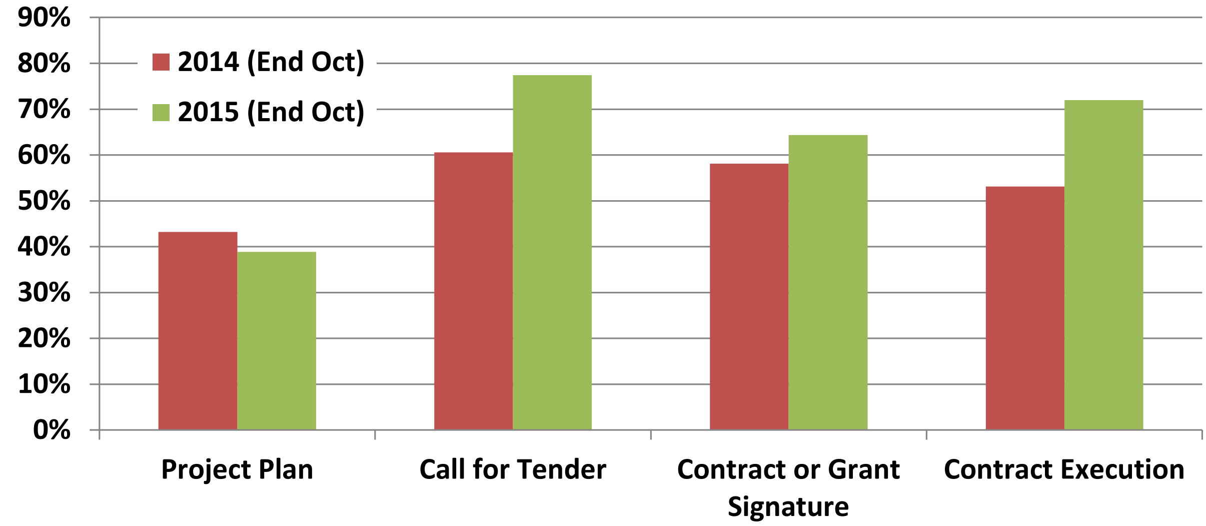
To obtain an indication of progress, one can compare F4E's achievements against the milestones set out in the annual planning documents approved by F4E's Governing Board (e.g. Project Plan, 2015 Work Programme, etc.) and F4E's Detailed Working Schedule. The following graph shows the completion in the following graph (as of end-October 2015):

- F4E Project Plan (PP) Milestones
- Annual Work Plan Milestones (AWP – CDWS and AWP – SMP)
- Signature of Procurement Arrangements (PA Sig)
- Calls for Tender (CfT) Published
- Contract and Grant Signatures (C/G Sig)
- Specific Contract and Specific Signature (SC/SG Sig)
- Contract Execution Milestones (Exec)



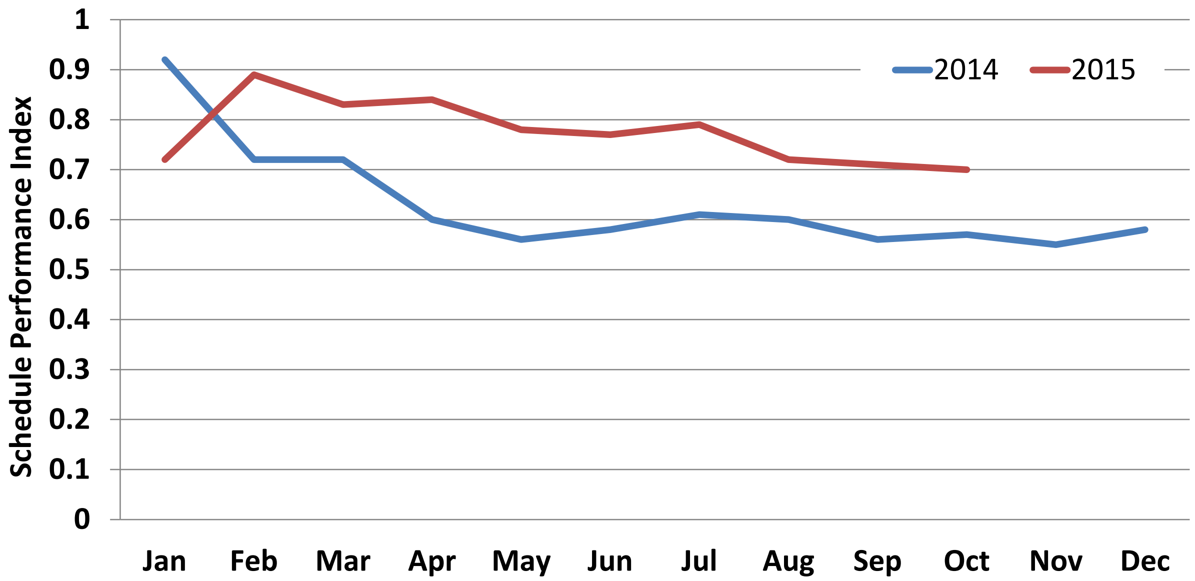
Achievement of Milestones until End-October 2015

One can compare the % completion of milestones between end-October 2014 and end-October-2015 where it is evident that there is a significant improvement in the achievement of milestones related to calls for tender and contract execution. The differences in the performance between 2014 and 2015 for the Project Plan and Contract/Grant signature milestones are not considered to be significant.



Comparison of % Achievement of Milestones on end-October 2014 compared with end-October 2015

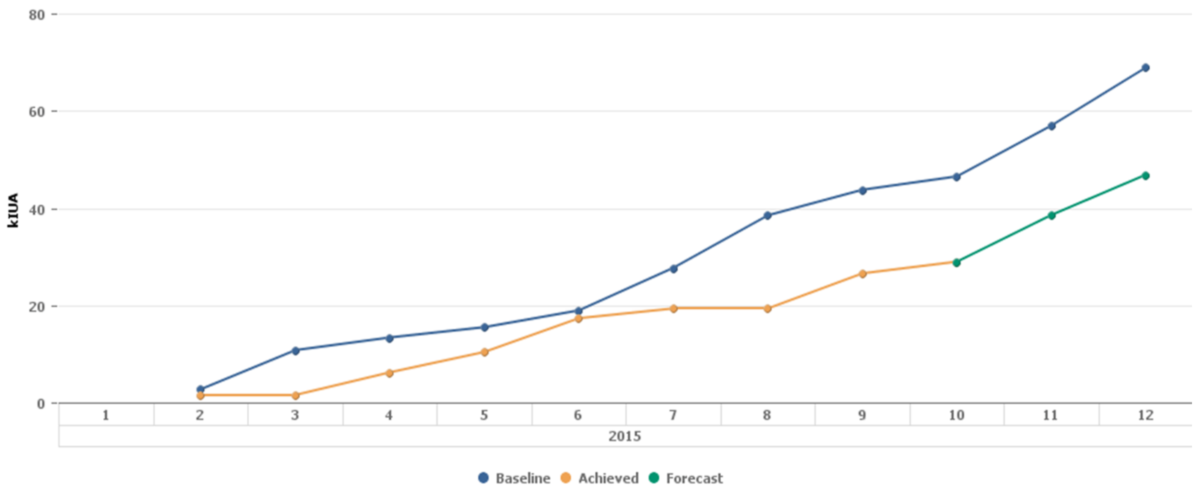
Tracking the month-to-month completion of milestones compared to plan, a Schedule Performance Index (SPI) can be inferred and the positive trend from 2015 compared to 2014 can be observed whereby the average for 2015 stands at 78 % for 2015 and 63 % for 2014.



Comparison of the Schedule Performance Index between 2014 and 2015

2.5 Quantitative Performance Assessment ("Earned Value")

While the evaluation of milestones provides an indication of performance, it does not take into account that some milestones are more important than others and that different "weights" should be applied to them. As part of F4E's 2015 Action Plan, an "Earned Value" reporting system has been implemented on the basis of the credits that F4E receives for the implementation of milestones. Note that the numbering of the x-axis refers to the calendar month and the y-axis the amount of ITER credit in thousand ITER Units of Account (kIUA).



Comparison of the Earned (Yellow) and Planned (Blue) Value of ITER Credit during 2015 (the numbers on the x-axis refer to the month where 1 = January, etc.)

A small number of milestones missed during July and August created the discrepancy between planned and actual credit awarded. In the area of the magnets, the delivery of some of the conductors for the coils was delayed by testing and the discovery of a broken strand. In the buildings area, there were delays for the Load Centre Distribution during the Manufacturing Readiness Review but these have no impact on the critical path. Finally for the Vacuum Vessel, following the introduction of a new consolidated schedule in June 2015 and a redistribution of priorities by the industrial consortium, a decision was taken to reschedule the complete of the jigs for the fourth sector.

2.6 Progress Report for Key Systems

2.6.1 Site and Buildings

Thirty-nine buildings and areas will house all the systems necessary for the operation of ITER. At its heart, the Tokamak Complex houses ITER and is one of the largest buildings of its type ever constructed being 80 metres tall, 120 metres long and 80 metres wide and requires 16,000 tons of iron reinforcement bars, 150,000 m³ of concrete and 7,500 tons of steel.

Keeping the construction on schedule is very challenging, not only due to the scale and complexity of the actual construction work, but also because IO was not able to provide the requirements of the whole complex before the planned start of construction. To mitigate the impact on the ITER schedule, F4E agreed in writing with the IO to start construction with the input data from IO only for the first floor of the Tokamak Complex and to receive the data for the remaining seven floors in a staged manner according to an agreed timetable, during the progress of the construction. This was a measured balance of the risks of delaying the start of construction against the risks of not receiving the data on time. Unfortunately, the timetable for providing input data for the buildings was not respected by the IO and there have been many project changes which have caused additional costs and delays.

Despite the challenges described above, there has been much visible progress on the ITER construction during the reporting period. In 2014 the foundation slab of the Tokamak Complex was completed which used 14,000 m^3 of concrete and contains over 3,500 tons of reinforcement bars. All the walls of the Diagnostic Building, level B2, and almost all the walls of the Tokamak Building are complete. In May 2015 the reinforcement works of the first level of the bioshield started and are close to completion. Finally, the steel structure of the Assembly Building was completed and the roof was lifted into place. Foundation work of the buildings for the cryoplant, and site services are being completed. Apart from the buildings, the technical galleries have also been advancing.

In July 2015 the Buildings, Infrastructure and Power Supplies Project Team (BIPS PT) was established and brings together 64 members of staff from F4E and IO with the aim of delivering through a single, unified team the scope which was previously under the responsibility on one side, of the F4E Site, Buildings and Power Supplies team and on the other side of the IO Buildings, Site and Infrastructure team. At the same time the new IO DG decided to block any changes that impact on the design of the buildings and in the second half of 2015 F4E has been able to finalize the design of the three first levels of the Tokamak Complex, and to approve the design of the fourth level. Taken together, these initiatives are expected to allow the contractors to have confidence in the schedule and to enable construction work to progress more rapidly than up to now.

A detailed assessment of the “lessons learned” from the ITER buildings was discussed by F4E’s Governing Board in December 2014. Subsequently, two independent assessments have been conducted and the outcome is expected in December 2015. Following the decision of the ITER DG to freeze the building designs there is more confidence in the rate of progress and a new schedule has been agreed with the contractors which has been submitted to the IO as part of the overall exercise to create the Updated ITER Long-Term Schedule.

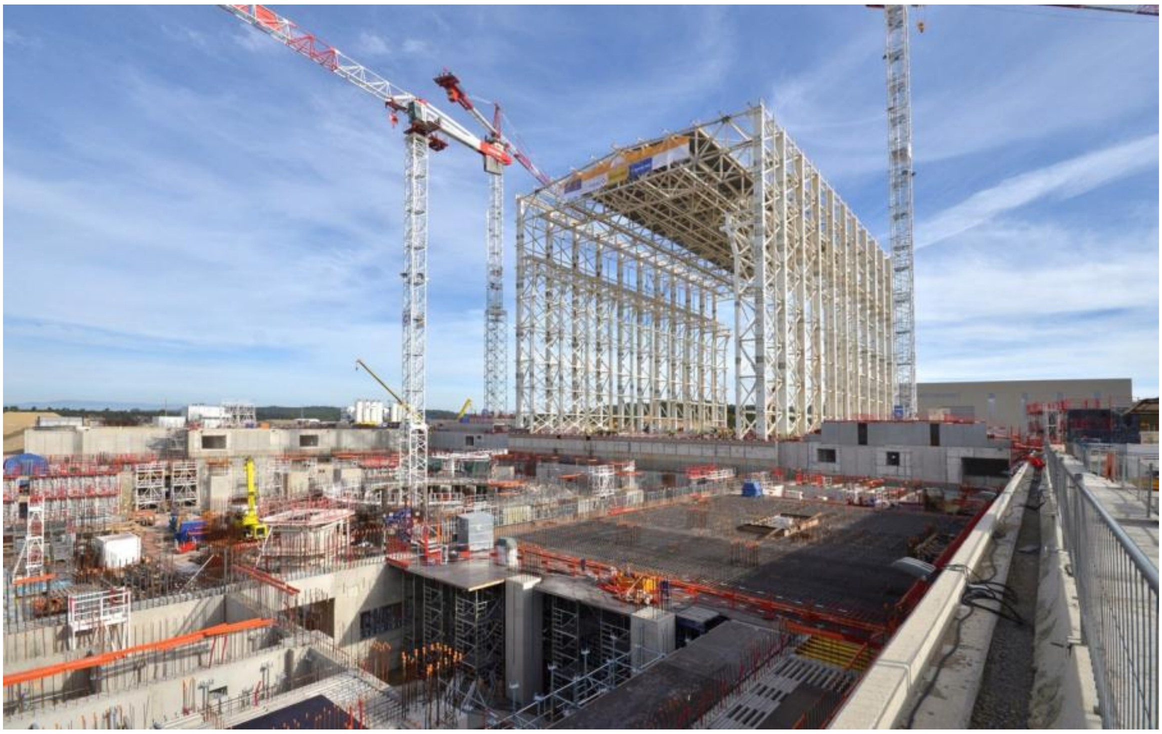
2.6.2 Vacuum Vessel

A special double-walled container, known as the **Vacuum Vessel (VV)**, keeps the reacting gases inside ITER and prevents them becoming mixed with other gases in the air which would prevent fusion. The VV will be twice as large in every direction as that in any previous fusion experiment; having an internal diameter of 6 metres and measuring a little over 19 metres across by 11 metres high. It will weigh in excess of 5,000 tons - equivalent to the Eiffel Tower.

The main part of the VV is divided into nine sectors, seven of which are the responsibility of Europe. A contract for fabrication of the seven sectors was signed by F4E in late 2010. It was originally planned that the final design of the VV would be available before that date. In fact, IO made most of the designs available only in mid-2012, with some design modifications in 2013. With the designs now largely frozen, good progress has been made with the mock-ups and modelling that underpin the manufacturing strategy of F4E’s supplier; which is to actively compensate distortions that naturally occur during welding rather than use massive jigs to try and resist the distorting effects.

Both TIG and Electron Beam (EB) welding will be used during fabrication of the VV. Qualification of the welding procedures has been completed for the TIG welding and is on-going for the EB welding. Qualification of the welders themselves was concluded by July 2015, so that the first welding activities could start. In terms of materials, the production of forged blocks and round bars for sector 5 of the VV has been finished and shipment started. To date, 60 tons of round bars and 136 tons of forged blocks have been produced.

View of the central part of the Tokamak Building where the first half of the bioshield perimeter (a 200 degree segment) comprising some 620m³ of concrete was poured in October 2015



View of the Assembly Hall where the 700 ton steel roof (100m long and 60 metres wide) was successfully lifted in place during September 2015

The newly created Integrated Vacuum Vessel Project Team (VV-PT) has fostered a process for improved efficiency in the F4E and IO-CT management teams. Among other changes, worth noting the merging of the review/approval cycles between F4E and the IO into a single review cycle went live from the second half of July and started to produce beneficial effects from September onwards. Further improvements in efficiency are expected in the coming months from the unification of Quality Control in the VV-PT, with the issue of a new surveillance plan to merge once more the efforts of F4E and the IO-CT. In response to recommendations from F4E's 2013-2014 Annual Assessment, F4E has increased the level of on-site supervision of work at the contractors by staff and inspectors.

2.6.3 Magnets

In order to "hold in place" the extremely hot plasma inside ITER, a system of 24 superconducting magnets will be used. These will be the largest and most powerful superconducting magnets ever made and F4E is at the forefront of their development. Of the ITER Magnets, F4E is providing ten **Toroidal Field (TF)** coils and 20 % of the Nb_3Sn superconductor, five **Poloidal Field (PF)** coils and 11 % of the NbTi superconductor, and nine fibreglass pre-compression rings.

2.6.3.1 Conductors

Excellent progress has been made with the worldwide production of the conductors for the TF coils. F4E has completed the fabrication and verification of the full amount of its contribution (97 tons out of the 500 tons to be provided by all the DAs). This is an important achievement given that the pre-ITER worldwide production of Nb_3Sn strand was ≤ 15 tons per year. The TF conductor is ~44 mm in diameter and contains 900 superconducting and 522 copper strands wrapped in a steel jacket. The status of the conduction production as of end-October 2015 is shown below:

Conductor Type	Number of lengths to be delivered by EU	Fabricated	Fabrication Completion [%]	Accepted by IO
TF conductor	30	28	93.2	24
PF conductor	13	9	69.2	3

Status of the Production of Conductors for the ITER Toroidal (TF) and Poloidal (PF) Field Magnets

2.6.3.2 Toroidal Field (TF) Magnets

Each TF coil, weighing ~300 tons, is made up of a Winding Pack (WP) composed of 7 Double Pancakes (DP) modules stacked together, impregnated and inserted in stainless steel coil cases. Each DP is made up of a Radial Plate (RP), a large D-shaped stainless steel plate with grooves machined on a spiral path on both sides. The 700 m long conductor is wound into the required D-shape, heat treated and electrically insulated before being inserted into the grooves of the RP.

Following the successful fabrication and testing of a DP prototype, F4E's contractor has started series production winding of 35 DPs, so far, of which 30 have been heat treated. This corresponds to five entire TF coils (composed each of 7 DP). Accuracies on the trajectory of the conductor of some tens of parts per million over the 700 m conductor length have been achieved. Such a high accuracy has allowed machining of RPs in parallel with the RP production, allowing an acceleration of the schedule. 30 RPs have been completed and delivered to the DP supplier with production of 1 RP every 13 days.

2.6.3.3 Poloidal Field (PF) Magnets

F4E will fabricate four PF coils (PF2 to PF5) at the ITER site and one coil (PF6) in China (under collaboration with ASIPP). The building in which the PF2-5 coils will be fabricated has already been completed and the winding tooling necessary for the fabrication is currently being manufactured. F4E is being supported in the implementation of the PF fabrication by an engineering integrator.

For PF2 to PF5, manufacturing phase of the winding tooling contract is completed for the PF5 table and this is now being delivered to the PF Coil Building in Cadarache after successfully passing the factory acceptance tests. Fitting out of the PF coil building in Cadarache and most of the tooling is now successfully installed: all the building work should be finished by January 2016. For PF6, the winding tooling has been adapted and improved during summer 2015 and is ready for acceptance tests. Various reviews and qualifications are underway to prepare for fabrication.

First full size Double Pancake prototype for the Toroidal Field (TF) Coils showing the scale of the superconducting coils which are some of the largest ever produced

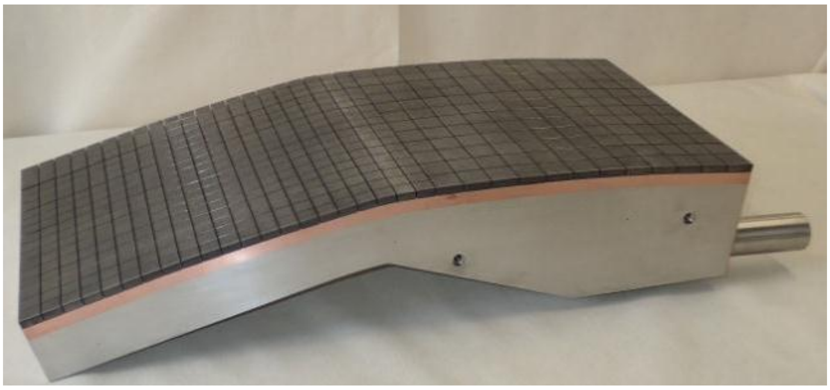
Tooling for the Poloidal Field (PF) coils under assembly for acceptance testing. The coils will have to be manufactured on the ITER site since they cannot be transported due to their size

2.6.4. In-Vessel Components

While the ITER magnets will hold in place most of the hot plasma, some will inevitably escape from its magnetic 'cage'. If this escaping plasma were to touch the Vacuum Vessel (VV) it could cause damage and, in any case, would result in evaporated metal extinguishing fusion reactions in the plasma. To avoid this, the VV is clad on the inside by 440 special blocks called **First Wall (FW) Blanket Modules** of which F4E supplies 218. There is also a special device at the bottom of the VV called a **Divertor** which soaks up much of the heat leaving the edge of the plasma.

The manufacture of the normal heat flux FW qualification semi-prototype has been completed and successfully undergone a first high heat flux test campaign for 7500 cycles at 2 MW/m^2 plus 1500 cycles at 2.5 MW/m^2. These tests, with the additional test campaigns planned with the other completed FW semi-prototypes, should allow the identification of the best Beryllium/Copper-Chromium-Zirconium joining conditions for the manufacture of the full-scale FW prototypes.

Moving to the Divertor, Critical Heat Flux (CHF) testing of an all-tungsten medium-size prototype has been completed to values above 35 MW/m^2. Work carried out with three contractors for the pre-qualification of the Inner Vertical Target (IVT) is progressing well. To foster competition, mitigate risks and reduce cost, F4E has procured 400 tungsten monoblock tiles which will be tested in the frame of the above pre-qualification programme. Three contracts for the manufacture of full-scale Divertor Cassette Body prototypes are progressing well including welding qualification and pre-production readiness review.



Prototypes of the Elements of the First-Wall Blanket Modules (above) and Divertor (below), the latter after testing at high heat fluxes (Photos courtesy of Atmostat and Ansaldo Nucleare)

2.6.5. Remote Handling

Remote handling will have an essential role in ITER once the nuclear phase has started and robotic tools will be necessary to conduct inspections and to repair components close to the device. This is especially challenging since some of the items that will need to be manipulated weigh up to 50 tons. F4E is providing a significant fraction of the ITER Remote Maintenance (RH) System; the **Divertor Remote Handling System (DRHS)**, the **Cask and Plug Remote Handling System (CPRHS)**, the **Neutral Beam Remote Handling System (NBRHS)** and the **In Vessel Viewing System (IVVS)**.

In 2014 and 2015 there has been a substantial amount of progress in all of the above areas. For the DHRS, two out of three main contracts have been placed for the preliminary design. The Divertor Test Platform 2 (DTP2) in Finland was able to successfully demonstrate tests of remote installation and removal of the so-called divertor central cassette. Work will now continue on DTP2 to optimise the divertor cassette locking system.

For the NBRHS, a contract has been placed for analysis of the system requirements, conceptual design and preparation of the preliminary design. For the pipe and lip seal welding technologies, there has been a successful demonstration of the remote operation as shown in the photo below. These tests have shown the basic validity of the tool design, and represent a solid starting point for the development of the design for the final tooling needed for NBRHS with potential application to other ITER systems.

Photos showing the simulated Remote Handling conditions for operating the tooling for cutting and welding the cooling pipes of the Neutral Beam components

Concerning the IVVS, further design analysis and optical system prototyping is being implemented as planned including the design and start of procurement of an optical test bed for further refinements on the laser-based scanning concept. As complementary activity, an updated neutronic analysis of the IVVS plug is being carried out. Finally, work is on-going on several common technologies related to electronics, software platforms and system studies.

2.6.6. Cryoplant and Fuel Cycle Systems

Complex systems are required to provide cooling of ITER components, most notably the superconducting magnets. F4E is providing the **LN_2 Plant and Auxiliary Systems** (about one-half of the Cryoplant), front-end **Cryodistribution with Cold Valve Boxes (CVBs)**, **Torus and Cryostat Cryopumps**, **Cryopumps for the Neutral Beams** and **Leak Detection and Localisation**. F4E is also providing the **Tritium Plant** consisting of the **Water Detritiation System (WDS)** and the **Hydrogen Isotope Separation System (ISS)**. Finally, F4E is providing Radiological and Environmental Monitoring Systems as well as radwaste treatment and storage.

An industrial supplier was contracted by F4E to manufacture the LN_2 plant and auxiliary systems following an extensive technical dialogue between F4E, IO and the supplier which enabled costs to be reduced. The final design review was successfully completed in July 2015. In parallel, the manufacturing of the long lead items was pursued actively. One more significant milestone was recorded with the acceptance of the first LN2 plant and Auxiliary components and two 80 K loop heat-exchangers passed helium leak tests, dimensional checks and final inspection.

Moving to the Tritium Plant, the Water Detritiation System (WDS) tanks, two 100 m^3 and four 20 m^3 tanks, were delivered to Cadarache earlier in 2015 (see photo below) and were accepted by the IO. Those deliveries mark a major milestone in the ITER project as they are the first components supplied by F4E to the ITER site. The preliminary design of the main WDS system also made significant progress. The test results of the Warm Regeneration Lines were under review at the time of writing.

Delivery of a 100 m^3 WDS tank to the ITER Organization – among the first European deliveries

2.6.7. Plasma Heating Systems

To create fusion in ITER, the plasma must be heated to 150 million degrees. By passing a large electrical current through the plasma, which also helps to hold it in its magnetic 'cage', it is possible to reach 20-30 million degrees. Since this is not enough on its own, additional heating is needed. ITER will rely on three additional heating systems.

2.6.7.1. Neutral Beam Heating

One of the most reliable ways to heat plasmas in present-day fusion experiments is to fire a beam of fast, uncharged particles into the plasma – this is called **Neutral Beam (NB)** Injection. A major part of the NB heating systems are being provided by F4E, including two NB injectors and the power supplies encompassing the beam sources, beam line components, confinement and shielding, coils, power supplies and assembly. Last but not least, F4E is making key contributions to the establishment of a Neutral Beam Test Facility (NBTF) in Padova in Italy and related procurements in cooperation with IO and the host, Consorzio RFX.

PRIMA building for the Neutral Beam Test Facility under construction at Padova in Italy

Considering the technological leap required for the ITER NB systems compared to those used in present-day tokamaks, the NBTF was considered to be essential. The NBTF hosts two independent test beds: SPIDER (Source for Production of Ion of Deuterium Extracted from Radio Frequency plasma), where the first full-scale ITER ion source will be tested and developed with an acceleration voltage up to 100 kV; and MITICA (Megavolt ITER Injector & Concept Advancement), which is a full-scale injector operating up to the full acceleration voltage of 1 MV at full power (16.5 MW).

Installation of the insulating transformer for SPIDER and MITICA at the NBTF Site

In relation to SPIDER, all of the foreseen industrial procurement contracts have been placed for final design activities and fabrication of components including the power supplies, HV deck and transmission line, beam source and vacuum vessel. The design of the MITICA core components (beam source, beam line components and cryogenic pump) is being finalised by addressing some of the residual modifications identified during the final design review process and the relevant technical specifications are also in the finalisation phase. The MITICA vacuum vessel contract was signed in 2014 and manufacturing is underway. The large insulating transformer for SPIDER and MITICA (insulating 100kV) was installed in its final outdoor location.

In parallel with the NBTF activities, F4E supports the construction and operation of a half-size ITER ion source test bed in Germany (ELISE). ELISE aims to accelerate to 60 keV 20 A of deuterium for 10 s extracted from a continuous plasma in the ion source. In relation to the design of the main NB system, the ITER preliminary design reviews for the Beam Line and Beam Source vessels, the Passive Magnetic Shield and the Active Correction and Compensation Coils has been carried out.

2.6.7.2. Radio and Microwave Heating Systems

Another way to heat up the plasma is to use radio waves to make the particles in the plasma vibrate and heat up, like a microwave oven heats food. ITER is using two systems: one heats ions, known as Ion Cyclotron Heating (ICH) and the other heats electrons, Electron Cyclotron Heating (ECH). Each system comprises power supplies and generators, tubes to carry the radio waves and antennae inside the Vacuum Vessel to transmit the waves into the plasma.

For the Ion Cyclotron (IC) Resonance Heating system F4E is responsible for an equatorial port plug incorporating one IC antenna. F4E, in collaboration with a consortium of European laboratories known as "CYCLE", is advancing the design of the ICRH antenna. Recent work involves electromagnetic, seismic, neutronic and thermo-mechanical analysis under a set of load conditions. In 2014 the neutronic analysis of the IC antenna was completed and high heat flux testing of the Faraday Screen mock-ups was undertaken successfully; both mock-ups survived 15000 cycles at 3.5 MW/m^2 (meeting ITER requirements) with no modification of their thermal behavior. Several task orders were also placed in 2014 with CYCLE for design and mechanical analysis.

For the Electron Cyclotron (EC) Resonance Heating system F4E is providing four upper port plugs incorporating EC launchers, 25 % of the gyrotron sources and two-thirds of the power supplies. For the gyrotrons, F4E is working with a consortium of European laboratories that possess special test facilities and an industrial supplier. Following the pre-validation of the design of the short-pulse gyrotron for ITER which is being developed by Europe, work is moving ahead. The European Continuous-Wave (CW) gyrotron prototype has successfully passed the final Factory Acceptance Tests – an important sign of progress. Good progress has also been accomplished in the procurement of the EC Power Supplies and the contract is on schedule.

Concerning the ECRH launchers, the final design phase is underway and F4E is collaborating closely with a consortium of European laboratories known as "ECHUL-CA". Most technical activities have focussed on the launcher components that are part of the ITER primary confinement and are safety critical: this includes waveguides and waveguide components, isolation valves, diamond windows and the rear of the port plug. Analysis showed that off-the-shelf waveguide couplings are unsuitable for the ITER environment and necessary work on the design of new waveguide couplings has been completed, with pre-qualification tests having been performed in 2014 to support their design development. The new integrated coupling design is more compact than the previous solution and is now capable of sustaining the anticipated mechanical loads.

2.6.8. Plasma Diagnostic Systems

When ITER is operating it is essential to know as much as possible about the behaviour of the hot plasma inside, not only for safety reasons but also to see how it compares with our theoretical understanding. Around 50 different plasma measuring systems, known as diagnostics, are planned to be installed on ITER of which F4E is developing thirteen.

During 2014, F4E signed all the Framework Partnership Agreements (FPAs) to finalise the design of all the major diagnostic systems for which European Fusion Labs (EFLs) have the necessary capacity. Similarly, a Framework Contract (FWC) was signed for the integration design of port-based diagnostic systems into ITER ports and the build-to-print designs of the housing and shielding structures hosting diagnostic components.

Significant progress was made in 2014 and 2015 on many fronts which, due to the large number of systems involved, cannot be reported in detail here. For the magnetics diagnostic, the first of manufacturing series for Continuous External Rogowski (CER) coil components were fabricated and successfully tested; the CER coils will be the first diagnostic delivery to ITER, planned for early 2016. Progress was made in R&D, design and prototyping for most of the other diagnostic systems including the bolometers, plasma position reflectometers, pressure gauges, radial neutron camera, charge exchange spectrometer, collective Thompson scattering system and finally on integration of the port plugs that will interface many of these systems to the plasma.

2.6.9. Test Blanket Modules

F4E is also developing special Blanket Modules, known as Test Blanket Modules (TBMs), which will demonstrate a necessary feature for future fusion reactors – the generation of its own tritium; one of fusion fuels that is not naturally occurring. The TBMs are not only technically complex devices but must operate reliability in an extremely harsh environment (heat, neutrons and magnetic fields). F4E is leading a programme to develop and test two different TBM designs.

Since the late 1990’s Europe has been developing two TBM concepts for ITER: the Helium-Cooled Pebble-Bed concept (HCPB) and the Helium-Cooled Lead-Lithium (HCLL). Both concepts are being pursued by F4E as part of an overall strategy and a strong partnership with European laboratories and industrial suppliers. While both concepts share similarities in terms of structural design and material, the tritium breeder material and the set of ancillary systems deployed to extract and recover the tritium is specific for each concept.

In 2014 F4E signed two arrangements with IO for the delivery of HCPB and HCLL TBM systems to the ITER site. F4E has produced mock-ups of TBM sub-components with standardised welding procedure specifications and within TBM reference tolerances. The TBM box assembly is also under development with the establishment of an optimized assembly sequence and development of standardized welding procedure specifications. In parallel, a programme of simulation and modelling is being supported by F4E to understand e.g. the effect of ITER’s magnetic fields and the migration of tritium in dynamic conditions. In 2015 the Conceptual Design Review Panel Meeting for the EU TBM Systems was organized jointly with the IO and hosted by F4E. The Review Panel commended F4E on the high level of preparation of the review as well as the clear strategic vision on the objectives. Progress was made on several aspects which cannot be reported in detail here.

3. Status of the Broader Approach Projects

3.1 Introduction

In addition to acting as ITER Domestic Agency for Europe, Fusion for Energy is also the Implementing Agency for the EU contribution to three Projects under the Broader Approach (BA) Agreement between Euratom and Japan. The BA Agreement was negotiated in parallel with the late stages of the ITER agreement (as a compensation to Japan for accepting to site ITER in Europe) to carry out activities complementary to ITER and aimed at a faster realization of fusion as an energy source.

Under the BA, Euratom and Japan contribute equally to projects taking place in Japan (338 M€ and 46 B¥ respectively, values of 5 May 2005). At that time, a number of Euratom Member States (France, Italy, Germany, Spain, Switzerland, and later, Belgium - the Voluntary Contributors) pledged support for the BA projects and committed to provide approximately 90 % of the EU contributions in-kind. The European Commission designated F4E to act as the Implementing Agency for the BA which coordinates the voluntary contributions and is also in charge of a limited amount of procurement.

Like ITER, contributions are formalised under Procurement Arrangements (PAs) between F4E and the Japanese Implementing Agency (JAEA), which in turn are backed by Agreements of Collaboration between F4E and institutions chosen by the Voluntary Contributors. Direct contributions by F4E through its own budget are limited to providing support, Quality Assurance, transportation of components to Japan, integration, and limited procurement for EU contributions not covered by the VCs. The accounting of the Parties' contributions is done in credits (BA Units of Account). The three Projects use as key performance indicator the ratio of credit awarded under the BA to credit planned at that date. The average for all together is above 75 %. The progress achieved for each project is described in the remainder of the chapter.

3.2 Satellite Tokamak Project

The **Satellite Tokamak Project (STP)**, located in Naka in Japan, consists of the upgrade of an existing tokamak (JT60-U, which was the Japanese equivalent to the EU JET tokamak) into a superconducting device capable of long pulse operation, with the aim of exploring some DEMO reactor regimes complementary to those studied in ITER. This upgrade involves the complete dismantling of the old machine, the refurbishing and reutilisation of the buildings, the power supplies systems and the additional heating system. All the core components of the new tokamak and additional auxiliary systems have been redesigned and they are in advanced manufacturing or assembly phase. In 2012, when the large majority of the industrial contracts was already placed, the Project was re-baselined, and since that date is progressing according to the planned schedule without cost overruns.

The schedule foresees the achievement of the first plasma in March 2019. The overall value of the EU contributions amount to 196 M€ (at current values). To date the EU has delivered 38 % of the overall contribution and achieved 71 % of the planned milestones.

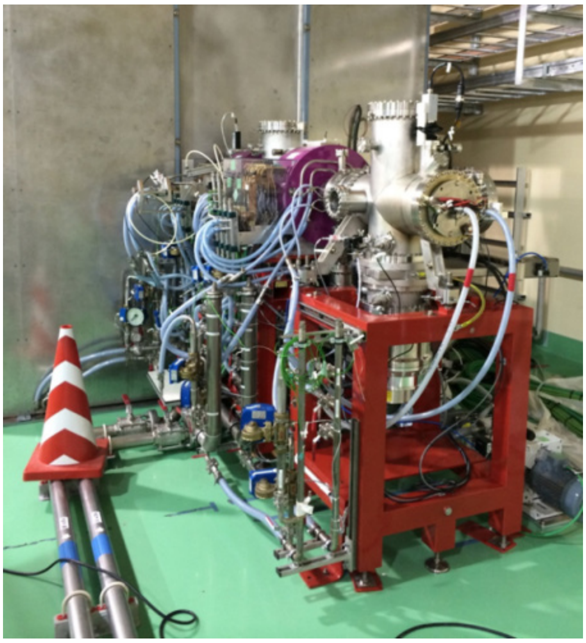
Europe is providing critical components such as the 18 large (8 m height 4 m width) superconducting Toroidal Field (TF) coil magnets which are presently in advanced phase of manufacturing and testing thanks to a joint effort from France, Italy and F4E A photograph of one of the superconducting TF coils, in the final phase of manufacturing, is shown on the following page. In 2015 the assembly of the machine has progressed, with a large number of EU components successfully delivered and commissioned. F4E staff is playing a key role in supporting this activity.

A superconducting Toroidal Field Coil (one out of the 18 to be provided by the EU) at the factory

3.4 IFMIF/EVEDA Programme

The **IFMIF/EVEDA Project** is hosted in Rokkasho, and is concerned with developing a prototype of a facility for testing materials under the conditions of neutron irradiation expected in future fusion reactors. The International Fusion Materials Irradiation Facility, known as IFMIF, is accelerator-based neutron source to produce a large neutron flux in order to qualify materials for future fusion reactors.

Design activities for IFMIF started in 1994 and since 2007 the proposal has been pursued by Japan and the EU under the BA Agreement, in the project IFMIF/EVEDA (EVEDA meaning Engineering Validation, Engineering Design Activities). After issuing the IFMIF Intermediate Engineering Design Report in 2013, emphasis has shifted from the design of an entire IFMIF facility, to the development and demonstration of prototypes. In particular, the linear accelerator needed for IFMIF requires significant developments with respect to state-of-the-art accelerators used in other fields of science.



The Injector (ion source) of the IFMIF linear prototype accelerator installed at Rokkasho.

The development of the modular accelerator (LIPAc) components has taken place in France, Italy, Spain and Belgium. The first LIPAc component, the Injector, was delivered by the EU to Japan in March 2013, and the first beam extraction was successfully demonstrated in November 2014. The commissioning was performed in 2015 and will be followed by the installation and commissioning of further modules and measuring instruments. The technological validation of the full IFMIF accelerator will be conclusive due to the success of LIPAc. As in the case of the STP, the IFMIF/EVEDA Project was re-baselined and progresses well according to the current schedule. It was recognised by Japan and the EU that the Project would benefit from a two year extension (until 2019) to develop the full capability of the injector. This will be accomplished by transferring a modest amount of BA credit from the IFERC Project to IFMIF/EVEDA thereby generating no additional net cost for the EU. At the end of September 2015 the EU will have claimed 70% of the credit allocated to the project.

3.5 IFERC Programme

The IFERC Project is also hosted in Rokkasho. Its main sub-project, the Computational Simulation Centre, is providing supercomputer resources to the fusion scientific and technical communities in EU and Japan. The supercomputer, provided by France, has operated very successfully since its scheduled start date in January 2012, and is the main computational tool for EU scientists in fusion. In addition, IFERC includes collaborative activities in testing and development of materials for future breeder blankets, joint work on pre-conceptual DEMO design (e.g. system codes and predictive modelling) and remote experimental facilities (Remote Experimental Centre).

The supercomputer “Helios” at the Computational Simulation Centre in Rokkasho

In summary, the BA Agreement is widely recognized as a successful collaboration, with the three BA projects now evolving towards their completion. It has led to major achievements for fusion, showing that such international agreements can provide substantial hardware and scientific output while making effective use of commitments in cash and in kind. At the end of September 2015 the EU has claimed 85 % of the credit allocated to the Project. All major milestones have been achieved.

4. Cost Estimates at Completion and Schedule Revision

4.1 Introduction

Since the Extraordinary Meeting of the ITER Council (IC), held in July 2010, when the ITER Overall Project Schedule was originally approved by the Parties, a series of successive delays in the progress of work in the overall ITER Project have regrettably materialised. Under this original schedule the First Plasma target date was between November 2019 and July 2021 with the start of high power Deuterium-Tritium (D-T) operation in March 2027. However, since that time the Schedule Performance Index was consistently about 0.5, meaning that the work progressed at about half the planned speed and the whole ITER Project has fallen behind steadily.

According to the conclusions of the 2013 ITER Management Assessment (MA) carried out for the ITER Council, this poor level of performance is attributed to several factors, including the inadequacy of the original overall organisational design of the ITER Project, the lack of a strong project culture in the ITER Organization (IO), poorly implemented decision-making processes combined with weak systems engineering and design integration. The MA also pointed out that the ITER target baseline approved in July 2010 was unrealistic and that there were insufficient incentives for the IO to reduce costs which in turn created conflicts with DAs and consequently delays.

In June 2013 the 12th IC meeting requested the IO to develop a realistic resource-loaded schedule. Progress with the development of the realistic schedule (the “Updated Long Term Schedule” as it came to be known) was reviewed at the following two IC meetings and progressed more slowly than expected. In particular, the global design maturity, required as a basis for the work, was considered to be insufficient and that systems engineering and configuration management processes needed to be reviewed to address known weaknesses, and be integrated with those related to management, propagation and verification of safety requirements.

In March 2015 the IC appointed the new Director General of IO (Dr Bernard Bigot) and endorsed an Action Plan which he had prepared in response, among other things, to the MA. Aside from pressing ahead with the finalisation of an Updated Long Term Schedule, the 2015 ITER Action Plan (see annex 1) proposed a number of specific measures aimed at addressing the root causes which were leading to the poor schedule performance, including:

- Setting up a new organisation characterised by a profound integration of the Domestic Agencies (DA) and the IO’s Central Team (IO-CT);
- Creating an Executive Project Board (EPB) composed of the IO DG and the DAs to allow for centralised and rapid decision-making on technical matters;
- Setting up common Project Teams (PTs) of managers and staff from the IO-CT and DAs for specific areas and facilitating greater exchange and mobility of staff;
- Establishing a new Reserve Fund to compensate DAs for cost increases that are incurred due to changes of the initial technical specifications by the IO.

In Nov 2014 the former Director of F4E (H. Bindslev) tendered his resignation and P. Barabaschi (the Head of F4E’s Broader Fusion Development Department) was appointed as Acting Director, taking up his duties on the 1st March 2015. In concert with the newly appointed ITER IO DG, the F4E Acting Director presented a F4E Action Plan (see annex 2) to the F4E Governing Board in March 2015 when it was endorsed. F4E's Action Plan complements the ITER one in a number of areas, but also addresses further issues in F4E's own organisation and operations (discussed further in the following chapter). Aside from continuing to contribute to the preparation of the Updated ITER Long-Term Schedule allowing a more accurate commitment profiles and a better implementation of its budget, the most important action was the development of a revised Cost Estimate at Completion (EAC) together with a system for the management of funds allocated to individual project areas.

4.2 Revision of the ITER Schedule

In response to the Parties' demands, and in preparation of the November 2015 ITER Council (IC), the IO together with all seven DAs have undertaken a focussed joint effort to prepare the Updated Long Term Schedule.

An important difference of this Updated Long Term Schedule exercise compared to previous such exercises (e.g. the one conducted in 2010 when the ITER Council last updated the schedule) has been the level of engagement of the DAs in the planning process. Planning efforts were focussed and made consistent with IC direction using a common set of top-level assumptions. An Updated Long Term Schedule was thereby prepared by joining together the schedules from F4E and the other DAs for the in kind contributions that they are providing. It should be underlined that such new Schedule needs to include many important elements of work that are not under F4E's responsibility, including the in kind contributions from other DAs and assembly activities by the IO.

The draft Updated Long Term Schedule was submitted by the IO to the IC and its preparatory bodies in October 2015. The main milestone of the First Plasma was determined to be substantially delayed beyond the former 2021 date and the IO requested significant increases in its own resources, in particular, staffing.

During the meeting of 18-19 November 2015, the IC decided to conduct an independent validation of the Updated Long-Term Schedule and the additional resources requested by the IO following an additional iteration with the DAs. The IC agreed on a series of key milestones to be closely monitored for 2016-2017. The IC committed to finalise the evaluation of the Updated Schedule and approve it until the First Plasma date at its next meeting, scheduled for June 2016. The IC also expects the full schedule (i.e. up to the D-T phase) to be finalised in the course of 2017.

As a follow up to the November IC, F4E has to ensure that: (a) the Updated Long Term Schedule to be submitted by the IO to the June IC is realistic with regard to assumptions made about the F4E in kind contributions and F4E's capacity to provide the associated in-cash contributions to the IO; (b) ensure that the proposed schedule is compatible with its capped budget of 6.6 B€[1] until 2020 through adjustment of its own plans and priorities.

The 2010 EU Council Conclusions, which defined the content of this report, requests F4E to *"…report to the Council at least once a year on the progress achieved in implementing the cost containment and savings plan as well as on the performance and management of the Agency and the ITER project…."*. With this in mind, in addition to participating to the above schedule exercise with the IO,

[1] All financial figures quoted in this chapter are in constant 2008 values

F4E has made significant progress in establishing a new cost Estimate at Completion (EAC). Taking into account that the Updated Long-Term Schedule has not been finalised, a number of caveats and uncertainties apply to the resulting cost EAC. Only during the course of 2016 is it expected that it will be possible to converge on a schedule that is fully consistent with financial constraints.

4.3 Cost Estimate Update

There are two very essentially different elements which form the basis for the F4E cost estimates for the ITER Project:

1. The expected cost of F4E's scope of work, comprising its in-kind contributions as well as its own running costs to manage such provisions. These are, to a significant extent (although not fully), under the control of F4E and its own governance and are subject of a detailed EAC analysis;
2. The costs of IO, administrative/staff and for the provision of hardware and services under IO's responsibility, of which F4E needs to contribute "in cash" for an amount of 45.5 %. These obligations are approved by the IC at which the European Commission represents Euratom. It is not yet possible to provide a figure for such costs at this point in time as the overall plan to completion has not yet been agreed by the IC.

4.3.1 Regarding F4E scope of direct supplies, and related management costs

In parallel to the scheduling exercise with the IO, in the spring of 2015, F4E initiated a major exercise for the revision of its own cost EAC. This exercise was deemed timely in view of the change of management in the IO, a reworked analysis of the risks, and the schedule revision being conducted in the same timeframe.

To conduct this work, the basis and structure of the cost EAC data and processes were defined at the level of individual running contracts and planned packages of work, together with a definition and quantification of cost impacts of associated identified risks. Consistent with best practices[2], a fact findings assessment phase for the various procurement packages was conducted to collect and analyse information on (i) scope and status of supplies, (ii) procurement strategies; (iii) the design and manufacturing readiness; (iv) procurement schedule assumptions; (v) available cost estimates; and (vi) risks and uncertainties.

Following the collection of available data, a contract/cost breakdown data structure and cost risk register was adopted and the data have been analysed statistically using Monte Carlo techniques which included the modelling of possible correlations amongst risks. In a nutshell, such calculations are intended to simulate as realistically as possible the different risks that might occur and what influence this could have on the final cost.

- The result of this analysis shows that, when compared with estimates made in 2008[3] upon which F4E's current financial framework capped budget of 6.6B € is based (albeit without the contingency originally requested by F4E) the cost EAC for direct F4E expenses for: a) its in-kind

[2] E.g. United States Government Accountability Office GAO-09-3SP 3/2009: Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs.

[3] R. Toschi, et al., Assessment of resources for the EU in-kind contribution to ITER, Nov. 2008

contributions[4], b) Test Blanket Modules, c) transportation, and all d) associated management/administrative costs are likely to increase by ~2 B €, assuming a normal 50% confidence level (EAC_{50}). Of these, ~85 % are foreseen as needed for the operational budget, the remainder for the administrative budget. While the latter value is due to the expected extra duration of the project, the former operational cost increase is in the topical areas of:

- Nuclear Buildings, alone accounting to 2/3 of such a cost increase;
- In-Vessel components, for approximately another 20 %;
- Remote Handling and Heating systems, for the remainder.

Relatively speaking, the cost EACs for other technical critical areas have so far remained altogether within the forecasted values.

The above cost estimates are neither optimistic nor pessimistic. It is important to note is that they do not include low-probability but high-impact risks such as major changes in the regulatory framework, withdrawal of any Party to the ITER Agreement, damage of critical components during transportation, bankruptcy of major suppliers, unforeseen problems during assembly, failures of key components (e.g. Magnets), etc. A presentation of the cost EAC was made to F4E's Governing Board of 1-2 December 2015 where the Director was asked to report regularly on this issue.

In F4E's previous Report to the Council for the period ending 31 July 2014, F4E reported a so-called "negative contingency" of -0.43 B€ but it should be stressed that this figure was only reporting upon the accumulated differences between the value of awarded contracts compared to their estimated value. In other words, the negative contingency was only "looking back" and is not looking forward at future risks, which is the main difference with the cost EAC carried out in 2015.

F4E will endeavour to do all it can to reduce the cost EAC. F4E has already implemented a system to allocate funds and to regularly review the cost EAC and will continue to strive to improve its accuracy. On the specific areas where cost increases are foreseen, F4E has initiated two independent reviews of the ITER buildings with a view to see if there are ways to improve the situation, and secondly has initiated with IO an effort to seek ways to reduce the complexity of their design in order to reduce their cost to the original forecasted values.

4.3.2 Regarding F4E extra costs related to the cash contributions to IO (and JA)

As mentioned above, at this very point in time it is not yet possible for F4E to assume in a comprehensive manner the extra costs associated with the IO scope of activities to complete the construction phase of the project, and hence a consolidated view of the EAC will be only available once the IC will agree on the new plan.

At the same time, in order to develop the revised project schedule, while reasonably ensuring compliance with the 6.6 B€ cap within the MFF to the end of 2020 (see below in 4.3.3), it is critical for F4E, even if subject to uncertainties, to assume an estimate of the additional cash contribution which IO will need from F4E in the period from now until December 2020. F4E has assumed that about

[4] i.e. including magnets, vacuum vessel, blanket first-wall, divertor, remote handling systems, vacuum and pumping system, tritium plant, cryoplant system, ion cyclotron antennae, electron cyclotron upper launcher, neutral beam system and EC Power Sources and Power Supplies, Diagnostics, Electric Power Distribution systems, Site and Buildings, Radiological Environmental Protection Systems, and waste treatment and storage. Also including the expected extra costs on F4E's in-kind contributions which will be implemented via the newly established reserve fund.

300 M€ will be necessary to that end. Thereafter, for the period after 2020 and until the conclusion of the construction phase, F4E has insufficient elements to provide a reasonably sound estimate.

Finally, also after 2020, F4E will also need to contribute an additional ~75 M€ cash contribution to Japan as a result of the agreement in January 2014 between the EU Commissioner and the Japanese minister as settlement of the dispute over the cost of EU procurements transferred to Japan in 2006 as part of the Host-Non-Host agreement.

4.3.3 The 6.6B€ cap in the Multiannual Financial Framework

In order to stay within the 6.6 B€ cap set within the present Multiannual Financial Framework a number of components and activities not essential for First Plasma will now have to be postponed until after December 2020. While a precise analysis and optimization of such postponements is still underway, depending also on the finalisation of the schedule, and will hence require a few more months to complete, F4E has reasonable confidence that the resources required to provide F4E's in kind contributions to achieve first plasma according to the new proposed baseline, including the impact of the additional cash contributions which the IO is likely to need, are compatible with the present MFF 6.6 B€ capped budget.

4.4 The Underlying Root Causes for Cost Increases

Three fundamental classes of reasons have been identified as the cause of the observed cost increases:

- Low Level of design maturity combined with an unrealistic schedule
  - At the time of signing the ITER Agreement in 2006 it is evident that the design of many parts of the ITER device and its plant equipment were at a low level of design maturity. This meant that the initial cost estimates were underestimated without fully considering the propagation of nuclear safety requirements into technical design specifications, missing items, spares and lastly adverse market conditions. One of the first main activities of the ITER Project in 2008-2009 was to conduct an extensive Design Review which exposed the problem of design maturity, missing items, etc. This problem had already been confirmed by various external assessments and continues to be a matter of concern (the IC is still examining the question of design maturity in recent meetings) and this has had a major impact on the nuclear buildings being provided by F4E;
  - The ITER Project worked at the beginning on the basis of a 10 year construction schedule which was not based on a "bottom up" calculation of the time required to perform all the required in the right sequence but rather according to a "top down" politically driven plan that assumed that the ITER Project would be working at full speed from the moment the ITER Agreement was signed. The IC was slow to recognise that the schedules were unrealistic and revise them accordingly. Hence, the combination of low level of design maturity coupled with the pressure of an unrealistic schedule have led to the IO often providing input data late to F4E and frequent changes. This has been a particular issue for the buildings where F4E signed large construction contracts with written promises from the previous ITER IO Director General that data will be provided according to a plan which was not respected. The stability of the regulatory environment, particularly after the Fukushima accident in Japan, has also exacerbated the issue of frequent changes to specifications

- Issues and inefficiencies in the project implementation have delayed the project significantly.
  - As also described in the MA and several other studies, the international setup of ITER was flawed in several respects and has been exacerbated by management weaknesses, leading to poor interface and configuration management, often unclear definition of responsibilities with regard to scope of supply, safety, schedule and cost, as well as a less than optimal integrated management systems to handle the design evolution, scheduling and interfaces;
  - Under these circumstances F4E has been asked to implement a project with inherent technical challenges and management boundary conditions which have hardly any precedent worldwide. These affects specifically the In-Vessel Components (i.e., first wall, divertor) and Remote Handling systems whose design has changed significantly since 2008 and for which recent industrial estimates prior to start of procurement point to potentially higher costs than previously anticipated due to technical complexity or first-of-a-kind technologies;
  - Underlying the above problems the present disappointing state of the ITER project derives, to a significant extent, from the initial incorrect assumption by the ITER Parties that the minimization of risks (schedule and cost) at the level of each Party/DA leads to an overall minimization of such risks for the entire ITER project. Such overarching problematics have been largely analysed in the IO and F4E Action Plans and therein addressed to the extent possible. In particular, given that most of the contributions to the project are provided in kind under the budget of the DAs, there has been no incentive for the IO to contain cost and this has been a source of conflict with the DAs which has led to protracted decision-making.

As far as possible actions from F4E side have been put in place to address the causes of the above cost increases:

1. Concerning the cost increases on the nuclear buildings: F4E has initiated in mid-2015 an independent assessment of this project. The assessment, conducted by Dr Norman Haste, a retired construction manager for the public sector with a long experience in large nuclear and conventional megaprojects, will be concluded with a report within early 2016. The assessment was designed to look into the management of the interactions between F4E and IO and the management effectiveness of F4E on the related contracts, while identifying the main reasons for the difficulties that have been encountered so far, and proposing measures to overcome them. F4E has already started to address issues outlined in a preliminary draft report and a specific assessment of the Architect Engineer was also launched. On that basis, work will continue in 2016 to address as much as possible all those issues which can still cause escalations of the costs.
2. On the cost increases on the in-vessel components: conscious that these are not necessary for the planned First Plasma scope but only needed for the finalisation of the construction phase scope, F4E has so far blocked the signature of any related Procurement Arrangement and has initiated, together with the IO relevant sections, a review of design with the objective to reduce costs back to their original values.
3. While on the whole ITER project institutional set up F4E is not in a position to be a pivotal and deciding actor, still F4E can, though the activities set out in its own action plan, complement and support the ITER DG in the reform of the ITER project. These are the subject of the next chapter.

5. Performance and Management of F4E

5.1 Introduction

In the 2014-2015 period covered by this report there have been a number of important changes which have an impact upon the performance and management of both the ITER IO and F4E:

- At an Extraordinary Meeting held in Paris in March 2015, the ITER Council appointed Dr Bernard Bigot as the next Director-General of the ITER Organization, succeeding Prof Osamu Motojima;
- The former Director of F4E (Henrik Bindslev) tendered his resignation in November 2014 and Pietro Barabaschi (the Head of F4E's Broader Fusion Development Department) was appointed as acting Director and took up his duties 1 March 2015;
- Both Bernard Bigot and Pietro Barabaschi presented Action Plans to their respective supervisory bodies (the ITER Council and F4E's Governing Board) which were endorsed and set out a number of important measures which are described below;
- The European Commission, representing Euratom in the ITER Council and F4E's Governing Board transferred the operational responsibility for ITER from the Directorate General (DG) for Research and Innovation to the DG for Energy;
- Finally, in October 2015, Johannes Schwemmer was selected by the Governing Board as new F4E Director and is expected to take up his duties in January 2016.

All of the above have had certain impacts on the performance and management of both the ITER IO and F4E which are on-going. It is clear that the proposed reorientation of the organisations will take some time to settle and it is not yet possible to draw conclusions of their effectiveness.

5.2 2015 Action Plan of the ITER Organization

5.2.1 Proposed Actions

On 5 March 2015 the ITER Council (at which Europe is represented by the Commission), appointed the new Director General (DG) of the IO (Dr Bernard Bigot) and endorsed an Action Plan (AP) which he had prepared in the wake of ITER's 2013 Management Assessment. ITER's Action Plan which had identified a number of weaknesses. The ITER 2015 AP proposed to set up a new organisation characterised by a profound integration of the Domestic Agencies (DA) and the IO's Central Team (IO-CT). Specific actions included:

- Creating an Executive Project Board (EPB) composed of the IO DG and the DAs to allow for centralised and rapid decision-making on technical matters;
- Setting up common Project Teams (PTs) of managers and staff from the IO-CT and DAs for specific areas and facilitating greater exchange and mobility of staff.
- Establishing a new Reserve Fund to compensate DAs for cost increases that are incurred due to changes of the initial technical specifications by the IO-CT;

5.2.2 Progress Made

- At the time of writing, the Terms of Reference (ToR) for the EPB were approved and fifteen meetings have taken place since its establishment, approximately every two weeks. The EPB adopted its terms of reference following a final consultation with the DA Heads, including F4E. F4E is represented in the EPB by Jean-Marc Filhol, Head of the ITER Department. F4E considers that the EPB is working well as a forum for quicker decision-making among the IO-CT and the DAs. In particular, the EPB has been playing an important role in the treatment of Project Change Requests (PCRs) and the associated implementation of the Reserve Fund as described below;
- In July 2015 the Buildings, Infrastructure and Power Supplies Project Team (BIPS PT) was established and brings together 64 members of staff from the IO-CT and F4E. F4E has provided 38 members of staff from the Project Team of Site Buildings Power Supplies and from the Legal, Contracts and Procurement, Technical Support Services and Planning Units. he ITER DG also initiated Project Teams (PTs) for Resource Loaded Schedule and Baseline (RLSB), Buildings, Vacuum Vessel, the Toroidal Field Coil and Cryogenics. The ITER DG appointed Chang-Ho Choi as Project Team Leader for the Vacuum Vessel (VV) PT, in which F4E's VV team is integrated. However, while the VV PT is advanced, as of end-October the Terms of Reference for the BIPS PT have not yet been approved by both the IO-CT and F4E;
- The ITER Council approved the creation of the Reserve Fund at its Extraordinary Meeting held on 5 March 2015. The purpose of this new fund was to create a common account that could be used to implement design changes in a timely way to prevent further schedule slippage and cost overruns. In order to generate an initial balance, funds were transferred from the IO Reserve, "ADI and Cost Risks not yet included in the Baseline," and the Additional Resources amounting to 115.3 kIUA identified by the ITER Council at its Extraordinary Meeting held on 28 July 2010. The Terms of Reference and the Reserve Fund Management Plan were approved by the ITER Council. These two documents govern the scope for which money from the Reserve Fund may be allocated as well as the way that decisions are made. An initial Reserve Fund balance of 186.14869 kIUA or 314.6 M€ was created through combining three previously separate funds. Since March, 16 PCRs requesting funds from the newly-created Reserve Fund have been considered by the Configuration Control Board (CCB). Cost estimates have now been provided and substantiated for 12 of the 16 PCRs, totalling 17.28190 kIUA or 29.2 M€. The CCB has also provisionally recommended a further four PCRs for implementation, pending validation of cost estimates in accordance with procedure. The current indicative cost claimed by the DAs with respect to these PCRs equals 36.5040 kIUA, or 61.7 M€. This means that 90.9 M€ out of 314.6 M€ (just under 30 %) of the current Reserve Fund is already earmarked.

5.3 2015 Action Plan of F4E

5.3.1 Proposed Actions

During the Governing Board (GB) meeting of 19 March 2015, the F4E Acting Director presented the 2015 F4E Action Plan (AP). The GB endorsed the main principles set out in the AP, in particular, the measures to support the creation of a new integrated organisation as envisioned by the new ITER Director General. The GB also asked the F4E Director to proceed with the implementation of the AP and report regularly on progress which was done at the June GB meeting. Many of the measures foreseen in the AP are in response to the findings of the Third (2013-2014) Independent Assessment of F4E which was transmitted to the Council in January 2015. Aside from the measures directly in support of the ITER AP, the main elements of the F4E AP are as follows:

- Encouraging the transfer of F4E staff from Barcelona to Cadarache where one can expect added value from the co-location of teams with the IO. Closely linked with this action is the integration of IO staff Into F4E processes which should bring about improvements in efficiency, in particular for the PTs;
- Exploring the possibility to transfer (novate) contracts from F4E to the IO when this can bring about more timely decision-making and reactivity (e.g. for the management of contract deviations or changes);
- Developing a more realistic estimate of the cost at completion of the work under F4E's responsibility taking into account that many of the risks are correlated. This would be followed-up by a reinforcement of the internal fund management systems;
- Establishment of an appropriate level of risk-appetite within F4E to ensure that there is a consistent understanding of the level of acceptable risk across the whole organization. A redoubling of efforts to review and implement audit recommendations;
- Implementing an Earned Value (EV) system using the ITER Credit Allocation System (CAS) so as to allow the supervisory bodies of F4E to have a better picture of project progress;
- Redeploying F4E staff to high-priority areas and reinforcing the on-site supervision of work at the site of contractors who are fabricating components;
- At the organisational level, the AP proposed the creation of a new department to reinforce project management infrastructure and project control including cost control. The appointment of a deputy for the ITER Department was also proposed;
- Finally, it was pointed out that F4E does not have an Enterprise Resource Planning (ERP) system in place and that this was leading to inefficiencies in the management of the organisation in particular for the management of contracts and cost.

5.3.2 Progress Made

Taking into account the appointment of the Acting Director in March 2015, there can only be an interim report on progress until the end of the period covered by this report. Nevertheless, the following can be noted:

- Various actions are being taken to pave the way for the orderly transfer of teams to Cadarache with focus on those teams involved in ITER plant systems where one can expect added value from their co-location. This is being done in close consultation with the Staff Committee. Relocation plans for three teams from the ITER Department where efficiency gains from relocation can be expected have been developed: Poloidal Field Coils, Cryoplant and Test Blanket Modules (TBM). The TBM Project Team Manager has already relocated to Cadarache along with six other staff members from different teams since March 2016. However, progress on the establishment of the PTs by the IO-CT has been slower than expected which has in turn not allowed some relocations to proceed as anticipated. The Head of the ITER Department will relocate to Cadarache in January 2016;
- As already mentioned above, two PTs have been established by the IO and F4E is fully involved in them. Efforts are now being focused on improving the integration of IO staff into F4E's processes and vice-versa in order to integrate processes that were previously carried out separated in F4E and the IO, shorten the time required for such processes and thereby contain costs;
- During its meeting on 6 May 2015, F4E's Audit Committee (AC) noted the draft discussion paper from F4E setting out a possible statement of F4E's risk appetite and appreciated the

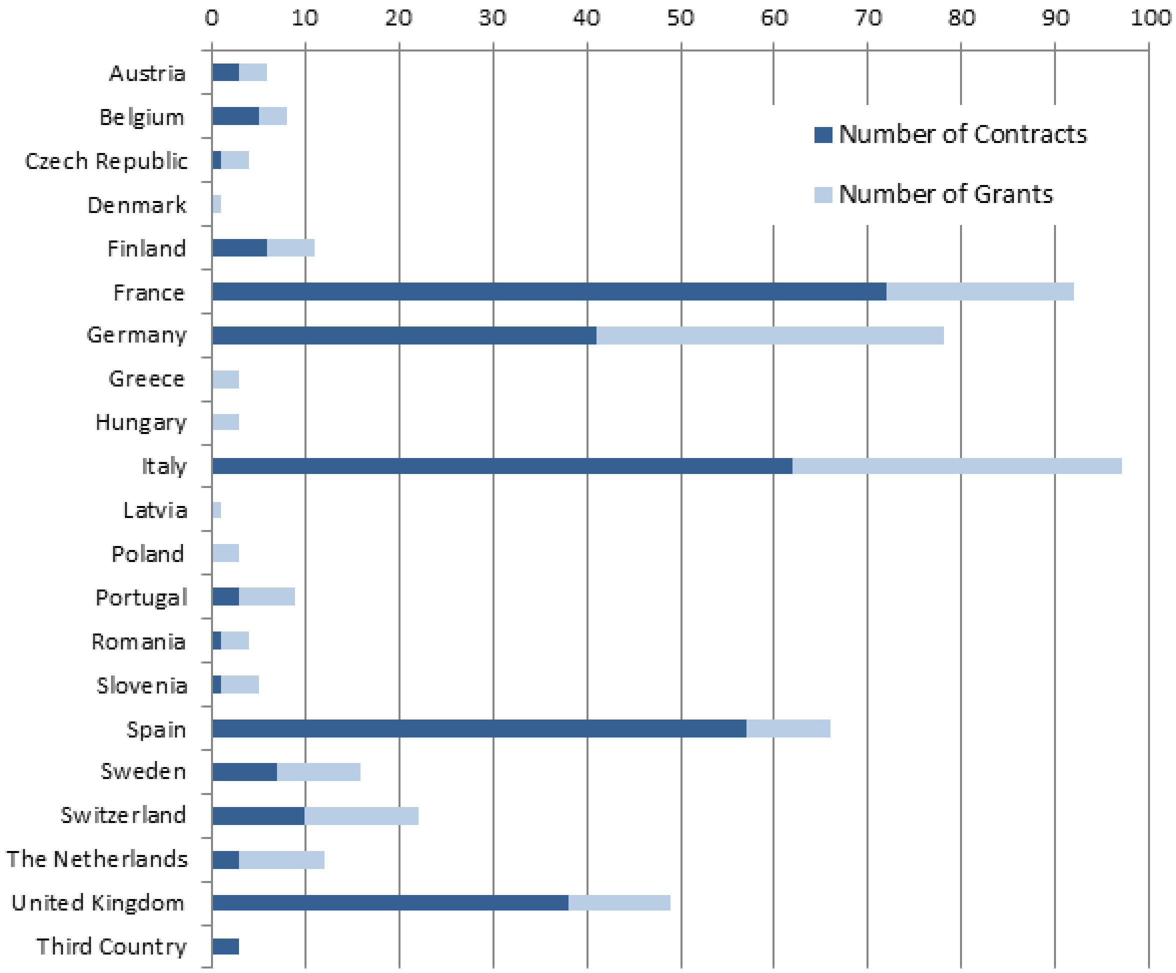
value of trying to ensure that there is a consistent understanding of the level of acceptable risk across the organisation. The AC supported the proposal of the Director to include practical examples of how the risk appetite translates into daily decisions that F4E's managers and staff face and recommended that the risk appetite statement be considered together with the wider risk management systems including the corporate risk register. The risk appetite was subsequently one of the main topics addressed at a retreat of F4E's senior and middle managers (some 30 persons) at end-June 2015. The AC will return to this topic at its next meeting in February 2016;

- During its meeting on 6 May 2015, the AC appreciated that there has been a lack of analysis in F4E which may have led in the past to actions being agreed to implement audit recommendations without thoroughly analysing the resource implications. The AC encouraged F4E to continue reviewing outstanding audit actions, assess their relevance and evaluate the residual risk so that AC may agree that they be closed. In relation to outstanding audit actions, the AC was examined examples which required allocation of significant human resources that may otherwise be devoted to core business activities and supported F4E's proposals to suspend/re-prioritise them. In relation to already implemented audit actions, the AC (a) appreciated that the evolution of the environment (e.g. the ITER and F4E 2015 Action Plans) may render some already implemented actions obsolete or inappropriate, (b) invited F4E to consult the IAS and the IAC, as appropriate and (c) in case the internal auditors are not content with F4E's proposal, to bring it to the attention of the AC. Since the June Action Plan Progress Report F4E has continued to advance its implementation of audit actions and as of end-October F4E has implemented >90 % of actions and >90 % of recommendations from the outstanding six internal audits;
- An Earned Value (EV) reporting using ITER Credit Allocation System (CAS) was implemented in June 2015 and is available to all staff by F4E's integrated reporting system. Steps are now being taken, in collaboration with the IO, to modify the profile of the CAS so as to allow an even better appreciation of the progress of work;
- An analysis of the 63 vacant positions has been completed and it was decided to focus on reinforcing high priority areas. As of mid-November, almost all the recruitments which took place so far in 2015 reinforced the operational areas and the majority of these new recruits possess industrial experience. Furthermore, an internal mobility policy has been put in place in order to be able to rapidly fill in critical areas in need of human resources. Finally, in 2015 the positions allocated to the Vacuum Vessel and Site, Buildings and Power Supplies Project Teams and to the Nuclear Safety and Quality Unit have been considerably increased;
- On-site supervision of manufacturing work at the site of the contractors has been ramped-up since 2013. Aside from the site and buildings where F4E was already co-located with the contractors, the level of supervision of work associated with the magnets in Italy and China has continued. For the Vacuum Vessel (VV), in 2013 there were 38 individual visits for a total of 184 person-days, 2014 saw the number of visits rise to 268 person-days and in 2015 the number is projected to be 1100 person-days and the number of external inspectors has increased to seven. There are also some F4E staff members based full time at the site of industries working on the magnets and VV. F4E understands that the external assessors will report to the GB and Council on their satisfaction on the way in which F4E has responded on this aspect.

5.4 Contracts and Procurement

During 2014, a total of 71 operational procurement procedures were launched and 61 procurement contracts were signed to the value of about EUR 391 million. Major operational procurements were awarded and signed in the area of Magnets and Remote Handling but significant procurements were also signed in relation to Buildings, In Vessel and Diagnostics.

Geographical distribution of awarded contracts and grants (Number in the period 2008-2014)



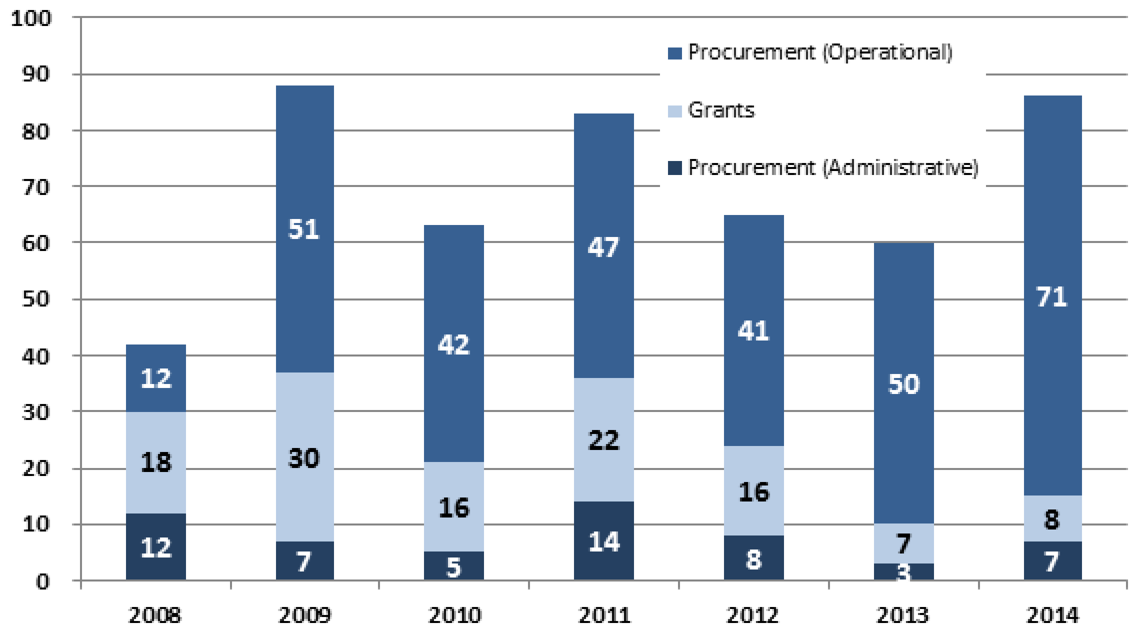
5.5 Financial Management

Due primarily to the unrealistic overall schedules that were defined the level of the ITER Council since the inception of the ITER Project and an over-optimistic planning on the part of F4E execution of the budget, implementing the annual budget has been a challenge. In particular, the implementation of the budget has often relied upon the timely signature of large contracts.

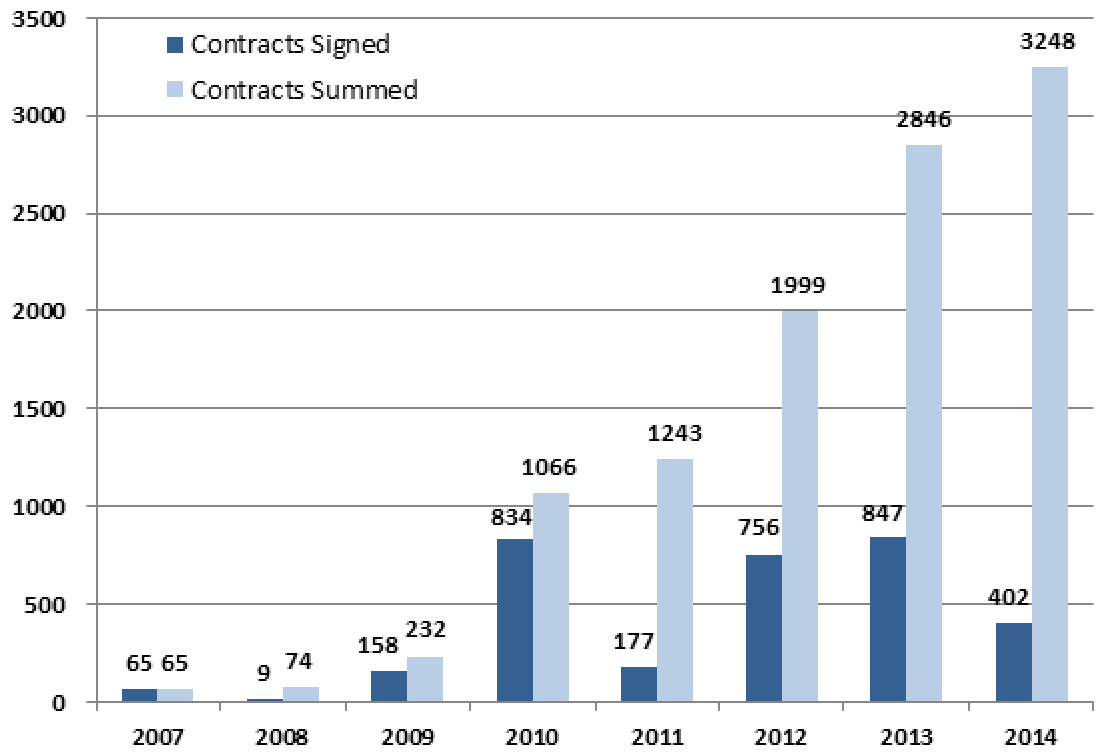
The following graph the historical evolution of the budget execution for commitments and payments is shown. One can witness that there has been a steady improvement in the ability of F4E to achieve the outturn of payments. Nevertheless it should be noted that the achievement of high levels of implementation for commitments has often relied up the earmarking of such commitments to the following year (the so-called global commitments).

To reduce the reliance on the use of global commitments and to move towards a more realistic financial planning, F4E has worked in close collaboration with the Commission during 2015 and agreed upon the postponement of some EUR 500 million of commitment appropriations from 2015 to later years in the current financial framework. This has been formalised through an amendment of F4E's 2015 budget which was approved by F4E's Governing Board in June 2015.

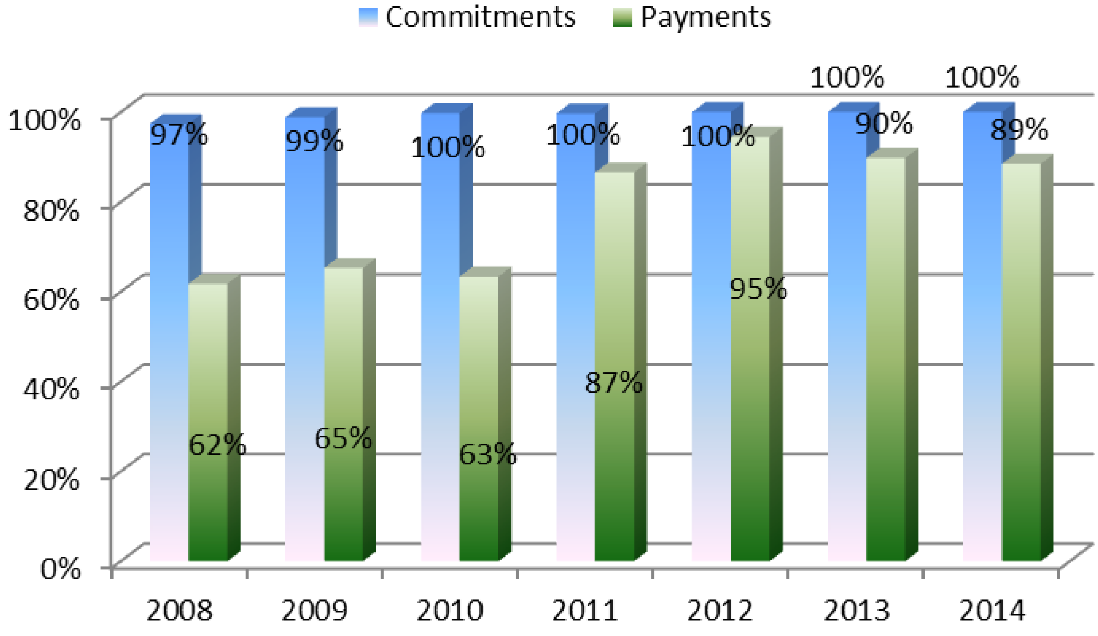
Procurement and grant procedures launched (number – excluding Task Orders)



Annual and cumulative value of contracts and grants signed by F4E



Historical Implementation of F4E's budget in commitment and payment appropriations



5.6 Management Systems

In response to the Council requests, the F4E Director proposed ways to improve the management system and in particular the project management system (paper F4E(10)-GB17-07), which was approved by the GB on 5th October 2010. The management systems in F4E needed to be changed for two main reasons:

a) The approach to project management within F4E needed to be improved to cope with the complexity and scale of the European part of the ITER construction;

b) The other processes in F4E also needed to be improved; to some degree they were bureaucratic and inefficient, or not in place.

This need has been addressed through the implementation of a wider initiative (F4E Integrated Management System) covering the whole Management System and addressing the two control environments in which F4E operates - the ITER-wide Quality System which is intended to ensure the performance of ITER and the compliance with the nuclear safety requirements, and the EU Internal Control Standards.

The main progress made during the period covered by this report may be summarised as follows:

- In July 2015 and following a Staff Engagement Action Plan requiring 'the rationalisation of the F4E working procedures, F4E decided to simplify the Sign-Off Authority Policy (SOAP) to enhance its decision making process and reinforce the process ownership responsibility. This exercise also aims at simplifying the process when appropriate to ensure further efficiency gain in managing our activities (see section 5.7 of the report);
- A policy on Evaluation in Operational Procurement Procedures was adopted in September 2015 and an optimisation of the related procurement processes was done by updating and simplifying the impacted procurement processes;
- F4E has started the Contract Management improvement exercise that includes the merge of the processes for managing deviations and amendments into an integrated process. This

allowed the development of an electronic tool for the management of the Contract Modifications and the traceability of any contractual changes in the future. This important improvement also includes the adaptation of the related policies and processes for the development of the tool and then for the release in the first quarter of 2016;

- In relation to the enhancement of the Integrated Management System, F4E is being updating its Standards in line with the revised ISO9001/2015. This process will also take into account the recommendations for simplification suggested by the management assessor in 2014. This exercise is expected to be completed by the beginning of 2016 and will be presented to the Audit Committee in its meeting of February 2016.

5.7 Project Management Systems

The main progress made during the period covered by this report may be summarised as follows:

- The F4E Integrated Reporting System (IRS), first deployed in October 2012, allows users (all F4E staff) to access standard reports directly from the F4E intranet, providing high quality, consistent reports based on a controlled data set maintained in a central data warehouse. Most of these reports are interactive allowing the user to filter the data live within the system and to drill down to more detailed reports where more detailed investigations are required. In total there are currently about 250 standard reports available. In addition to the standard reports available, trained users are also allowed to create bespoke reports by directly creating queries on the data warehouse;
- Development of a new cost estimate at completion (EAC) at Level 6 of the Work Breakdown Structure (i.e. contract level) to also include cost risks with their correlations.
- Earned Value (EV) reporting through ITER Credit Allocation System (CAS) is available. A modification of the credit allocated to specific milestones is now in progress, in collaboration with IO, to be more in line with the true progress of work;
- As far as Fund Management is concerned, the Acting Director has provided the new ceilings of budget to the units based on the results of the EAC exercise and considering the overall ceiling of 6.6 B€ until 2020. The data is stored in the Cobra system and will be queried prior to every new commitment;
- Almost all Procurement Arrangement (PA) technical risk tables have been migrated from Excel to the Oracle system, thus allowing linking the risks to the activities. This step allows the IRS to provide reports out of risk data. The first reports are already available;
- Processes and procedures have been developed for the inclusion of payment data, at an appropriate level of detail, into the planning system to facilitate budgetary planning of payments. The system is already in use since a few months to provide the required data;
- F4E schedules have been managed under change control with all changes to the F4E Performance Baseline subject to review. A total of about 480 changes have been considered up to now;
- A new Contract Management Platform has been released by F4E to support the planning, execution and monitoring phases of F4E contracts, with an approach in line with the F4E Quality Assurance policy. It provides a workspace to develop, release and sign off the schedule baseline, to report the contract progress and to support the contract implementation; exchanging quality and technical documentation, tracking commercial correspondences and managing action lists and meetings. Use of the platform is now mandatory at least for management of documentation exchanges and of the top-level control plan for all contract

procedures initiated after mid-November 2015 with estimated values above the financial threshold for negotiated procedures.

In conclusion, an Integrated Management System is largely in place and is being continuously improved to support the F4E Control environment.

5.8. Monitoring and Control Systems

Monitoring and control actions are in place in order to follow the evolution of the projects within the organisation and anticipate any possible issue that requires the intervention of Senior Management.

At organisational level:

- Every two weeks a Senior Management (SM) meeting is chaired by the Director and involves the Heads of Departments and their Deputies. The meeting split into two parts: the first part with the SM only and the second part is extended to include the other Unit Heads that report to the Director (e.g. Management Systems and Organisational Improvement Unit, Communication and Stakeholder Relations Unit) and the Commission;
- A Monthly Monitoring Meeting takes place with the participation of the Director, the SM, the Unit Leaders and all other required key actors in the organisation. The aim is to report on the evolution of the project as far as schedule, risk, cost and budget implementation are concerned and also to identify specific issues that need SM attention;
- The Management System and Organisational Improvement Unit in the PMIC Department oversees the Internal Control environment and provides support to the Senior Management contributing to the “assurance chain” to provide to the F4E Director and external stakeholders reasonable assurance on the state of Internal Control in F4E;
- An F4E Assurance Board has been set up within the organisation to support the assurance chain within the organisation and ensure that the weaknesses identified in relation to the compliance issues are addressed enhancing the Control environment. The Assurance Board also plays the role of “Internal Knowledge Management Body” discussing and sharing issues and challenges the F4E administrative and financial services are addressing in supporting the Project Team in implementing the operational activities. This internal body aims at enhancing the functioning of the F4E matrix structure.

At project level:

- The progress of the ITER work as a whole is monitored on a monthly basis at the Project Performance Review meeting which involves all 8 actors (IO and 7 DA’s). The progress of the project is analysed at this meeting with specific focus on those milestones that are not being achieved on time and their proposed mitigation and recovery actions;
- Following the action plan proposed by the ITER DG, common Project Teams (PTs) of managers and staff from the IO-CT and DAs are being implemented for specific areas thus facilitating greater exchange and mobility of staff;
- As in the past, every month the F4E Detailed WBS Schedule is sent electronically to the ITER Organization, which integrates it into a single environment that allows detecting inconsistencies and delays due to interface issues. The results of such integration are sent back to F4E and the impact is internally analysed and taken into account for reporting at different levels.

5.9 Assessment of Organisational Performance

In June 2013, the Director promoted a further decentralisation of the financial and administrative delegations and responsibilities to the senior and middle management of F4E. In parallel, controls have been strengthened in order to compensate for the increased decentralisation. Furthermore, processes, procedures, templates and model contracts have been standardised. Paperless workflows have also been developed paving the way to implement an electronic workflow towards the end of 2014 for all financial transactions.

In May 2014, a first assessment was performed to compare the processing time for a range of key procurement processes before and after implementation of the changes introduced in June 2013. The preliminary outcomes showed a significant efficiency gain in term of the number of days to perform the financial and procurement activities before and after increased decentralisation in June 2013.

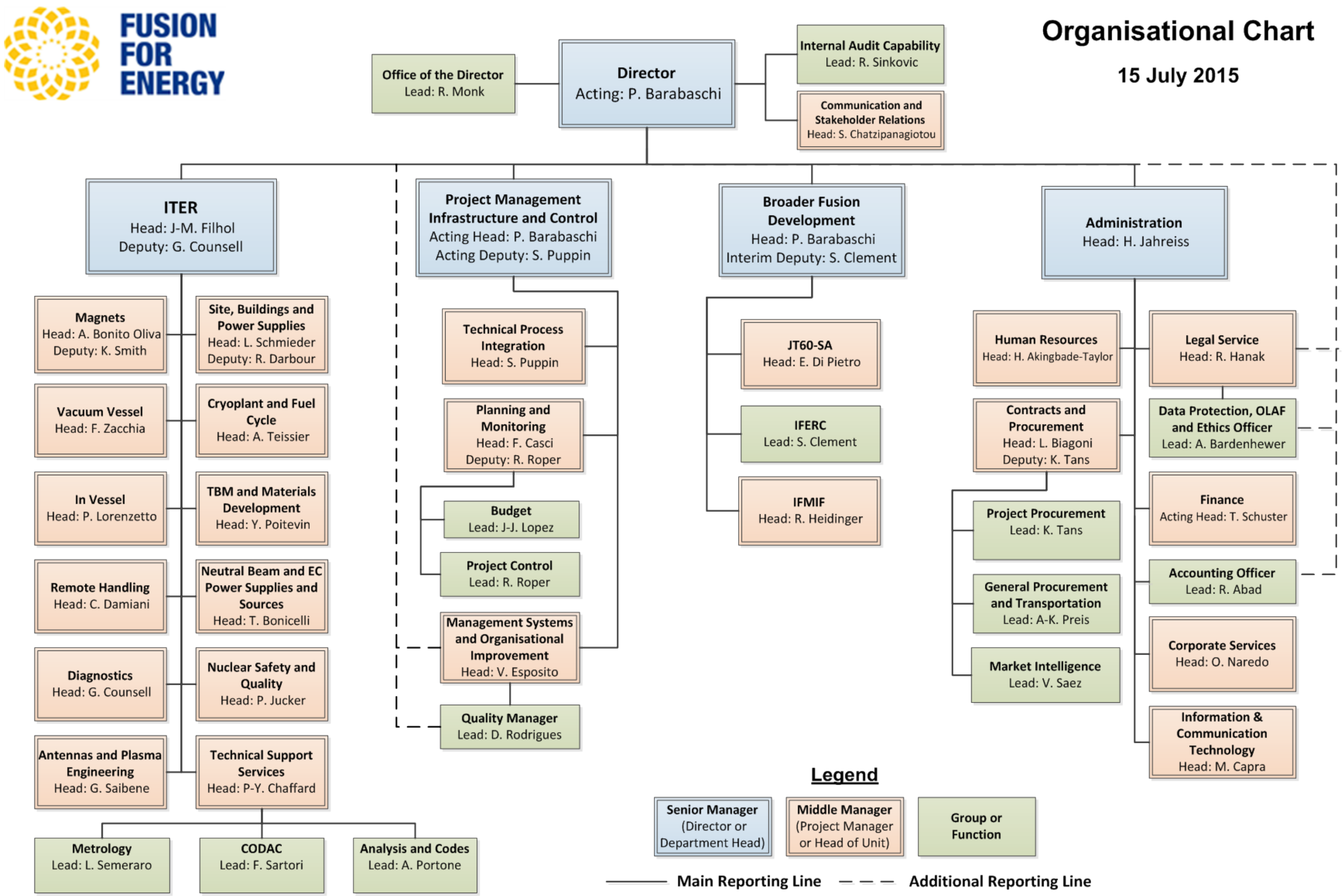
Since then a more detailed analysis of data from 2013-2015 has been performed which has revealed that a simple statistical analysis in terms of averages is not suitable for some of the datasets related to procurement processes. Taking data in the 95 % confidence interval[5], the time between approval of the technical specifications and call publication remained constant, while for the time between submission of tenders to completion of the evaluation worsened (the reasons for this are being investigated). Nevertheless, one of the main improvements in 2014 (the reduction of time from completion of the evaluation complete to contract award) has been confirmed in 2015.

Considering financial transactions which are subject to less statistical variation that the procurement processes, the positive effect of increased decentralisation observed in 2014 has been confirmed with the data from 2015. In particular, pre-financing payments continue to be executed ~45 % more quickly in 2015 and 2014 compared to 2013. Payments related to delivered goods and services continue to be processed ~20 % more quickly in 2015 and 2014 compared with 2013.

Finally, it has to be noted that efficiency strongly depends on the nature of the processes which need to adhere to the F4E financial regulations. As these are largely based on the framework financial regulation defined at EU level which foreseen a mandatory number of controls to be embedded in the processes, there is a limitation on the level of efficiency which can be achieved within F4E.

Nevertheless, F4E is continuously enhancing its decision making process and has launched a set of simplification exercises which will be completed with the update of policies and processes to be aligned with the new Financial Regulation and its implementing rules that will enter into force in January 2016.

[5] Validated during the 2014-2015 Annual Assessment of F4E as a reasonable approach

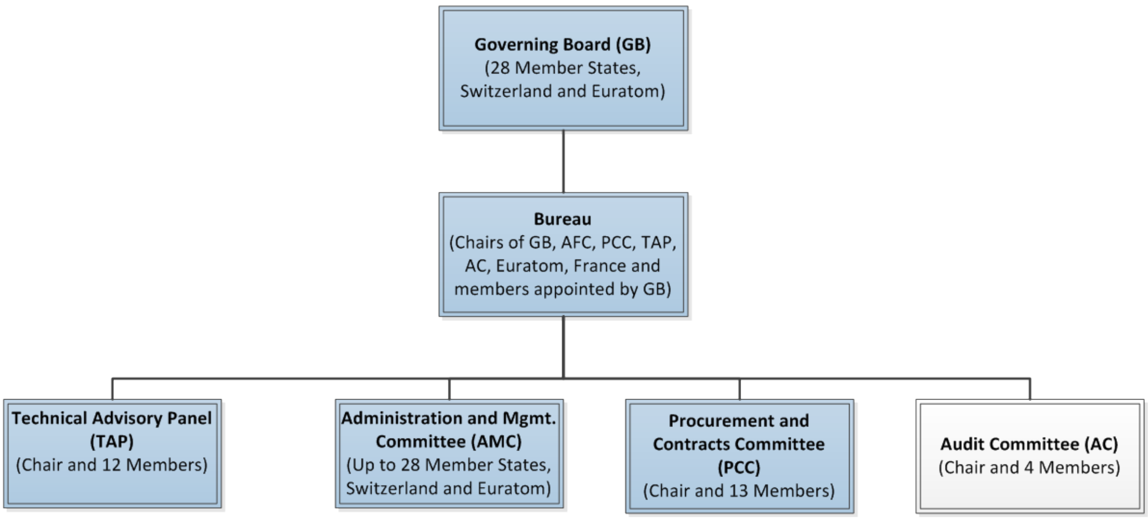

FUSION FOR ENERGY
Organisational Chart
15 July 2015
Director
Acting: P. Barabaschi
Office of the Director
Lead: R. Monk
Internal Audit Capability
Lead: R. Sinkovic
Communication and Stakeholder Relations
Head: S. Chatzipanagiotou
ITER
Head: J-M. Filhol
Deputy: G. Counsell
Magnets
Head: A. Bonito Oliva
Deputy: K. Smith
Site, Buildings and Power Supplies
Head: L. Schmieder
Deputy: R. Darbour
Vacuum Vessel
Head: F. Zacchia
Cryoplant and Fuel Cycle
Head: A. Teissier
In Vessel
Head: P. Lorenzetto
TBM and Materials Development
Head: Y. Poitevin
Remote Handling
Head: C. Damiani
Neutral Beam and EC Power Supplies and Sources
Head: T. Bonicelli
Diagnostics
Head: G. Counsell
Nuclear Safety and Quality
Head: P. Jucker
Antennas and Plasma Engineering
Head: G. Saibene
Technical Support Services
Head: P-Y. Chaffard
Metrology
Lead: L. Semeraro
CODAC
Lead: F. Sartori
Analysis and Codes
Lead: A. Portone
Project Management Infrastructure and Control
Acting Head: P. Barabaschi
Acting Deputy: S. Puppin
Technical Process Integration
Head: S. Puppin
Planning and Monitoring
Head: F. Casci
Deputy: R. Roper
Budget
Lead: J-J. Lopez
Project Control
Lead: R. Roper
Management Systems and Organisational Improvement
Head: V. Esposito
Quality Manager
Lead: D. Rodrigues
Broader Fusion Development
Head: P. Barabaschi
Interim Deputy: S. Clement
JT60-SA
Head: E. Di Pietro
IFERC
Lead: S. Clement
IFMIF
Head: R. Heidinger
Administration
Head: H. Jahreiss
Human Resources
Head: H. Akingbade-Taylor
Legal Service
Head: R. Hanak
Contracts and Procurement
Head: L. Biagoni
Deputy: K. Tans
Data Protection, OLAF and Ethics Officer
Lead: A. Bardenhewer
Project Procurement
Lead: K. Tans
Finance
Acting Head: T. Schuster
General Procurement and Transportation
Lead: A-K. Preis
Accounting Officer
Lead: R. Abad
Market Intelligence
Lead: V. Saez
Corporate Services
Head: O. Naredo
Information & Communication Technology
Head: M. Capra
Legend
Senior Manager (Director or Department Head)
Middle Manager (Project Manager or Head of Unit)
Group or Function
Main Reporting Line
Additional Reporting Line

5.10 Governance

On 10 February 2015 the Council adopted amendments to the statutes of F4E upon the proposal of its GB to provide voting rights for Croatia and to make improvements to the governance structure[6]. The main changes to the existing governance arrangements were as follows:

- The **Administration and Management Committee (AMC)** was established to prepare opinions and recommendations to the GB on the budget, resource estimates plan, annual accounts, the project plan, the work programme, etc. This is very similar to the remit of the previous Administration and Finance Committee (AFC) but the GB may now delegate tasks to the AMC should the GB choose to do so. The AMC is composed of representatives from the members of the GB;
- The **Procurement and Contracts Committee (PCC)** gives recommendations to the F4E Director on the award of contracts. It has an advisory role, unlike the previous Executive Committee (ExCo) which had an approval role but which was deemed by subsequent audits to infringe upon the responsibilities of the F4E Director. The "upstream" role of the ExCo to review procurement strategies will continue with the PCC. The other tasks concerning the budget etc. currently entrusted to the Executive Committee are re-allocated to the AMC. The PCC is composed of experts acting in a person capacity;
- The **Bureau**, a committee that helps to prepare GB meetings and originally set up by a decision of the GB in 2011, is now specifically defined in the statutes. The main differences from the present Bureau are that the GB may appoint additional members to those already participating and the GB may delegate tasks to the Bureau.

In March 2015 the GB adopted a number of decisions to give effect to the amended statues including adopting the rules of procedure for the new committees and delegating the approval of certain GB decisions to the AMC in order to allow the GB to focus on more strategic matters. The GB also decided to reinforce measures to minimise and manage any potential conflicts of interest in its committees in line with the best practice of other European agencies. The new governance structure is shown in the schematic below.



[6] Decision 2007/198/Euratom

Annex 1: 2015 ITER Action Plan

Action Plan 2015

Foundations for a new phase of ITER

Proposed by Bernard Bigot, DG nominee, January 2015

Abstract

In its November 2014 meeting, the ITER Council requested Mr. Bigot as Nominee Director General to submit to the IC, no later than February 1st 2015, his action plan to deal with pending issues in ITER. In response to the request, this action plan first considers the analysis of the present situation based on the information collected in the last 2 month period. Major changes of the general processes and overall management are overwhelmingly required from all the received analyses. The ITER Project is unique not only for its extremely challenging technical and scientific aspects but also for the complex in-kind procurement arrangement with DAs having most of the financial resources. In the recent past, there have been numerous blockages, duplication of effort and profound inefficiencies caused by confusion on determining who from IO and DAs had the legitimacy for making changes on the initial design and who should pay for them. This action plan thus proposes **a new organization characterized by a profound integration of the DAs and the CT (central team)** in all major central decisions on technical matters of the ITER Project. Emphasis is placed on the **key role of the new Executive Project Board, chaired by the DG controlling a cost effective Central Fund and on building strong transverse activity units** also including DA staff directly. Special attention is paid to highly unusual aspects, generic to the tokamak, which imply a complex integration of different systems, each one with its own technological and innovative issues. This has important implications for the global project organization and on the way transverse activities are organized. At all stages, the proposed organization is totally project oriented and it is **mandatory that IO-CT staff represent at all time the project and not their original institution**. Finally, the action plan lists a series of major decisions required for setting up this new organization. **The DG nominee requests that the Council endorse them and actively support the implementation of the new organization, which should be in place within one year. At the same times, he would establish a robust resource loaded schedule based on a revised baseline with the explicit commitment of all the stakeholders**. **The DG nominee feels that he could only accept the extremely challenging directorship of the global ITER project and commit himself to fulfill the agreed scope and schedule if these plans were wholeheartedly accepted by all the ITER stakeholders**.

1. Introduction

In November 2013, the ITER Council during its thirteenth regular meeting "*insisted on the need to take urgent actions in response to the recommendations in the 2013 Management Assessment Report (2013 MA)*". In February 2014, during an extraordinary meeting, "*The ITER Council responded to all of the recommendations of the 2013 MA and took note of the*

Action Plans developed by the ITER Organization and the Council Preparatory Working Group (CPWG) in response to the recommendations". In November 2014, the fifteenth regular ITER Council requested *"Mr. BIGOT as the Nominee Director-General to start the preparatory work that he would require and to submit to the ITER Council, no later than 1 February 2015, his action plan outlining how to deal with pending issues including the acceleration of the pace of the project execution and completion of the project in a timely fashion".* In the following two month period, many persons were consulted and many contributions and recommendations were received. The evaluation emerging from these extensive consultations, regarding the difficulties experienced, so far by the ITER project is unanimous and coherent. It is summarized in the first half of this document and leads to proposals for major changes in the project management and the global ITER Organization which are given in the second half. The ITER Council is requested to endorse these changes and support actively their implementation. In fact, the ITER design is very challenging: the systems and the relationships implemented between IO-Central Team (CT) and DAs which are supposed to deliver jointly the largest research facility ever built are complex: the electromagnetic and thermal loads are huge, the requirements on tolerances are demanding, the QA/QC requirements are very strict, etc.

Not trying to be an alarmist, I judge the situation with respect to execution of the ITER project to be worrisome. The complexity and potential inefficiency of the over 90% in-kind contribution scheme have been considerably underestimated. Without significant change in the organizational structure, as well as the functioning and working methods, within the rules defined in the Joint ITER Agreement (JIA), the future of the project will be seriously compromised. On the other hand, I am convinced that all actors in the Project have now recognized that it is the last opportunity for accepting this change; therefore, if all unite to join in a well-organized collective effort, I see no fundamental reason why the Project, whose objectives remain appealing and well supported, could not be put on the right track to limit its cost increases and schedule delays enabling full success.

2. Difficulties in the present ITER Project Management

The 2013 Management Assessment (MA) has identified a substantial list of missing, inappropriate or inefficient functions in the present management processes of the ITER Project. This evaluation has been validated by the Council as well as by the consultations of many stakeholders that were conducted during the last two months. The project faces at once management issues, project issues and technical issues.

<u>To sum up the evaluation:</u>

<u>a)</u> The overall governance of the project should be improved by addressing the difficulties outlined in the MA 2013 report. Not only should measures be taken to create a closer link between the DG and the IC, but also to strengthen the operation of the IC as a governing board for addressing the financial and technical issues inherent to in-kind procurement.

b) There is a lack of management and overall coordination of the project. Even if IO is theoretically the prime contractor of the project, it is not presently in a situation to act as such. It does not have really the power to control the work assigned to the DAs and there is not an effective operational management structure enabling the IO and DAs to arbitrate disputes (technical, planning, financial). In the end, the project is not really managed but is a loose collaboration of competing interests. The management structure encourages a silo behavior, in which lower levels of the structure operate too independently. Decision making is slow, responsibility is diluted and the chain of command is diffuse.

c) There is no effective project culture: The collective teamwork operation, flow of ideas, rapid decision-making, clear definition of boundaries and responsibilities, existence of measurable and achievable goals that mark out the progress of the project, knowledge by all of the objectives, shared transverse methods of working, reference configurations, evaluation of the organization to meet context changes, movements between teams, importance of planning and costs and everything that makes a project culture effective is not present, or if so, inadequate. In a nuclear project like ITER, it is also essential that all parties have the appropriate safety culture, and this is also lacking.

d) Systems engineering: Technical integration usually includes an integrated design office, transverse functions, configuration management, interface management, system performance evaluation, database management and documentation, links with industrial partners and the like. In IO so far, the overall systems engineering does not exist.

e) The methods and project management tools do not exist or are misused. The fundamentals of project management are to control the definition, work scopes, configuration, interfaces, risks, performance, schedule, and cost. To get there, standard methods and tools are required. They do not exist at the level required for ITER, in particular for configuration and interfaces management. The tools that exist are too complicated and do not meet the real needs of the project: it is essential that this is remedied urgently.

f) The management of a resource loaded schedule which would commit all stakeholders does not exist. There is no complete useful schedule management in ITER and so there is no realistic master schedule as a reference for action. The schedule construction so far is considered by all the stakeholders as largely unrealistic because it is either purely bottom-up without overall control and direct investigation at the source, or purely top-down with unrealistic durations being specified with no chance of being met. The existing schedule representation within IO is much too complex with insufficient prioritization and lack of clear control. Gaining control, in contrast to merely monitoring, of the schedule, the backbone of any project management team, must receive a very high priority and involve all the key stakeholders. An updated schedule summary must be readily available to the DG providing overall direction and should not be submerged by a massively complex scheduling system.

This diagnosis calls for the implementation of a long list of drastic changes in the ITER management processes in order to improve the situation. A few of the most important issues are developed in the following paragraphs:

-- **Respective roles of the IO-Central Team (IO-CT or CT) and the IO-DAs and their relationship:** the IO-DAs are at the same time collaborators as well as suppliers to the IO-CT. However the IO-CT does not have the real control of the work assigned to the IO-DAs because of regular conflicts on who should have the legitimacy of bringing changes to the initial design and organization and who should finance the unavoidable modifications of the initial definition of in-kind component procurement in order to secure and optimize the assembly and operation phases. The recent creation of the ICET, a committee of executives of the IO-CT and the DAs, does help negotiations towards a faster decision, when possible. But this issue remains a conflicting one: the CT, responsible for achieving the required Project performances, may decide on design changes which in turn can increase the cost of the in-kind procurement of some of the DAs.

-- **Inside the CT, there is insufficient communication** between the groups (even with the safety Regulatory Group) responsible for the various PBS elements. Therefore each group appears to be focused on its individual goal and solutions that optimize the overall Project goals are not systematically addressed.

-- **The central management of the whole Project by the CT is particularly weak**; only two small Divisions, Project Control and Configuration Control, are in charge. In line with the preceding paragraph, these Divisions only exercise a monitoring function with no power to control and even less to manage the schedule: there is no visible Systems Engineering for the global Project, no verification that the launched procurements will satisfy the specifications and achieve the Project objectives.

2.1 The root cause of some of these difficulties is that the ITER Project is a complex integration of different systems, each one with its own technology and innovative issues.

-- This fact induces a partial isolation of the different systems from each other; they have little to share with the other systems, except the common requirement to achieve the Project operational performances in reliable and safe conditions.

-- Even the auxiliaries are specific to each system. They involve specific power supplies with widely different technologies and remarkably specific cooling systems.

-- Each system has specific safety issues of its own when operating in isolation, in addition to issues associated to its possible interactions with other systems when operating together.

-- Each system calls for a specific assembly method, control instrumentation, commissioning and maintenance process.

The highly specialized nature of the different systems results in specialization of personnel which have to focus on their system. Under the pressure for resolving the issues faced by their own system, they could easily become isolated in the global ITER Project.

On the contrary, the ITER Project will not be achieved without the full integration of these highly specialized plant breakdown systems. A parallel effort should concentrate on management aspects linked to their interactions and simultaneous operation, their coherence in performances, safety and schedule. Only this centralized effort, not organized in the present management structure, provides the opportunity to minimize the overall risks, costs and consequently the schedule by optimizing the scope of each component/system and its method of manufacture, adjusting costs to the required performances in coherence throughout the whole project.

2.2 The ITER Project is unique by its number of complex technologies

The number of large plant breakdown systems, using different technologies, is much larger in ITER than in any other project of similar importance; it drives the obligation to consider the management of the Project in two levels, at each system and at entire Project. If the lower level is not considered properly and separately, the upper level will require too many staff to assemble the necessary competences and detailed design knowledge in all the different technologies, thus duplicating what needs to exist already at the component engineering level. **Nevertheless, the need for a strong and visible Central Group managing the whole Project is critical**; it should include a dedicated core staff supplemented with part-time specific delegates from each engineering Division responsible for the plant breakdown systems. Particularly important integration issues are:

-- Permanent control of the design (hardware and functional analysis) for satisfying the required performances; analysis of remaining risks in quantitative terms before application of all mitigation measures; safety analysis;
-- Configuration control and operational interfaces with auxiliaries;
-- Assembly, Instrumentation and Control (I&C), Commissioning and Maintenance, Qualification tests;
-- Schedule and costs.

It is important to note that addressing the management of the project at both the plant breakdown systems level and at the integration level would greatly improve communication across the Project.

3. Proposed measures to resolve some of the present difficulties

3.1 The ITER Project should be built by an integrated team of the IO-CT and the IO-DAs under the leadership of the Director General

An integrated IO-CT/DA team is mandatory in order to improve efficiency, to limit duplication in the IO-CT and the IO-DAs and to avoid the CT-DA conflicts which have so often delayed urgently needed decisions in the past. This integration should be achieved at all levels of the hierarchy and in all functions of the Project, in particular in those applied to the overall Project management. A few measures are novel and are indicated below by bold letters:

-- The DG, appointed by the Council, has the global technical, ultimate responsibility and the power to make decisions for the whole Project as a Chief Executive Officer, even if the DAs have their own line management. In order to avoid conflicts between these two levels of authority, the **DAs should participate in all decisive processes in place for managing the entire Project** but should by their participation become bound by the decisions: they should remain loyal to the DG's technical decisions and no longer representative of their sole national interest**.**

-- Enlarging the role of the present ICET as a decision making body based on a consensus process, DA Heads will join the DG, the DDGs', and the CT Heads of technical Departments depending on the subject, in an **Executive Project Board (EPB).** The role of the EPB will be to support the DG in his responsibility of integrator of the whole Project and of nuclear operator, to inform the Heads of Delegations and the Council of the Project progress, to take all strategic decisions keeping the Project inside a new baseline (scope, cost and schedule) and to direct their implementation through the joint efforts of the integrated IO-CT and IO-DA teams.

-- IO-DAs should delegate some members to the **Project Control Office** (in charge of the baseline, WBS and earned value; control of schedule, costs and risks) and to the **Central Integration Office** (in charge of design control; systems engineering; configuration management; documentation), equipped with all management tools which should become, as fast as possible, common to the CT and all the DAs. Thus these DA members become fully associated to the responsibility of implementing the central functions of the whole project and are not limited to the problems associated with their national in-kind contribution. They will participate in making transparent the operation of these Offices and their conclusions largely communicated both in the CT and the DAs.

3.2 Project Teams

When an IO-DA has to provide an important in-kind procurement item to ITER, the members assigned to this realization should be integrated with the relevant IO-CT members in **a Project Team (PT), charged by the EPB to implement** for this item all sequential steps from definition, engineering, specifications for fabrication by an industrial firm of recognized qualification, until final acceptance after delivery on site. The responsibility of this chain of tasks is permanent and should be preserved by the PT even when its membership is changing in time. The leader of the PT, coming either from the IO-CT or the IO-DA, should be chosen according to his/her competences. Appointed by the EPB, he/she will report to it and inform his/her line manager. During the entire cycle, responsibility is vested in the PT, inside the limits of authority delegated by the EPB or, in case of difficulties, back to the EPB.

The only part of the chain, which remains under the sole responsibility of the IO-DA, is the administrative handling of the industrial contracts of fabrication, according to its national method (application of national rules for the choice of firm and agreement on prices); details of the technical specifications should have been established first in the PT; then, industrial proposals and relevant risks should be analyzed by the PT and conclusions advised to the IO-DA, which will decide on the choice of the industrial firm and conditions of the contract, in full respect of the technical specifications and time delivery, agreed upon in the PT.

In need of changes in the initial technical specifications (Baseline 2010) agreed upon by the PT and backed by the EPB in “the interest of the global Project”, there is no justification for the associated cost increase to be supported only by the involved DA(s), as proposed in MAC 10 guidance. This cost increase should **rather be supported by a Central Fund in the DG’s hands, contributed by all the Project stakeholders** according to their relative share to the global project. **This objective is based on the superior interest of the Project; the method is highly cost effective and prevents delays**. It provides a powerful incentive to implement the most cost effective solution to arising problems. The DG will provide the Council with an annual report on the usage of this Fund, in particular showing the spending in the best interest for the Project. This new arrangement **cannot be applied retroactively**; the support to the cost increase for all specifications changes registered until now in all contracts is assumed to be agreed upon and might be discussed again, if necessary, only among ITER Members at IC level.

Operation of these PTs will require exchange/mobility of staff between the CT and the DAs (both ways), joining the engineering resources, in particular CAD support after harmonization of IT tools, for the global optimization of the works.

Only a small number of in-kind procurement items will require the establishment of a dedicated PT, because of specific difficulties (the component is on the critical project path, for example) or complexity (many DAs involved together) or a large gap in financing a component, or for any reason which requires the involvement of the DG authority. In all other cases, progress will be the result of joint collaborative efforts of the CT and the DA staff members under the guidance of their line managers and reported to the Project Control Office.

3.3 Administration

Facilitating the two above initiatives, staff mobility and IT tools harmonization, is presently in the domain of responsibility of the Departments of Administration, which includes many different activities without functional or technical links. If Finance and Procurement Contracts can belong to one Department, the Sections on Documentation Control (in charge of IDM mostly for the benefit of technical divisions) and on System Management should be transferred (and reorganized) to the central management function of the Project.

The main issue is the role of “Human Resources” (HR Department): in a Project, its role should exceed largely the usual administrative services for a more important strategic role.

HR, in a joint agreement with the vision of technical divisions, based on the resource loaded schedule, should establish a quantitative plan of present and future competence requirements, in order to avoid recruiting on the basis of immediate needs without sufficient strategic consideration of longer timescale needs.

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; it has led regrettably in the past to recruitment of candidates not competent enough for the position to be filled. So, HR faces the new task of deploying innovative instruments for stimulating new applications of top grade candidates, in priority staff seconded, coming from the Members, their national Laboratories and large Industry. Indeed it is a matter of concern that the number of good candidates emanating through the DAs is decreasing markedly; advertising job descriptions in specialized media may improve the situation; the CT and the DA should compete for the discovery of key individuals.

Furthermore, it is estimated that a tidying up of the Staff Regulations is necessary, as they need to be simplified, clarified or completed, e.g. simplification of recruitment procedure, creation of new categories of contracts for non-staff personnel to seek more flexibility (ex. CERN project associate) while taking into account legal risks of outsourcing.

It is considered by many people that there is not enough CT staff for controlling procurements with the expertise of the manufacturing technologies, not enough specialists to perform promptly complicated structural analyses for addressing numerous detail design changes during manufacturing. Reinforcement can be done with the help of resources available in the DAs in the frame of the new global organization, e.g. the IO-CT/IO-DA integrated teams should jointly monitor manufacturing at the industry premises (such a clause should be included in the contracts which the DAs place with industry).

The two months of consultation pointed out the very high number of contractor posts vs the IO-CT staff due to the cap put on the IO-CT staff number, which is "compensated" via increasing the number of contractor posts. This has a number of deleterious consequences, namely the high turnover for the best contractors and legal risks if contractors have been active during years under the directives of the IO-CT. To the best interest of the project, contractors should be hired for routine or short term services and long term directly employed CT staff should ensure that the know-how necessary for the various phases of the project is preserved.

As a consequence, there is an urgent need to leave to the IO and the DAs the possibility to find jointly the most effective financial and technical solution (by using staff from the IO-CT and the IO-DAs in a more efficient integrated way, by hiring staff rather than contractors for strategic and permanent tasks) for the best interest of the Project.

4. Implementation

As explained in the previous chapters, it is fundamental that the DG has full authority on all technical aspects of the project; in addition he is the Chief Executive Officer of the Central Team of the ITER organization (IO-CT) and in this position, his main concern and driving motivation will always be the best interest of the ITER project. It is proposed to implement the responsibility of the DG with an organization along the lines of the charts given in figures 1 and 2.

4.1 Overall organization

The key words of the overall organization must be simplification, traceability and efficiency of its operation **and mutual trust, project loyalty and team spirit of staff relationship in the IO-CT as well as in the IO-DAs.**

At the top of the overall chart, we find the Parties overseeing the DAs, the ITER Council supervising the ITER organization, the National Institutions in charge of the National Laboratories and the ITER France Agency. The ITER France Agency implements the commitments made by France in relation to offering the construction site. Within this framework it operates the Welcome Office on site.

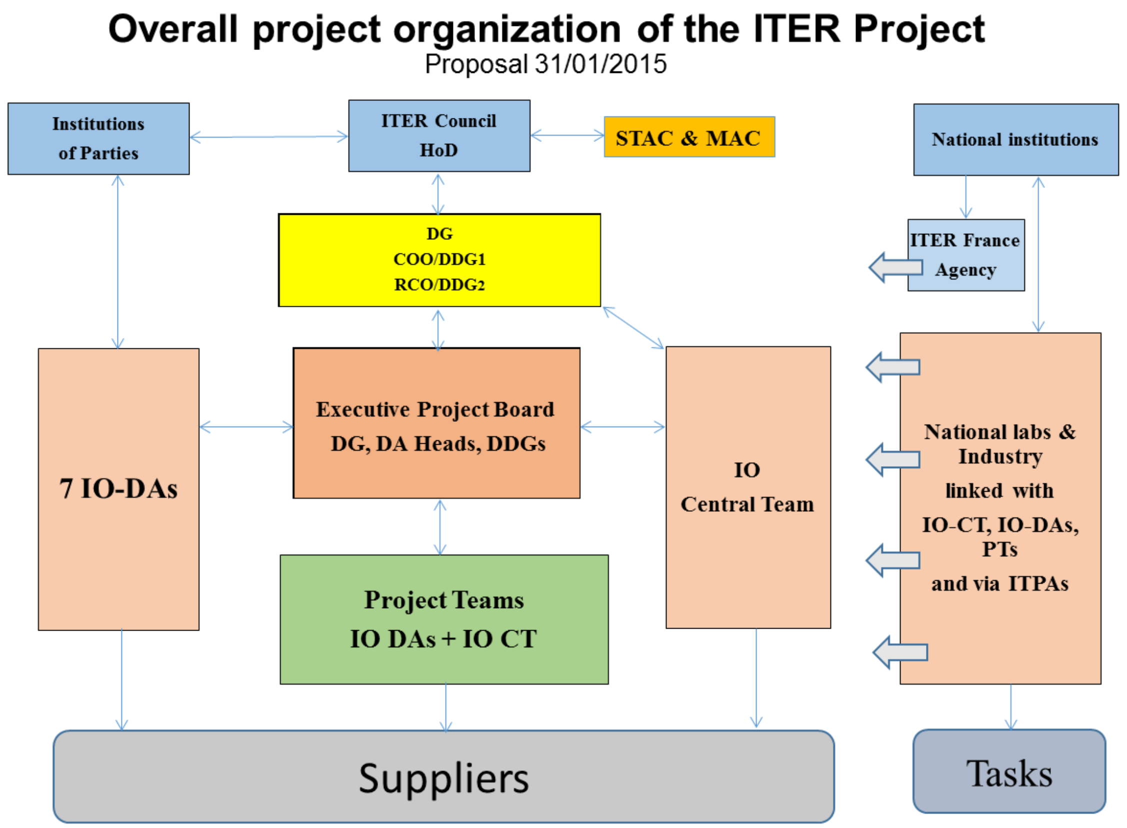


Figure 1: Proposed overall organization of the ITER project

This organigram indicates that the **National Institutions and Industry** can be linked to all the various organs located to the left in the chart. Historically they have provided, since the early design phase of ITER, essential contributions to its definition via the ITPA (International Tokamak Physics Activities), a unique arrangement for addressing tokamak physics issues. The ITPA will continue to play an important role for the ITER physics basis, but we can already envisage other major contributions in the fields of commissioning, heating and current drive, plasma control, diagnostics and operations. Therefore, we must welcome strengthening the links of the ITER Organization with the National Institutions or Industry, either directly or through the DAs or the ITPA.

The **ITER Council and the DG** are jointly responsible for the success of the Project. Strong links, mutual trust and transparency between the DG and the Council are essential. As a general rule, the DG should take the initiative for giving the Council regular well documented reports on the Project progresses or difficulties, as well as proposals for its consideration. In order to respond rapidly to DG requests to the Council for help to resolve blocking difficulties, the Council could establish a Support Board to closely interface between the IO project management and the concerned HoDs, and, if required by the IC, to prepare a Council Resolution either to be validated by IC as a Decision during its next meeting, or to be approved by written procedure. While the Council has the possibility to request from the DG any specific information, study or analysis, besides its demand to STAC and MAC, it should refrain from making any micro-management or direct intervention within the Project or towards the IO-CT staff. Similarly towards the DAs, the Council should remain totally independent from their declaration; they participate in the EPB and there have collectively approved the decisions expressed by the DG. The agenda of the Council and the charges to STAC and MAC should be agreed by the DG in order to generate a constructive dialogue preserving the specific role of each entity.

The DG chairs the Executive Project Board (EPB). The **EPB,** which replaces and extends the role of the ICET, includes ex-officio the DG, the DA Heads, the DDGs, the ICO. In addition, appropriate CT, DA staff and Project Team leaders may be called to attend the board meeting whenever the agenda warrants it. The EPB, which will meet at least once a month, supervises the technical aspects of the project, creates and manages the PTs, resolves technical issues with the aim to serve the best overall interest of the project, helps the DG to determine the suitability the PCRs and their eligibility for the Central Fund. The DG formulates the decisions after in-depth discussions. The EPB is collectively responsible for elaborating solutions involving constraints (financial or otherwise), to problems which need to be submitted for resolution by the Council.

To sum up, the EPB should be working

a) To create and supervise the IO-CT/IO-DAs integrated teams;
b) To provide a shared vision of the technical progress within the entire project;
c) To refresh the overall project working schedule as often as necessary;
d) To troubleshoot technical conflicts;
e) To support DG to make binding decisions, including advising the DG for the use of the Central Fund.

Project teams (PT) will become a normal instance of the ITER project for the fundamental reasons explained in 3.2. They will be created for dealing, in an integrated manner, with major operations (components, subsystems, transverses functions etc.) requiring multiple interveners. A single PT leader will be chosen among the most competent persons within the project (IO-CT or DAs) and appointed by the DG after consultation of the EPB.

The Project Teams are constituted of both IO-CT staff and IO-DAs staff. They receive delegation of power from the EPB to manage all sequential steps for the realization of a major operation, from definition, engineering, specifications for fabrication by an industrial firm of recognized qualification, until final acceptance after delivery on site. The Project Teams will report to the Executive Project Board in order to allow the key issues they face to be fully shared and known by the IO-CT and the IO-DAs, thus allowing a global approach for their resolutions. The Project Teams only need to get approval from the EPB and not separately from the managers in their home organizations. The PT terms of reference will describe the scope and the resources (human and financial) attributed to the project as well as the domain of authority for making rapid decisions. The Project Team leaders will have real delegation of power enabling them to make decisions within the frame of the delegation they receive. This delegation will be made in writing under the joint responsibility of the DG and the DA Heads directly concerned. Simplicity, faithfulness, trust and transparency must be key shared values. A PT will be responsible for submitting to the EPB the arguments for resolving issues which exceed its own domain of authority. Clearly not the whole ITER scope needs to be managed by Project Teams. Only key components or actions which are particularly challenging or are on the critical path will need such an organization. At present, there is urgency to create a number of PTs, in particular for dealing with the vacuum vessel, the buildings and the manufacture of the PF and TF coils.

4.2 Proposed Organization of the Central Team (CT)

Figure 2 summarizes the proposed organization of the IO-CT. The three levels, Department Heads, Division Heads and Group Leaders below the DG level result in a focused CT team. Two DDGs form with the DG a united group where the DG can delegate, temporarily or permanently, some specific duties, without being discharged of his responsibilities, to the other members of the group, if the Project efficiency requires it. The DG and the two DDGs are the only senior personnel in the Project. Each DDG is given the responsibility to supervise a number of departments (there are nine of them), 'vertical units' in charge of major tasks, and offices which are 'horizontal units' in charge of providing transversal services encompassing the entire ITER organization. The COO (Chief Operating Officer) is responsible for the departments marked with the red square and the RCO (Relations Coordinating Officer) for the department marked with the green square. The details of these units are given as an example; they will be adapted to the skills of their Leaders, when chosen by the DG after consultation with the HoDs and DA Heads.

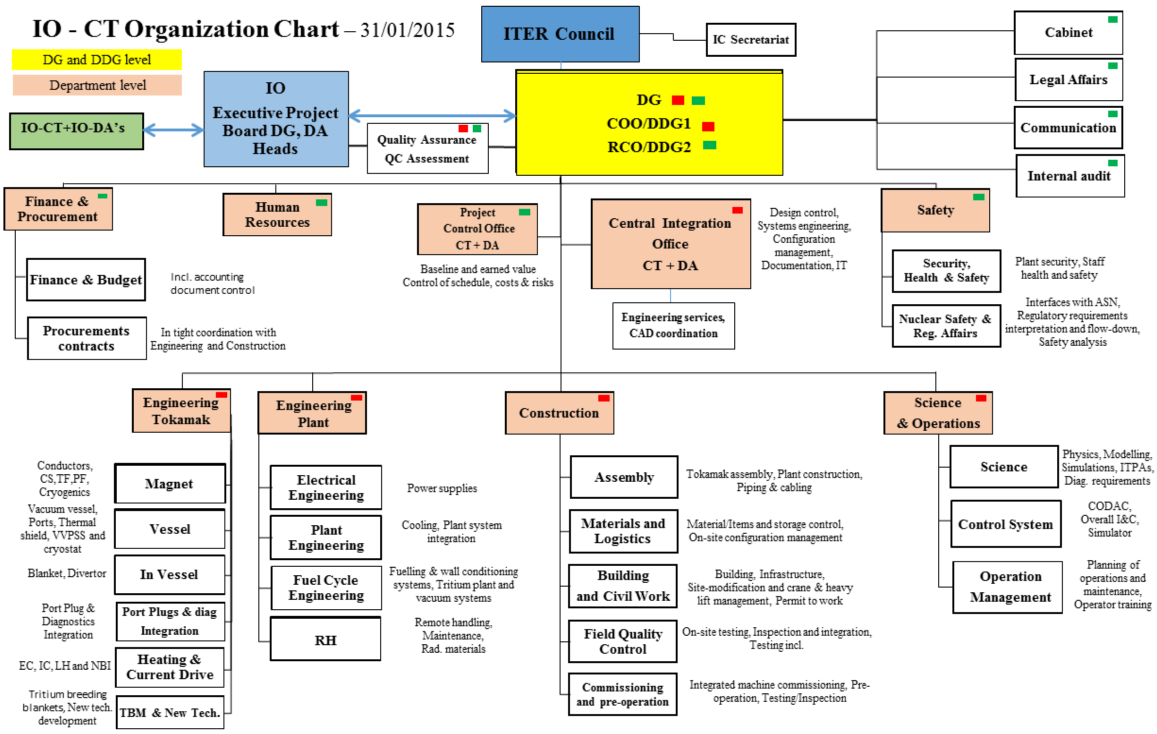


Figure 2: Proposed indicative organization chart of the central team. An enlarged figure is given at the end of the document

The importance and the role of these 'horizontal units' have to be emphasized. The **Central Integration Office** coordinates, at the project level, the control of the design and configuration, the systems engineering and the technical documentation of the project which should ultimately include up-to-date as-built drawings of the entire machine. This unit will have a significant core staff made of personnel from both the IO-CT and the IO-DAs, but its core staff will ***not*** by far regroup all the officers in charge of transverse activities. In particular most of the system engineers will be distributed in the technical divisions. Indeed, due to the unusual highly diverse disciplines, specific to tokamak engineering already highlighted in sections 2 and 3, it is proposed that the application of the transverse functions (e. g. systems engineering, quality, documentation, safety, quality, code and standards, etc.) be an integral part of the tasks to be performed by each technical division in coordination with the Central Integration Office. The required staff will be part of the divisional team although its staff report will also include markings from the management of the central integration office in order to assess the effectiveness of his/her contribution to the coordination and coherence of the transverse functions.

The **Project Control Office** will be in charge of monitoring and, more importantly, controlling and steering the project baseline, producing the updated project resourced schedule and risk register. This office, which is also in charge of interfaces with Regulatory Affairs and Finance & Budget, covers WBS and CBS and will be staffed in a similar way as the central integration office, drawing much of its resources in quality control and scheduling from the relevant sectors of the project. It is critical to develop project management practices, and effective PDM tools.

The **engineering services** will be a division in the Central Integration Office essentially coordinating and prioritizing the work done by the CAD designers and other engineering support services for the technical divisions.

Four departments (**Engineering Tokamak, Engineering Plant, Construction** and **Science & operation**) are dedicated to the technological and scientific activities of the project. The **Engineering Tokamak** and **Engineering Plant** should remain for all stages of the project: design, manufacturing, assembly and commissioning. As said earlier, the specificities of the tokamak do not allow, for many subsystems, to separate in an efficient way design, procurement and control aspects. For instance, a stable core of RF specialists is needed for the design, procurement, installation, commissioning and finally operation of an RF system. It would be very inefficient to distribute these tasks in different entities. Therefore this RF group will have to perform the transverse functions (e. g. scheduling, quality, safety etc.) at the level of the RF system and deliver the corresponding contributions to the central integration groups for coordination and checks of coherence. The two departments, **Engineering Tokamak** and **Engineering Plant,** are organized by subsystems/components, the other two, **Construction** and **Science & Operation** concern activities involving the entire project. The machine assembly and plant construction will be a major undertaking of the IO-CT and the DAs and therefore will require intense preparations and a very strong level of management. As ITER progresses from the stage of procurement to installation, commissioning and operation, there will be a need to adapt accordingly the structure and even to review the existence of some units. Substantial staff mobility will be required. Staff job descriptions should therefore include the necessity of such flexibility for most appointments. It will be a task of the **Human Resources** department to include such flexibility for new recruitments or to retro fit them whenever appropriate.

The CAD models should be kept in one single place, within the IO-CT. It is necessary to create a united drawing office with the DA designers working with the IO-CT as needed. This is the necessary condition for ensuring that interfaces between the CAD offices in the CT and the DA are controlled properly through to the assembly stage, in particular to reflect changes done by industries during manufacture.

The **Quality Assurance division and the Safety** department will support directly the DG in his role of nuclear operator. Utmost attention will be given to traceability and transparency of all documents which can be released in conformity with the ASN rules. For such a task, staff from the DAs and the other CT units, with strong safety training, will participate in the activity of the Safety department. These specialists will have a double affiliation: both to the Safety divisions and to a technical division, where they implement the quality control of procurements. These measures are also seen to be essential for propagating the safety culture everywhere in the project.

As explained in 3.3 the **Human Resources Department** should largely exceed the usual administrative services to the individuals and provide the more important strategic role of forecasting and providing for the staffing needs on a longer time scale encompassing the various phases of the project.

The **Finance & Procurement** Contracts department manages, in coordination with relevant technical divisions, finances as well as contracts for the procurement of items directly financed by the IO-CT. It will also manage the task for maintaining up to date the administrative documentation. There seems to be a great complexity and stiffness between the various budget titles. This will be reviewed and enhanced administrative efficiency will be proposed for the best interest of the project.

Currently for example, the IO budgetary procedures involve a budgetary structure which marries both the Work Breakdown Structure (WBS) of the IO and also a conventional government/public sector oriented structure sub-divided by Titles, Chapters and Articles according to the type of expenditure being incurred (e.g. salaries, missions etc.), with budgetary control being exercised by Chapter. A move towards simplified budgetary control by Title (Direct Capital, R&D and Management and Support) would be helpful in simplifying associated administrative processes. The procurement contract division will have to adapt soon to a new strategic phase with the placing of large contracts for the assembly and construction phase.

The MA 2013 report pointed out excessive bureaucracy both in administrative and in technical procedures (far too many signatures before a document becomes valid, which makes evident the absence or at least the tight limits on delegations). The recent preliminary findings during the preparation of this action plan do confirm this assessment. Both next internal and external reviews will pinpoint where the balance between process control and expediting decisions needs to be rectified.

4.3 Transition Plan

The preceding chapters have described the management processes to be established with emphasis on Central Functions for the whole ITER Project. They have emphasized the necessity for a tight integration of the CT and the DAs (same WBS), for common management tools, for a single CAD model and for a unique documentation system. Staff with a dual assignment will facilitate internal communication, and insure by their participation to the Central Functions, in addition to their role in engineering groups, that the Central Functions will never work in a bureaucratic isolation. The proposed organization, shown in the two colored charts, indicates where to arrive as soon as practical without disrupting work: nine Department Heads (in brown) under the authority of the Director General group (DG+DDG's) (in yellow) will optimize the work done in Divisions, Sections and Groups, always relying on the largest delegation of authority and requesting complete trust and loyalty in personal relationship. The transition from the present situation to a new stable one will be implemented within this calendar year.

The first envisaged steps, not at all comprehensive, are tentatively:

- To meet with as many CT and DA staff members as possible in order to become more familiar with the present status of most activities and organizations around them. These meetings will also aim at being briefed on methods and present results on long-term schedule, costs studies and on preparations for assembly;

- To preserve during the transition period the continuity of work in its present environment (Divisions and lower levels) for all activities, in particular on the Project critical path, but to start reviewing staff competences, achievements in service and adequacy to the desired functions, before redefining their potential roles in new Divisions/Groups;

- To review the future status of all staff presently above Division Heads and to replace their present roles by establishing as soon as possible the nine Departments of the new organization with interim Heads;

- To launch the procedure for hiring new staff for key positions and negotiating the termination of contracts as required, according to staff regulations;

- To hold the first meetings of the EPB, whose agendas should review present PTs and if possible create at least two new ones;

- To start building the Project Control Office and the Central Integration Office by bringing together all staff, distributed across the present structure, whose present responsibilities are similar to those of the two Offices; The priority tasks are to formulate a new technical Baseline, to acquire an efficient tool for Configuration Management and to develop a plan for establishing a resource loaded schedule consistent with the technical baseline;

- To elaborate with high priority the methods establishing the most reliable resource loaded project schedule;

- To formalize and implement progressively new procedures with high priority given to HR issues in the administrative field and to Safety and Quality Assurance issues in the technical field;

- To define the procedures for the creation, operation and control of the Central Fund, and identify its amount.

5. Establishing new foundations: key decisions submitted to the IC for endorsement

5.1 The Director General (DG)

For the fundamental reasons given under 3.1, **the DG is given full authority to take all technical decisions for the best interest of the project.** He is the Nuclear Operator of a Nuclear Installation under the French Regulations and he is the Chief Executive Officer of the Central Team of the ITER organization (IO-CT). He shares with the ITER Council the responsibility for the success of the ITER project. He reports to the Council and is responsible to it for the execution of his duties. He submits proposals for implementing the ITER baseline. His main concerns and actions are driven by the best interest of the entire ITER project.

In order to be responsible for the entire ITER Project, the **Director General has to be informed in advance for advice on all relevant technical points and documents to be discussed in meetings of the Governing Board or Executive Committee or equivalent of every DA**. This is essential for establishing a commonality of purpose and the consistency of approaches across the whole ITER Project. On invitation of their Chair, the DG or his nominee should be invited to the meeting of these DA governing bodies.

In order to be technically responsible for the whole integrated team (CT and DAs) the DG should be consulted on the proposed organization changes to be put in place in each DA and approve them with the relevant Members authorities. **He should be consulted and agree on the choice proposed by the Members authorities of key individuals, in particular the DA Head who will collaborate with the DG in the EPB on technical issues and be loyal to his decisions. Conversely the DA Heads will be consulted by the DG before the nomination of a Department Head in the IO-CT.**

The DG will need to establish strong but easy relations with the Council and its Chairman between IC sessions; to be efficient and quick to come to a decision, these interactions could occur first through a **IC Support Board (see 4.1)**, a Group of Standing Technical Experts (one per party acting ad personam) experienced in management of large projects and available a sensible amount of their time (30%) to follow ITER issues and prepare IC decisions either by delegation or by written procedure. **This Support Board could be combined with the CPWG once reinforced with the required expertise.**

5.2 The Executive Project Board

The DG chairs the newly created Executive Project Board (EPB) which replaces, with enhanced responsibility, the ICET. The DG formulates all relevant decisions after in-depth discussions in the Board. As described in 4.1, the EPB is, with the DG and the IC, the main element of governance of the whole ITER Organization. The DG assisted by EPB will take, or at least propose for endorsement by the Council, all strategic decisions driving the whole Project. **The EPB is collectively in charge for elaborating solutions involving constraints (financial or otherwise) to problems which need to be submitted for resolution by the Council.** The EPB will supervise all technical aspects and follow overall activities to control the Project costs and schedule; it will participate in integrating the CT and the DA members in a single, united and effective team of the ITER Organization. The EPB is the structure which helps the DG to manage the whole Project.

5.3 Central Fund

The DG is given authority to draw from a Central Fund. When a **PCR is judged by the DG as being for the best interest of the project, it will be financed from the Central Fund.** This fund is created through contributions of all stakeholders in accordance with their share of the global Project. The DG has authority to draw from this fund with the obligation to report annually each operation at the Council meeting. This new arrangement cannot be applied retroactively; the support to the cost increase for all specifications changes registered until now in all contracts is assumed to be agreed upon directly among the members and should not be discussed again. **The total volume required in the fund could, in a preliminary analysis, be up to 20% of the total procurement cost of ITER. It will be a priority of the transition period to refine the estimate.**

5.4 Project Teams

Project Teams (PT) are created by the EPB for dealing, in an integrated manner, with major operations (components, subsystems, transverses functions etc.) requiring multiple interveners. The PT membership will be drawn from the CT, the DAs staff and/or external sources. A PT leader, appointed by the EPB will be chosen among the most competent persons within the project. The terms of reference of the PT will describe the scope and the resources (human and financial) attributed to the project as well as its domain of authority for making rapid decision. It will be responsible for submitting to the EPB proposals for resolving issues which exceeds its own domain of authority. The Project Teams only need to get approval from the EPB and not separately from the managers in their home organizations. **They will have direct access to the suppliers jointly with DA's representatives.**

5.5 Human Resources

The **Human Resources** department has a key role to play in the implementation of the present action plan since all organizations succeed or fail based on the quality and motivation of people. **Human resources** will be organized for increased efficiency and cost effectiveness:

- **The Council authorizes the DG to transfer or reassign all staff to another position inside the CT for the benefit of the project**, even if this new position does not follow precisely the terms of his letter of recruitment.

-**The cap on the CT staff number is requested to be replaced by a cap on the overall staff budget**. The staff-cap forces to increase the number of contractor posts which is often inappropriate.

-There is presently considerable difficulty for recruiting staff with the necessary high profile. **Therefore recruitments should be done principally on the basis of excellence for the post.** The staff quotas allocated to each party should only be a secondary consideration.

-New instruments for stimulating the applications of top grade candidates need to be deployed as the number of good candidates emanating through the DAs is decreasing significantly. **The Council is requested to allow the flexibility for advertising job descriptions directly in specialized media and to urge DAs to transmit all relevant applications.**

- **DAs are requested to allow staff, meeting the required criteria to keep their post for more than a single five year term**; some DA staff having made a major contribution in one phase of the project (for instance construction) should be available on site for the next phase (for instance installation and commissioning).

- Finally the **mobility of staff between the DAs and the IO-CT** needs to be improved, possibly by creating an **appropriate statute** and a supporting mobility program. Indeed, it will often be essential to assemble either on site or at a DA site the staff participating in some PTs or supporting procurement arrangements. To facilitate mobility, a staff training program will be launched to expand the staff member's capabilities to acquire additional skills which the project requires; well-chosen high quality training in addition to the mandatory training can be a significant motivation for encouraging staff to deploy their skills within the project; this will be important as the project evolves.

5.6 Organization charts

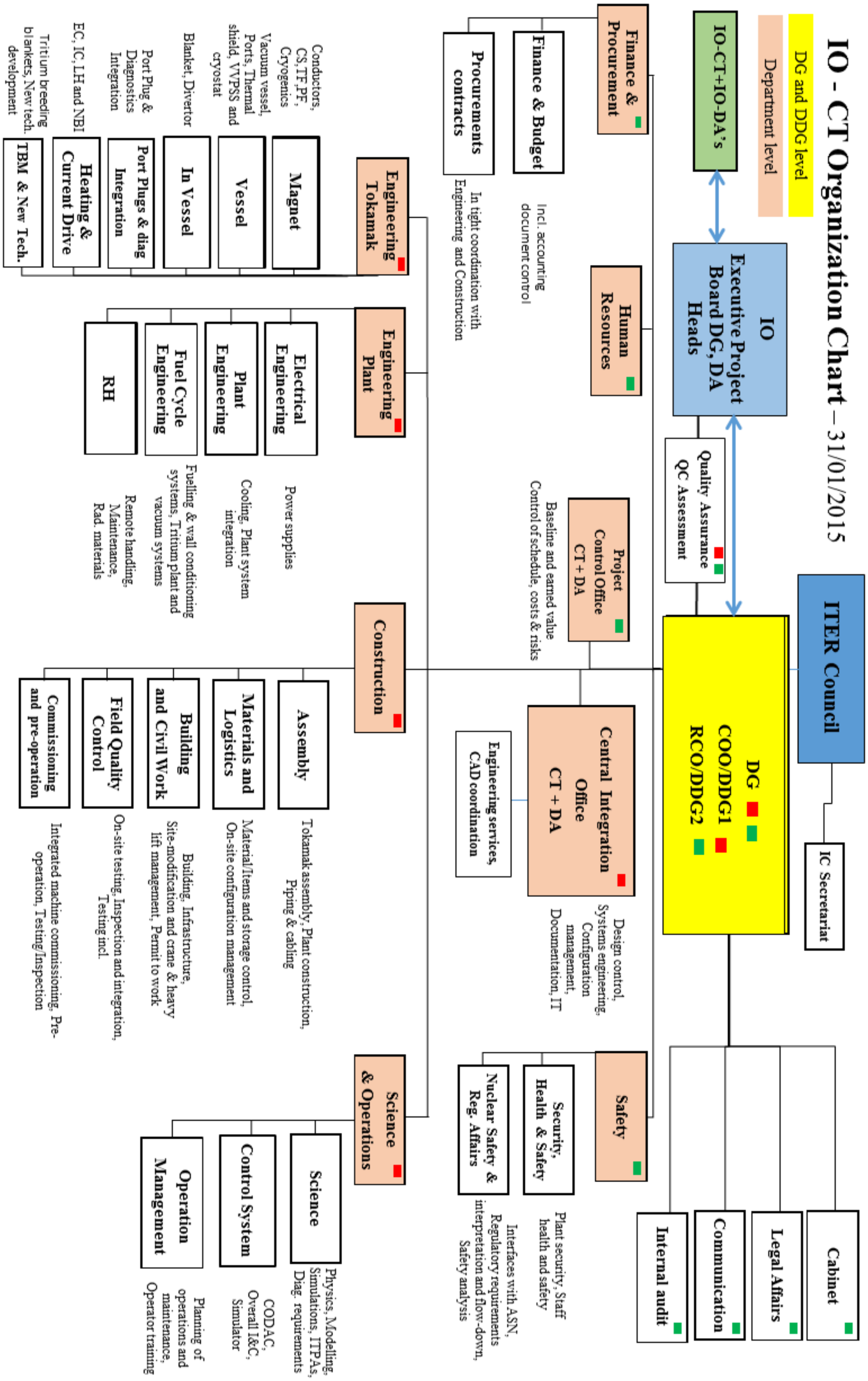
The Council is asked to approve, in broad terms, the proposed organization as shown in charts of figures 1 and 2. Clearly some modifications will occur in order to take into account the specific skills of key managers. **The DG and the two DDGs are the only senior personnel in the Project. All the other CT posts will be appointed or dismissed directly by the DG according to staff regulations.** Three managerial levels (Department Heads, Division Heads and Group Leaders) below the DG/DDG level and nine Departments are foreseen resulting in a focused CT team with only four technical departments. **Emphasis has been placed on strong central integration entities with active participation of the DAs** (EPB, Central Integration Office and Project Control Office). A complementary organization is suggested in the relevant sectors in DAs in order to facilitate the joint CT/DA work and avoid duplication.

6. Conclusion

The action plan for the new phase of the ITER Project has been outlined. It would be progressively implemented starting immediately after the eventual ITER Council approval in early March 2015. The plan addresses issues identified in the 2013 Management Assessment report and by the recent analysis made over the last two months. It includes a major reorganization of the IO Central Team (IO-CT) and a drastic improvement of the IO-CT/IO-DA interactions. The action plan will largely benefit the ITER Project from the expertise, high professionalism and strong dedication of many staff members in the IO-CT and the DAs. Maintaining and enlarging these features are key factors for the success of the ITER Project. It is envisioned that the transition plan will be completed in 2015 and a fully operating organization will be established before the end of the year. However, a continuous improvement will be maintained throughout the Project lifetime and this Action Plan only describes the initial important steps.

7. Definitions

ASN	Autorité de Sûreté Nucléaire (French Regulator)
AWP	Annual Work Plan
CBS	Cost Breakdown Structure
CEO	Chief Executive Officer
COO	Chief Operating Officer
RCO	Relationships Coordinating Officer
CW	Civil Works
DA	Domestic Agency
DG	Director General (He is the CEO of the IO-CT)
DDG	Deputy Director General
EPB	Executive Project Board
HoD	Head of Delegation of the ITER Members
IC	ITER Council
IO	ITER Organization
PT	Project Team
PA	Procurement Agreement
PBS	Project Breakdown Structure
WBS	Work Breakdown Structure



IO - CT Organization Chart – 31/01/2015
DG and DDG level
Department level
IO-CT+IO-DA's
IO Executive Project Board DG, DA Heads
ITER Council
DG
COO/DDG1
RCO/DDG2
IC Secretariat
Cabinet
Legal Affairs
Communication
Internal audit
Quality Assurance QC Assessment
Finance & Procurement
Finance & Budget
Incl. accounting document control
Procurements contracts
In tight coordination with Engineering and Construction
Human Resources
Project Control Office CT + DA
Baseline and earned value Control of schedule, costs & risks
Central Integration Office CT + DA
Design control, Systems engineering, Configuration management, Documentation, IT
Engineering services, CAD coordination
Safety
Security, Health & Safety
Plant security, Staff health and safety
Nuclear Safety & Reg. Affairs
Interfaces with ASN, Regulatory requirements interpretation and flow-down, Safety analysis
Engineering Tokamak
Magnet
Conductors, CS, TF, PF, Cryogenics
Vessel
Vacuum vessel, Ports, Thermal shield, VVPSS and cryostat
In Vessel
Blanket, Divertor
Port Plugs & diag Integration
Port Plug & Diagnostics Integration
Heating & Current Drive
EC, IC, LH and NBI
TBM & New Tech.
Tritium breeding blankets, New tech. development
Engineering Plant
Electrical Engineering
Power supplies
Plant Engineering
Cooling, Plant system integration
Fuel Cycle Engineering
Fuelling & wall conditioning systems, Tritium plant and vacuum systems
RH
Remote handling, Maintenance, Rad. materials
Construction
Assembly
Tokamak assembly, Plant construction, Piping & cabling
Materials and Logistics
Material/Items and storage control, On-site configuration management
Building and Civil Work
Building, Infrastructure, Site-modification and crane & heavy lift management, Permit to work
Field Quality Control
On-site testing, Inspection and integration, Testing incl.
Commissioning and pre-operation
Integrated machine commissioning, Pre-operation, Testing/Inspection
Science & Operations
Science
Physics, Modelling, Simulations, ITPAs, Diag. requirements
Control System
CODAC, Overall I&C, Simulator
Operation Management
Planning of operations and maintenance, Operator training

Annex 2: 2015 F4E Action Plan

This document is largely in support of the ITER Action Plan [7] (AP2015) prepared by the ITER Organization's (IO) Nominee Director General (DG), Bernard Bigot for the March Extraordinary ITER Council, establishing the "Foundations for a new phase of ITER". Measures are herewith also presented in order to address supplementary issues affecting F4E as raised by audits, annual assessments, as well as the judgment of management and staff.

1. Observations

The 2013 ITER IO Management Assessment [8] has identified a substantial list of issues in the ITER Project. With a few exceptions, the analysis presented therein was largely supported by the consultations held by Bernard Bigot with all ITER stakeholders. The main thrust of the AP2015 is the creation of a new fully integrated organisation through a profound integration of the Domestic Agencies (DAs) and the ITER Central Team (CT).

While the F4E management entirely agrees with the findings of the AP2015, there is however an additional important observation, which it is worth adding: the present unsatisfactory state of the ITER project derives, to a significant extent, from the initial incorrect assumption by the ITER Parties, that the minimization of risks (schedule and cost) at the level of each Party/DA leads to an overall minimization of such risks for the entire ITER project. As a consequence, several fundamental mistakes were made in the setup of the ITER Agreement, and thereafter in its implementation:

- The IO management team was at first too often chosen on the basis of political agreements rather than their professional experience, thereafter inducing prevalently unfortunate recruitment and placement of staff members. To the predictable technical difficulties which surface in the construction of a very complex and first-of-a-kind "system" like a Tokamak, management invariably responded by asking for more staff, with the result of making things only worse as the few externally available skilled staff were not motivated to join the project.

- With cost and performance control assumed by different organizations to a massive 90% value of the project allocated to in-kind procurement, difficulties were aggravated by: a) vague definition of the scope baseline b) very complex and at times even illogical sharing of procurement (e.g. the vacuum vessel) and c) "inadequate design integration and system engineering, leading to the inability to react promptly to technical difficulties to contain domino-effects of design changes.

[1] Action Plan 2015 - Foundations for a new phase of ITER - Proposed by Bernard Bigot, DG nominee, January 2015

[8] Madia et al. ITER IO 2013 Management Assessment

- The IO-DA relationship and division of responsibilities was from its onset cumbersome and ill-defined leading to frictions and confusion. In addition, Article 13 of the ITER Agreement on Field Teams was ignored altogether. Procurement Arrangements (PAs) signed between IOs and DAs were seen in different ways, most of the time even as a customer-supplier relationship, which is deemed as unfortunate for a collaborative project of this type. Subsequent initiatives such as the “Unique ITER Team” concept have often remained largely as a slogan, and provided not much more than a platform for meetings, task forces, and the likes.

- The introduction of so called “MAC-10 guidelines”, defining the responsibilities to be assumed for funding design changes and originally introduced with the objective to streamline decision making processes, have compounded instead of improving the difficulties described above. This has led to a practically non-existent value-engineering effort in the IO, with cost overruns and further tensions developing amongst DAs and IO. This problem is severe for all DAs, in particular F4E, where for example the impact of constant changes on components affects the building almost by “default”, as evidenced by the papers provided to the GB in the December 2014 meeting.

- Finally, managers and staff in both the IO and the DAs, facing conflicting pressures from their own Stakeholders, have gradually drifted to a “blame game” approach, which has surely hindered the creation of a common team spirit. A significant cultural shift will be required to rectify the situation and rebuild mutual trust - this will not happen overnight and will require a sustained effort on all sides.

It is essential that towards the IC demand of *“… acceleration of the pace of the project execution and completion of the project in a timely fashion*.” the Parties and the GB alike take stock of the mistakes made in the past, that is before any recovery action can be pursued with effectiveness. Indeed, from a certain perspective the AP2015 does not go far enough. Ideally, the project should now refocus into a single organization with a single budget, in control of all contracts, and staffed by a single team. Given the international and political dimensions of the Project, such a fundamental restructuring will almost certainly not be feasible in a timely manner. Even accepting that limitation, it can be anticipated that not all Parties/DAs may interpret and implement the AP2015 to the same extent. This will be influenced by several factors, ranging from all the way from cultural aspects to difficulties in overcoming legal constraints.

Nevertheless, considering the severe management difficulties facing the ITER project as well as the natural expectations from the other ITER Parties (which, by the way, may have previously found it difficult to understand some of the tensions between IO and F4E which started some time ago), it is recommended that, given that a full merge of F4E and IO is not a realistic option, the GB is wholeheartedly committed to supporting changes to F4E that will bring about a much more profound degree of integration than hitherto achieved.

Adapting F4E’s operations to the new integrated project organization envisioned in the AP2015 may well require some structural changes to F4E’s frameworks, including possible revisions of certain regulatory constraints. While the extent of the changes will only become clear in the process of working out the details of implementation plan, they may entail revisions as deep as: a) responsibilities of the F4E Director in relation to parts of the F4E budget, b) the relationship between the role of an individual in financial decisions and his/her staff status (i.e. being or not-being an F4E staff member), c) changes in the governance review process d) changes in the internal review processes which, at times, were set up to answer audit concerns, etc..

Within the AP2015, it is worth noting that:

- The F4E management have stated on many occasions that is the MAC10 guidelines are unfair, costly, and has only served to strain relations between the IO and DAs. The Council has now decided that the Reserve Fund as the Central Fund will now be called) will supersede the MAC10 guidelines. If properly implemented, the new Reserve Fund approach would be a very welcome tool: project decisions resulting in over-costs on contracts managed by the DAs being centrally funded under the full responsibility of the ITER DG. This would be a cornerstone for fairness and value engineering by the IO. As stated in the AP2015 further work will be needed to develop the mechanisms for the method, as it is likely to be implemented in different ways by different DAs and will have to be realised within each Party's legal constraints.

- Behind the (re-)establishment of Integrated Product Teams (IPTs) remains the underlying need to increasingly *merge* activities and WBSs of F4E and IO. While the "original sin" of 2006 of not fully integrating teams, data, and processes cannot be undone at this stage, it is however essential that not only processes be integrated as much as possible and duplications of responsibilities are avoided, but that a cultural change on both sides is promoted by the respective managements. For example, it will undoubtedly be necessary for F4E to integrate IO staff within F4E's processes for contract management. Moreover, core contract management processes and tools for contract deviations, amendments, NCRs and the likes, will have to improve in efficiency as well as to adapt to the new conditions. This will require a redoubling of the effort from staff presently engaged with process improvements as well as management tools still under development. Accomplishing of this goal is likely to require more than a year and needs complete and sustained support from Euratom and all the GB Members.

Besides the above, there are additional difficulties affecting F4E and impacting upon its ability to carry out its core tasks which should be highlighted to the GB:

- In F4E the ratio between the man-hours spent on direct core activities and administration plus management is disappointing: estimated to be in the order of 10%. Not only is manpower *directly* performing design and contract technical follow-up activities about a third of the total F4E staff, but the time that such staff may devote to their core tasks is diminished by inefficiencies deriving from the present IO-DA arrangements as well as administrative burdens, often due to the regulatory framework of F4E. Simply increasing the staff complement cannot always be the answer to this underlying issue, especially since some staff have specific expertise which cannot easily be found. Therefore, in addition to improving the global efficiency of the IO-DA system, it is deemed necessary for F4E management to set clear priorities and in some cases discontinue tasks completely, in particular those which have been imposed on F4E to achieve a "zero-risk" implementation.

- Errors of judgement have indeed been made very early in the setup of F4E where the investment of establishing a "standard" integrated management system, or even better: one *integrated with IO*, was not made. As a result, there is currently a variety of tools available in F4E and used for such purposes. These are weakly integrated and often require the staff to perform activities which are inefficient. While the full integration of these diverse management system(s) and tools is, at this point in time, impractical, quick-and-dirty solutions should be avoided or should be minimised to avoid even more demands on staff for the proper upkeep of the baseline material. The actions below are along these principles.

- While preparing, implementing, and managing procurement contracts is a priority for F4E, a complete, uniform and "perfect" algorithm for contract management system may however be excessively heavy and may divert the available resources away from other more important core activities (e.g. contract technical follow up). Therefore the documentation set needed for contract preparation, implementation and management should be, to some extent, commensurate with the risks of each contract in terms of cost, schedule and quality on the entire ITER project.

- There are presently a total of about 50 open audit recommendations, out of which a large fraction are classified as critical or very-important, and resulting in an even greater number of outstanding actions to be implemented by F4E. Many of these open recommendations are indeed proper for the sound functioning of the organisation. At the same time, it appears that F4E has been somewhat hasty in implementing some other past recommendations. As a result, we can make the analogy that F4E has gradually covered its body with bandages and patches, adding policies, processes and documentation requirements which at the end and seen in their entirety are not meeting F4E's project requirements.

2 Planned Actions

1) Following from the last observation above, F4E should address as a matter of urgency open audits recommendations which are classified as critical and very important some of which date back to 2010. Many of them are often interrelated and indeed often aligned with past GB requests or weaknesses outlined in the recent Annual Assessment of F4E [[9]]. At the same time, the establishment of the appropriate level of risk-appetite for and within F4E needs to be discussed with the GB in order to establish the right framework for future F4E management responses to audits. F4E is very different in its objectives from other EU agencies and institutions, and given the interconnectivity between contracts and activities, a risk-averse approach at local level is often generating high risks at global level. As a consequence F4E also should rethink in a holistic manner, and on the basis of the work experience gained some of those past actions which may have ended up hindering F4E's effectiveness through waves of other small-return improvements.

2) F4E should review again and possibly limit the use of legacy practices/tools, which are mostly in place to ensure "cultural" continuity with past EFDA environment. Specifically needed is a revision in the use of grants so that procurement is used for tasks which are not purely R&D. Most European Fusion Laboratories (EFLs) can as effectively work with grants as they can with procurement contracts, on the other hand grants impose a disproportionate overhead in terms of cost verification which is needed neither by F4E nor by the EFLs themselves. Whilst an attempt was made to try to minimize this burden using lump sum grants, it would appear more efficient to reduce the number of grants (whichever type) and favour the placement of contracts with EFLs.

3) Project and contract management tools as well as their use along the definition of management processes have been and still are under constant *development* and *improvement* within F4E, efforts will continue along the following integrated lines:

   a) Earned Value (EV) reporting using ITER Credit Allocation System (CAS) milestones and the associated credits will be implemented and available immediately at Procurement Arrangement (PA) level and above. The available system within IO of recording credits

[[9]] 3rd Annual Assessment of Fusion for Energy – K Tichmann, MR Di Nucci, J Loughhead according to CAS milestones will be utilised and should be adopted as the main KPI for the core activity of “delivering ITER components”. Actions will be gradually implemented, in close cooperation with IO to correct some of the CAS management limitations, and correct past errors. Plans for EV management based on actual contract values will be defined once a clear decision is taken on implementation of EV at project level under IO coordination.

b) Further integration of contract management tools will be pursued aiming to improve effectiveness as well as to keep close track of the consumed funds:

   i) Primavera is and will remain the key tool for planning activities, defining estimates and target costs, and linking contracts with *Incoming Orders* (i.e. PAs, ITER Task Agreement (ITAs), etc.);

   ii) The reference allocation of funds will be divided among to each PA, ITA, etc. in F4E’s central Data Warehouse and subject to change control processes;

   iii) The Contract Tracker (a recently introduced tool) will be better integrated with the ITER Document Management System (IDM) and Primavera, and will progressively evolve to become the tool for the management of Deviations, NCRs, Contract Amendments, etc. The integration of this tool with IO, in particular its use by IO staff, will be essential for implementing the AC2015.

4) The gradual and progressive merging of configuration management processes and tools will have to be implemented for the ITER project as a whole. Indeed weaknesses in configuration management and systems engineering have impeded the efficient management of cost and schedule for the ITER project since 2006. While the first IO management team accomplished some improvements, their successors in 2009 rolled back these improvements leading to a currently complicated and confusing situation. Nevertheless, the improvement and merging of these processed needs to be led by the IO, in its capacity as Project Integrator, but is a very ambitious task which will require an extraordinary joint effort, likely to take 1 to 2 years to reach fruition. Active support and participation to this effort must become a priority for F4E.

5) The Work Program and Project Plan, as presented by F4E to the GB as well as the ITER Annual Work Plan, as presented by the IO to the IC, clearly need to be fully coherent. The most efficient way to achieve this objective is for the ITER-Project-level documents to contain direct extracts of the F4E-level documents. This requires a deep level of cooperation between the IO, IC and F4E’s GB.

6) As also recommended by the recent F4E Management Assessment [3], contract follow up will require a gradual but substantial increase of F4E presence on the premises of suppliers. A close monitoring of contracts, although entailing additional mission expenses, will provide a faster and more responsive way of communication with the suppliers and will improve F4E ability to promptly prevent faults which can help to mitigate cost increases. This is particularly important for first-of-a-kind components such as the most critical ITER devices, in these cases frequent unforeseen technical issues require rapid resolution. The very problem of the “legal” separation of IO and F4E only exacerbates this problem. At the same time, due to limits in staff resources, this will only be possible, to the extent required, when core staff will become less burdened with administrative tasks and when efficiency gains will therefore be obtained.

7) The implementation of the system to manage cost estimates and fund/contingency allocation will be completed as a matter of urgency:

a) As preamble, it is important to point out that it is simply not feasible to completely breakdown the scope of a project, particularly one like ITER with a duration lasting more than a decade, in individual contracts (i.e. WBS Level-6) from its onset (i.e. with a stable scope). Even assuming a perfect and stable definition of the scope (which regrettably was not available and done for the ITER project for a number of technical and organisation reasons most often beyond the control of F4E) the breakdown of the works into individual contracts, for significant ones as well, is gradually accomplished as the design matures and the time for the implementation of the specific contracts is approaching. This is so in order to take into account market conditions, detailed scope and interfaces definition, and also to make proper use of available human resources as well as contingencies. For this very reason the Work (and cost) Breakdown Structure gets gradually more detailed as time progresses. In simple terms, using the analogy of wishing to build a simple house, though a cost analysis can be made, even at the level of number of estimated bricks, cements, manpower, etc.. the ensuing grouping of such work (and cost) scope is done only once the time comes to define all individual contracts which are decided to build the house itself. And even at that point in time, some smaller level contracts may be left for a later stage of the construction project.

b) Notwithstanding the above, the absence of a full breakdown at WBS Level-6 does not mean that there is no system to monitor costs. In fact there is already a system to control and monitor costs at the level of PA, WBS Level 4. Therefore the illusion that cost estimation and fund management depends on cost breakdown to WBS Level 6 must be dispelled.

c) What is indeed currently still missing, and being developed with vigour, is a central and uniform system to manage all the data. Specifically, F4E is currently working on further developing the existing reporting systems so to bring together the existing Cost Baseline together with a system for the management of funds.

d) F4E aims at developing and using this control tool in an efficient manner, finding the right balance between propagating the cost estimate to the more detailed levels and the intensive use of resources that this complex exercise entails. It should be noted that there is a point of diminishing returns on refinements of cost estimation where additional effort in cost estimation leads to modest reduction in the uncertainty in the cost estimate, particularly when considering components where industrial prior experience is weak or absent all together.

e) At contract level, particularly for large contracts, cost estimates and risks will be controlled. For smaller contracts, this review will be proportionally less accurate. To complete the scope within a PA, contracts packages will be planned. It will not be possible to assume that a static breakdown of the entire scope can be complete at contract level. The overall project budget will be broken down and maintained at PA level. Thereafter reporting and reconciliation with cost estimates prepared during PA preparation will be maintained.

8) The need to increase F4E presence at the Supplier premises as well as gradual move of manpower towards Cadarache will induce an increase in the associated mission costs as well as salary costs (due to a higher cost of living in France compared to Spain). It shall therefore be necessary to allow for an increase of F4E's administration budget (in Titles I and II) poses a problem for which clear support from the GB is sought.

9) Some changes will be implemented in the organisation:

a) Some staff resources will be redeployed to high priority areas, the Vacuum Vessel and the Buildings, where the potential large impacts of difficulties call for such transfers.

b) In line with previous decisions, the part of the Magnet unit dealing with the PF Coils, will be moved to the Cadarache site. Some other teams, or a part of them, may be asked to follow once a careful analysis will have been performed in concert with the affected staff. Some individual staff from other units may also be moved and integrated within the global ITER project organisation, including those operating in integration and horizontal activities across F4E. Beyond a certain threshold of staff number, administrative support functions will also have to be provided in Cadarache. Any staff move to Cadarache will be organised in concert with the concerned staff.

c) The ITER Head of Department will represent F4E as ITER-EU-DA in the overall ITER Project Organisation context. This will require him being more and more present in Cadarache and at a given stage the balance will justify that he be based in Cadarache. To enable and support this, the ITER department will need an additional management level between its Head and the Heads of Units (Project Team Managers). Possibly up to three “Divisions” will be formed, respectively coordinating:

   i) Tokamak Systems (mostly in Barcelona);

   ii) Building and Plant Systems (mostly in Cadarache);

   iii) Integration and Support Services (mostly in Barcelona).

d) Some HR functions which were previously distributed will be recentralised and fully assigned to the HR Unit.

10) To meet cost and schedule targets, a project such as ITER needs *agility* in its ability to react to difficulties, and to enact decisions with contractual deviations and the likes. Delays in so doing are not only adding time to complete individual actions but, due to the extreme interconnectivity of activities in our project, become a major source of over-costs [[10]]. Compared with IO, F4E has a more rigid framework to follow and hence doesn’t have the possibility for such reactivity in the management of contracts. This very issue should be a driving force for F4E, with the support of the relevant services from the Commission, to investigate the possibilities to benefit of an increase level of flexibility given within our implementing rules. In parallel F4E, and hopefully other DAs, should also seriously explore the possibility to *novate* (i.e. transfer the contract with the funds needed to cover the legally committed dues) some contracts directly to the IO and thereafter act in support in their technical management. This measure, already foreseen in the ITER Agreement [[11]], will achieve the very essence of the key reform outlined in the AP2015 towards the centralisation of the costs for design changes, while not only being a way to overcome some legal concerns related to the IO-F4E contract management but also conceivably allowing a more direct and expedite system for its daily implementation. In such solution F4E would thereafter provide its staff (e.g. second or detach) to the IO for the contract follow up.

11) To complement the above measures, steps should be taken to reinforce the collective team spirit of the new organisation in line with the vision set out in the AP2015. In particular, there should be a more open communication between IO and F4E internally and, a single voice towards the external world. Combined with the structural measures above, it is hoped that a more common ITER-centric identity would emerge that staff at both IO and F4E could be proud of.

[[10]]F4E(14)-GB30-07.4 Status of the Procurement of the Buildings by Fusion for Energy, Analysis of the Delays and Lessons Learned, December 2014

[[11]] Joint Declaration 6.5, sect 6.

3 Conclusions and Recommendations to the GB

Committed individuals, who have joined both the IO and F4E, often originating from scientific projects with similarities to ours, with the objective to contribute in realising the next step to fusion energy with the construction, commissioning, and operation of ITER, have been confronted by a problematic, and at times even abstruse, project implementation environment: full of structural inadequacies as well as excessive bureaucracy. The resulting productivity is unsatisfactory at best.

With the appointment of the new ITER DG, we are presented with an important opportunity, perhaps the last one, to put the project on to a new sustainable path. We need to refocus on the short term construction objectives, while maintaining the long term vision towards the operation of the device. The AP2015, as endorsed by the ITER Council, sets out the vision of a new integrated organisation which may help to overcome many of the difficulties that the ITER Project has experienced in the last eight years.

Europe, as both the Host Party and main contributor to the ITER Project, has a crucial role to play in the successful implementation of AP2015. To achieve this result, the GB inasmuch as the F4E management, should take a bold approach towards enacting decisions and changes.

Regaining confidence in the ITER project will require a very significant and sustained effort by F4E and the IO. Both organisations will be require to “tie their own shoe laces while running” with the risk of tripping up. Such investment should bring about indispensable long-term improvements but will require many short-term challenges to be overcome. The GB should be prepared for this to happen and should carefully consider before placing any additional burdens on F4E during this period.

The concepts set out in this paper provide the broad lines for a number of actions which aim to complement and supplement the AP2015. For many of these actions, much additional work is needed to understand how they might be implemented and the short-term costs versus the longer-term benefits. Amongst the various approaches, the GB may wish to express its views on the extent to which the actions #10 above could be implemented. On balance, this may well be the solution sought to practically gradually return to the approach originally foreseen for ITER during the Engineering Design Activities (EDA) phase, whereby a DA was to act solely in the procurement phase leading to a contract, and thereafter leaving to the integrator the role to manage the implementation phase to its conclusion.

The GB is asked to support the F4E management in the forthcoming period to undertake the actions listed above, including all the organizational and managerial changes which will be required to ensure that the changes can be implemented in a way which is effectively supporting the AP2015.