# ITER ORGANIZATION
# 2016 ANNUAL REPORT

## JANUARY
- Scientist Fellow network launched

## FEBRUARY
- Monaco-ITER International Fusion Energy Days (MIIFED), third edition

## MARCH
- First components installed in Tokamak Complex basement (water detritiation tanks)

## APRIL
- ITER Council reviews independent assessment of the updated project schedule in extraordinary meeting

## MAY
- ITER Robots contest, fifth edition

## JUNE
- Eighteenth ITER Council validates the updated schedule through First Plasma
- Construction Management-as-Agent contract awarded to the MOMENTUM joint venture (Amec Foster Wheeler, UK, in partnership with Assystem, France, and KEPCO Engineering and Construction, Korea)
- Main cranes installed in Assembly Building

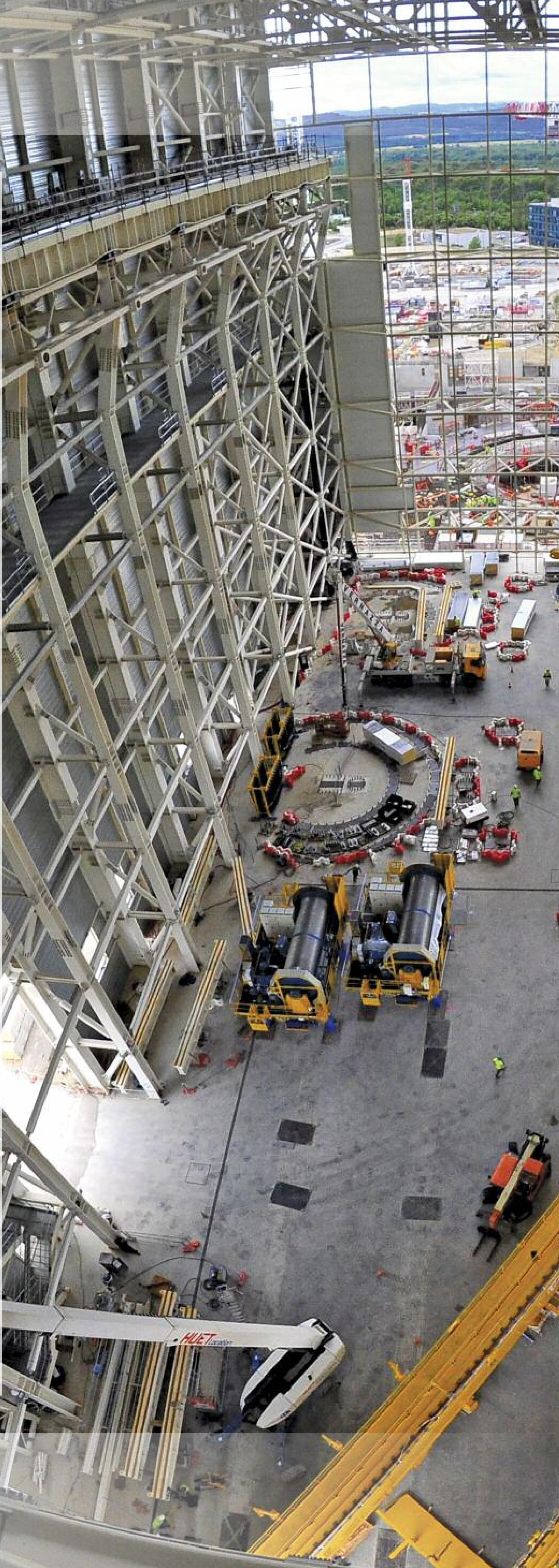
## JULY
- Project Team created for cryogenics
- First ITER Project Associate arrives

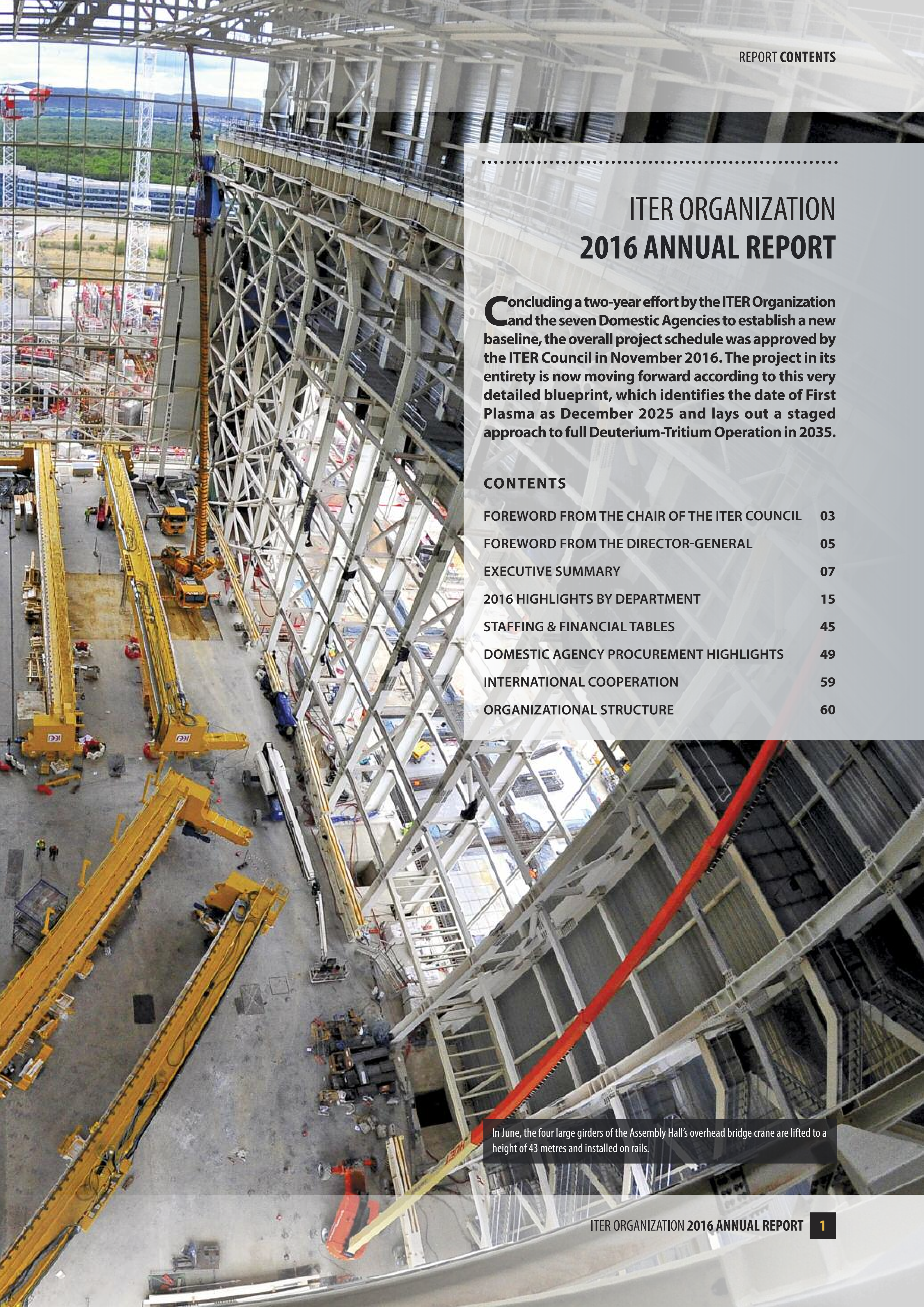
## SEPTEMBER
- Cooperation Agreement signed with the Australian Nuclear Science and Technology Organisation (ANSTO)
- Cryostat welding begins on site
- New organizational matrix for construction oversight
- ITER Games, sixth edition

## OCTOBER
- First toroidal field winding pack completed in Europe
- Open Doors Day with 600 participants
- Two-day press event for international journalists

## NOVEMBER
- Nineteenth ITER Council endorses updated project schedule to Deuterium-Tritium Operation

## DECEMBER
- 15,000 people visit the ITER construction site in 2016
- Immersive reality tour of site construction launched
- 19 of 20 ITER Council milestones achieved for the year





# ITER ORGANIZATION
# 2016 ANNUAL REPORT

**Concluding a two-year effort by the ITER Organization and the seven Domestic Agencies to establish a new baseline, the overall project schedule was approved by the ITER Council in November 2016. The project in its entirety is now moving forward according to this very detailed blueprint, which identifies the date of First Plasma as December 2025 and lays out a staged approach to full Deuterium-Tritium Operation in 2035.**

## CONTENTS

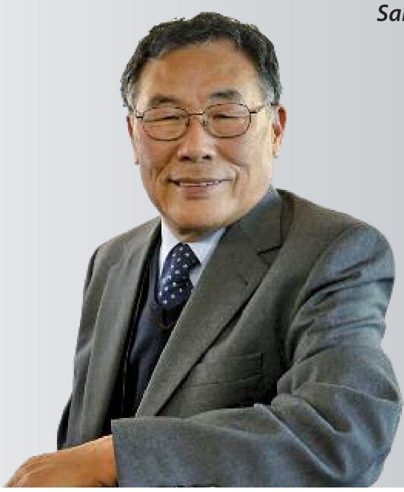


In June, the four large girders of the Assembly Hall's overhead bridge crane are lifted to a height of 43 metres and installed on rails.

US contractors complete the winding of the first central solenoid module in April. Six modules – each made from approximately 6,000 metres of niobium-tin superconductor supplied by Japan – will be stacked to form the 13-metre-tall central magnet. *Photo: US ITER*

# FOREWORD FROM THE **CHAIR OF THE ITER COUNCIL**

**Won Namkung**
***Saint-Paul-lez Durance***
***July 2017***



It is my pleasure to introduce the 2016 ITER Organization Annual Report, the first under my tenure as ITER Council Chair.

The year that has passed has been one of transition, as the actors of the ITER Project came together around a clear roadmap to ITER construction. In approving the Overall Project Schedule in November, as well as the Overall Project Cost *ad referendum*, the ITER Council recognized the project-wide improvements that have resulted from reforms carried out by the Director-General in the framework of his Action Plan.

Although the implementation of these reforms is an ongoing process, actions tailored to address the difficulties identified in project management have already made a difference. Reports received in 2016 from the ITER Council Review Group (ICRG) and the 2015 Management Assessment both confirmed the reinforced capacity of the project to properly forecast, manage and execute. Improvements in a number of critical areas such as systems engineering and integration, project control, decision-making processes, and international coordination made the development of a credible updated schedule and associated resource estimates possible.

We now have two distinct milestones ahead of us: a clear date for the achievement of First Plasma (December 2025) and a detailed approach to the start of Deuterium-Tritium Operation in 2035.

Without minimizing the challenges, I believe that the ITER Project is on the path to success. Performance against ITER Project Milestones as reported to the Council every two months has been steady. The original list of milestones for 2016-2017 has been extended through to the achievement of First Plasma, with each incremental step bringing the project closer to completion. The ITER Council will continue to closely monitor and support the project's ability to achieve these milestones as well as its capacity to anticipate and mitigate eventual risks to delay in the schedule.

Maintaining performance in the years ahead will be critical, as delay related to construction or manufacturing – or even financial or political hurdles – will set off a ripple of accompanying difficulties. I have no doubt about the commitment of all ITER Members to supporting the project's momentum, with the common understanding that each Member still needs to go through its domestic process to secure support and financial resources for the updated project baseline.

The construction of ITER, which can only be achieved by overcoming monumental complexity, will be a testimony to the scientific and technology capabilities of all participating Members. Together, we are engaged in one of the most thrilling human adventures of our times and one that could permanently alter the course of history.

I congratulate the entire team – from the Director-General to every staff member at the ITER Organization and the Domestic Agencies, plus contractors and suppliers globally – for their commitment to effective collaboration that has put the project on the path to success.


The pace of Tokamak Complex construction accelerated in 2016 due to an increase in the number of workers and the introduction of a second shift. The main Tokamak Building must be ready for early-access assembly activities in late 2018.

# FOREWORD FROM THE **DIRECTOR-GENERAL**

**Bernard Bigot**
*Saint-Paul-lez Durance*
*July 2017*

For the project to move forward, it was essential for us to accomplish two objectives over the past two years: first, to execute sweeping organizational reform, fully addressing and correcting the problems identified in the 2013 Management Assessment report; and second, while in the midst of this reform, to shift to full-paced construction and manufacturing in respect of milestones agreed with the ITER Council for the years 2016 and 2017, even as the examination of our updated long-term project schedule and associated resource estimates was underway.

The successful achievement of this ambitious program was critical to ensuring that the ITER Members, the ITER Organization and the Domestic Agencies regain full confidence in the project and in themselves. It was a prerequisite for the pursuit of ITER and, finally, success.

Thanks to the joint effort of the management, staff and contractors of the ITER Organization and the Domestic Agencies, and the strong, continuous support of the ITER Members, we have reached the goals we set for ourselves and, today, the ITER Project has turned the page. More remains to be done but I do believe that we have created a new culture of collaboration, within which we candidly face the challenges that arise and jointly seek solutions that are in the best interest of the project.

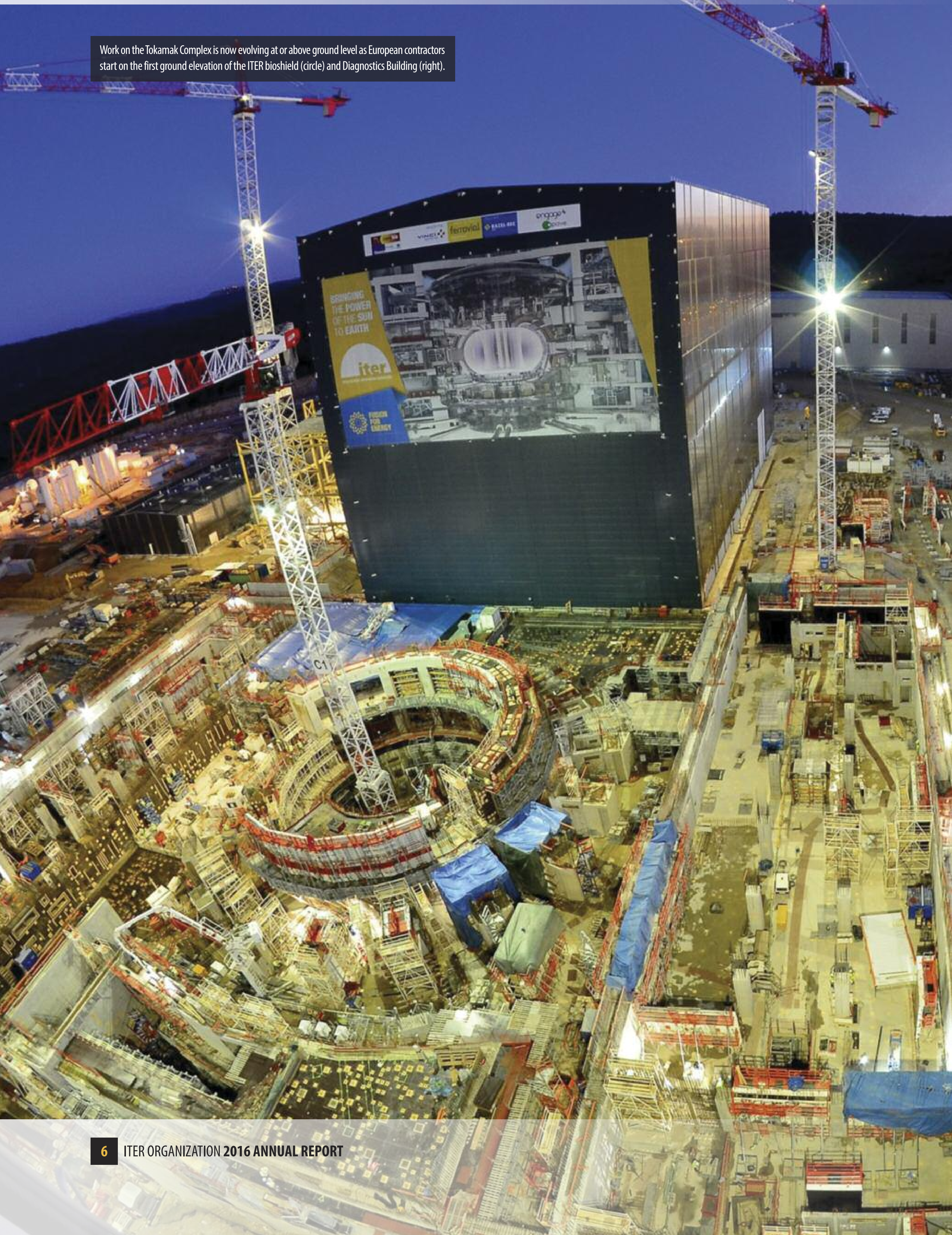
In 2016, we successfully concluded a series of iterations to develop an updated resource-loaded schedule, taking a comprehensive look at each Member's technical, financial and political constraints to arrive at the best compromise. Within the revised baseline schedule endorsed by the ITER Council in November 2016, First Plasma is planned for December 2025, followed by a staged approach to the development of machine and auxiliary system performance that culminates in the transition to deuterium-tritium operation in 2035.

This intense collaborative work on the schedule has had important side benefits as – in order to successfully complete the exercise – we had to resolve pending questions related to design completion, project change requests, and technical issues. The project as a whole is in a much stronger position due to this effort.

In parallel, we are completing ambitious milestones in building construction and the fabrication of First Plasma components as scheduled and preparing for the assembly and installation phase of the machine and plant. A new construction management organization – based on construction teams with responsibility for specific areas on the worksite – as well as the selection of the ITER Organization's principal assembly contractor, the Construction Management-as-Agent (CMA), were two important steps to ensuring that the knowledge of components and systems that exists within our respective organizations is successfully integrated with the industrial expertise of the CMA as we enter a new chapter of ITER construction.

And because I feel strongly that to exploit the machine's potential and to optimize its performance ITER will rely on major contributions from the Members' fusion science communities, we are striving to reinforce interaction. There are now 45 international organizations, national laboratories, universities and national schools from the ITER Members that have signed scientific or technical cooperation agreements with the ITER Organization, and in 2016 we welcomed the first non-Member entity – the Australian Nuclear Science and Technology Organisation, ANSTO. The first scientists accepting to participate in the new ITER Organization Scientist Fellow network and collaborate with our specialists on simulation and theory in support of ITER also met on site to confirm short- and long-term research objectives.

It is not an exaggeration to say that thousands of people are working around the world to make ITER a success. At the ITER Organization, in the Domestic Agencies, in factories, labs and universities our efforts are focused on building, commissioning, and operating a unique scientific device – the only one on Earth capable of producing a burning plasma in the next decades. With me, and you, they share the conviction that ITER will show the way to a new, safe, environmentally responsible and virtually inexhaustible energy source that is well worth the large investment of the seven ITER Members and the best joint efforts of our staff and industries.




Work on the Tokamak Complex is now evolving at or above ground level as European contractors start on the first ground elevation of the ITER bioshield (circle) and Diagnostics Building (right).

# EXECUTIVE **SUMMARY**

**On 21 November 2006, the government representatives of the People's Republic of China, the European Atomic Energy Community (Euratom), the Republic of India, Japan, the Republic of Korea, the Russian Federation and the United States of America signed the constitutive document of the ITER Organization in Paris. In the Preamble of the ITER Agreement, the Members emphasized their belief that "ITER is the next important step on the path to develop fusion energy" and affirmed the significance of "genuine partnership in implementing this long term and large scale project."**

**Ten years later, the Members' vision is crystallizing on the ITER site in southern France, as the buildings of the scientific installation emerge and components shipped from factories around the world are stored for the start of assembly and installation. The stage is now set for the world's largest fusion reactor to enter operation in 2025.**

**From design and early construction activities, the project has transitioned to full-paced construction and manufacturing. Broad reform has increased the fundamental strength of the organization, its management, and the international collaboration that underwrites all efforts. A detailed work plan defining project scope, schedule and cost through First Plasma and Deuterium-Tritium Operation – the 2016 Baseline – has earned the approbation of internal and external observers.**

**In an early sign that the ITER Organization and the Domestic Agencies have the capacity to meet the baseline schedule as proposed, 19 out of 20 high-level technical and programmatic milestones planned as a way to measure performance in 2016 were achieved, and the twentieth was delayed by only a matter of weeks. Through organizational effectiveness and sustained physical progress, the project is demonstrating its capacity to complete the construction phase of the project with reliability and accountability.**

The ITER Director-General welcomes H.S.H. Prince Albert II of Monaco to the site in September. Through the Monaco-ITER Partnership Arrangement, signed in 2008, the Principality of Monaco has funded over 20 postdoctoral researchers at ITER for two-year assignments and hosted three international conferences.

## ORGANIZATION

*Completing reform*

The bulk of the Action Plan proposed to the ITER Council by Director-General Bernard Bigot at the start of his mandate in March 2015 has effectively been implemented. Three essential pillars of reform – management and organizational restructuring at the ITER Organization, improved collaboration between the central team and the seven Domestic Agencies, and improvements to project management practices – have resulted in stronger control of schedule, cost and risk.

The ITER Organization has reinforced the transversal functions of engineering integration, configuration control, quality assurance, project control and human resources, and introduced the first phase of a new construction management organization to prepare for the lead role that it will play in the assembly and installation of the machine and plant. The Executive Project Board, introduced in 2015 to unite the top management of the ITER Organization and the Domestic Agencies, is working well to resolve issues at the senior level. Project Teams for buildings, the vacuum vessel, and cryogenics now focus cross-project resources on highly integrated and/or schedule critical areas. Decision-making efficiency has been improved at the working level through the Central Team Management Board (ITER Organization) and the Joint Project Coordination weeks (ITER Organization/Domestic Agency).

The proposed updated long-term schedule and associated resource estimates as well as the ITER Organization's management of human resources were the object of rigorous review by the ITER Council Independent Review Group (ICRG) beginning in February. Its report, which provided the ITER Council with external validation of the credibility of the proposal and its underlying assumptions as well as recommendations related to human resource management, was accepted by the ITER Council during an extraordinary meeting in April (IC-Ex/04.16). The ITER Council also convened for two regular meetings during the year on 15-16 June (IC-18) and 16-17 November (IC-19), during which it reviewed the continued development of the baseline and the implementation of project reforms. The Management Advisory Committee (MAC), the Science and Technology Advisory Committee (STAC) and the Test Blanket Module Program Committee (TBM-PC) met ahead of each Council session to provide support for strategic issues. The results of the 2015 ITER Management Assessment were reported to the ITER Council in June.

## BASELINE

*First Plasma in December 2025*

Concluding a two-year effort by the ITER Organization and the seven Domestic Agencies to update the baseline, the overall project schedule was approved by the ITER

Council in November 2016. The Overall Project Cost was approved *ad referendum*, meaning that it will now fall to each Member to seek approval of project costs through respective governmental budget processes.

The updated resource-loaded schedule identifies the date of First Plasma as December 2025 and lays out a staged approach to full Deuterium-Tritium Operation in 2035 in which periods of machine operation alternate with sequential phases of assembly. The 2016 Baseline is considered the best compromise between the common will of the ITER Members and the ITER Organization to advance quickly, technical constraints (including risk), and the financial constraints of the Members.

Throughout the re-baselining exercise, the ITER Organization and the Domestic Agencies worked in close coordination to verify design maturity, confirm supplier manufacturing schedules, and clarify the component need dates and assembly sequences within the frame of the staged approach. All outstanding configuration issues were addressed and resolved through the Joint Project Coordination weeks or the Executive Project Board.

In addition to tracking performance against high-level ITER Council milestones, a new tool now reinforces the project control function at the ITER Organization: the simplified Master Schedule. Resulting from lessons learned during the development of the updated long-term schedule, the Master Schedule registers the physical progress of work against each procurement package on a monthly basis. Other improvements in project management processes planned for implementation next year include a full set of key performance indicators (KPIs) and earned value management (EVM) systems.

A strengthened approach to risk management is being implemented across the project. A senior Project Risk & Opportunity Management Committee (PROMC) has the responsibility for identifying and prioritizing risks and opportunities and ensuring that they are managed at the correct level. The probability of occurrence and potential impact is now calculated in months and euros, and the top ten risk and opportunity families and response actions are clearly identified in the project-wide register. These new risk management practices are helping the project to anticipate challenges in critical-path areas such as Tokamak Building construction, vacuum vessel sector manufacturing, and the fabrication of in-wall shielding. In one demonstration of the maturing risk management culture in the project, where potential risks to the fabrication and delivery schedule are identified and response actions set into place, Europe transferred the responsibility for two vacuum vessel sectors to the ITER Organization in 2016 for fabrication in Korea. This procurement transfer will have no effect on overall cost sharing.

## CONSTRUCTION

### *Tokamak Complex emerging*

Work on ITER's main scientific facility – the Tokamak Complex – is now evolving at or above platform level as European contractors started on the first ground elevation of the ITER bioshield and Diagnostics Building in 2016. The basement levels of the Tritium and Tokamak buildings were also transformed through interior partitions and columns, the pouring of the last basement floor slab (B1) around the bioshield, and the installation of the first captive components. On site, the workforce grew to 1,200 people.

The 60-metre-tall Assembly Building was insulated with several layers of cladding and equipped with overhead handling cranes; activity on interior finishings is now underway to prepare for the delivery of the first massive assembly tool. In 2016, construction teams began erecting the steel frames of the cryoplant and radio frequency heating buildings, advanced work on the electrical switchyard infrastructure and underground technical galleries, and initiated early activities in the zones reserved for magnet power conversion and heat rejection. All major civil works contracts have been awarded by the European Domestic Agency for the buildings and infrastructure that must be in place for First Plasma.

Once completed and made ready for equipment, the buildings will be handed over progressively to the ITER Organization for the assembly and installation of the machine and plant. In anticipation of this new project phase, the ITER Organization has begun to adjust its internal organization for construction management.

The extensive cryogenic power needed to cool the ITER magnets, thermal shield and cryopumps will be delivered from a single location on the ITER site – the ITER cryoplant, under construction now.

Just outside the three-metre-thick ITER bioshield (partially covered in blue), workers pour the south side of the bioshield mezzanine. *Photo: F4E*

In June, a contract was signed with the Construction Management-as-Agent (CMA) contractor chosen to help to plan, manage and supervise the assembly and installation activities on site. In addition, the first phase of a matrixed construction organization was introduced to closely integrate the CMA's industrial expertise with the systems-based engineering knowledge that exists at the ITER Organization and the Domestic Agencies.

Finally, the procurement strategy for work packages related to assembly and installation was revised to match the updated project schedule and to reduce the risk inherent in large-scale contracts. The ITER Organization is also procuring specialized tooling for assembly and handling, and planning for the storage of bulk (electrical, piping) and exceptional components (magnet coils, vacuum vessel sectors, cryostat segments). During the year, 23 highly exceptional convoys reached the ITER site, representing an increase of around 50 percent over 2015.

## LICENSING

*Committed to learning and responding*

Regular technical exchanges continue with the French Nuclear Safety Authority ASN on the prescriptions related to the demands of the official Ministerial decree that created the ITER Basic Nuclear Installation (INB) in 2012. An important milestone was reached in July when a hold point related to the construction of neutral beam cells in the Tokamak Building was lifted. In 2016 ASN also monitored changes to the internal organization of the central ITER Organization team, confirmed that the staged approach to assembly is compatible with ITER licensing, and carried out four on-site inspections. Corrective actions were undertaken by the ITER Organization and the Domestic Agencies in response to ASN requests linked to these inspections.

Efforts continue to encourage the full commitment of each project actor to a strong nuclear safety culture across all areas of activity. Surveillance plans were reinforced in 2016 to ensure proper propagation and implementation of the defined safety requirements for systems with protection-important components; a program was launched to qualify Project Team staff on applicable nuclear safety regulations; and workshops were held on the management of non-conformities and the diffusion of safety regulations in design and manufacturing.

The Beryllium Management Committee, formed in 2015, continues to meet regularly to pursue the safe implementation of beryllium handling and storage at ITER. A new Nuclear Integration Unit composed of ITER Organization and Domestic Agency staff was introduced by the Director-General in 2016 to promote a fully integrated nuclear engineering approach in compliance with project and regulatory requirements.

## MANUFACTURING

*Intense activity worldwide*

The principal ITER magnet systems are now all in production. Milestones were recorded in 2016 for the toroidal field magnets (first winding pack in Europe, case segment fabrication in Japan); the poloidal field magnets (start of series fabrication in Russia, final qualification activities for winding lines in China and Europe); the central solenoid (first production winding in the US); and the correction coils (bottom coil in production in China). Domestic Agency contractors are also advancing on work packages for magnet feeder components, high temperature superconducting leads, magnet supports, and instrumentation. The first completed magnet – a toroidal field coil produced in Japan – is expected to reach ITER in 2019.

Industrial activity for ITER's other sizeable machine components – the vacuum vessel and cryostat – also achieved strong and measurable progress in 2016. In Korea, manufacturing is advancing on vessel sectors #6 (55 percent complete at the end of 2016) and #1 (22 percent complete) and contractors are assembling the first of two large sector sub-assembly tools. In Europe, large-scale electron beam welding was employed for the first time to realize a poloidal segment subassembly for sector #5. The manufacturing design for all sectors has been completed; port extension and stub extension fabrication is underway in Korea and Russia; and thousands of in-wall shielding elements are in production in India.

Welding and radiographic testing activities started in the on-site Cryostat Workshop on tier one cryostat base segments. All second-tier base segments were delivered and fabrication is underway in India for the next section – the lower cylinder. Good progress was recorded in Korea for the vacuum vessel and cryostat thermal shields.

ITER plant systems for coil power supply and distribution, electrical distribution, cryogenics, cooling, vacuum, diagnostics, and heating are all in production.

The first serial element of the poloidal field coil procurement program has been produced for ITER's smallest coil, PF1. *Photo: ITER Russia*

The 17-metre excavation in the platform, the seismic foundations, and the lowest level of the Tokamak Complex are no longer visible as contractors move forward on the Tritium, Tokamak and Diagnostics buildings.

Electrical distribution will be the first ITER plant system to come on line with the planned energization of one portion of the steady state electrical network next year. To prepare the transition from design and manufacturing to the installation and commissioning of the cryoplant, a Cryogenic Project Team was formed in July. Piping for the vacuum and cooling water systems, electrical distribution components, switching network components, and elements of the cryogenic plant formed the bulk of plant system deliveries in 2016.

The ITER Organization estimates the level of design completion for First Plasma components and systems at 92.4 percent and the level of manufacturing completion at 41.1 percent based on ITER Unit of Account value credits at the end of the reporting period. The arrival of components on site is accelerating – among the "firsts" expected next year are poloidal field AC/DC converter and reactive power compensator units, the pre-production cryopump, stainless steel piping for the Tokamak cooling water system, and the first diagnostic systems. Metrology teams have been dispatched to ITER Member manufacturing sites to record the as-built dimensions of large machine components in fabrication and to verify tolerances.

## R&D

*Identifying and testing the best solutions*

Two testbeds under construction now at the PRIMA facility in Italy will help resolve challenging physics and technology issues related to the project's most powerful heating system – neutral beam injection – and validate concepts before the neutral beam system is built at ITER. The implementation phase of the ion source testbed SPIDER is well advanced, with commissioning and experimentation set to begin on schedule in 2018. Component design for MITICA, the full-scale injector prototype, was completed early in the year and manufacturing has started on some elements.

Strong headway was also made on research and development activities for the divertor and the blanket – two of the systems that will be installed during the assembly phases planned after First Plasma. As part of qualification and testing programs, prototypes of the divertor cassette body, inner target and dome were realized and beryllium-tiled blanket first wall "fingers" were tested successfully in ITER-like conditions. In positive news for the divertor program, the ITER design solution for monoblock front-surface shaping was demonstrated to be satisfactory from a physics and engineering point of view.

Progress was recorded in the design of diagnostic systems; the diagnostic first wall of the blanket; the primary and secondary cooling loops of the installation; the components of the ion cyclotron system; the disruption mitigation system; and the technological solutions for tritium breeding. Concluding a multiyear R&D program for ITER's in-vessel coils, a contract was signed with a supplier for conductor fabrication. A group tasked with the re-design of the vacuum vessel pressure suppression system also completed its work during the reporting period and submitted the new configuration to the Agreed Notified Body for review.

## FINANCE

*Rigorous monitoring and management of resources*

The implementation of the annual budget for the ITER Organization was closely monitored in 2016, resulting in the effective execution of 93 percent of planned commitments and 86 percent of planned payments. Resource estimates for each Department and Division were finalized in accordance with the updated baseline schedule through First Plasma, and the use of the Reserve Fund – an account created from contributions by all stakeholders that allows the Director-General to fund unavoidable change orders – was closely tracked and reported to the ITER Council.

The final total of commitment appropriations for 2016 was EUR 423.6 million, of which EUR 94.6 million was held in the Reserve Fund and EUR 6.7 million was in Undistributed Budget. During the year, commitments of EUR 299.9 million were made, leaving a balance of unused commitment appropriations for distributed budgets of EUR 22.5 million to be carried forward to 2017. The payment appropriations for 2016 were EUR 380.8 million, including EUR 103.9 million in the Reserve Fund and EUR 13.1 million in Undistributed Budget. Of this amount, EUR 227.1 million was paid or credited, leaving a balance of unused distributed payment appropriations of EUR 36.8 million. Financial income of approximately EUR 1 million was realized over the course of the reporting period.

Since 2007, the ITER Organization has signed a total of 108 Procurement Arrangements for the delivery of components, systems and buildings with the Domestic Agencies, representing 90.86 percent of the project's in-kind allocated value.

The Financial Audit Board conducted two on-site audits during the year, certifying in April that the ITER Organization 2015 Financial Statements gave a true and fair view of the financial situation of the Organization. During its September meeting, the Board audited the financial transactions of the ITER Organization for the period from 1 January to 30 June in accordance with International Public Sector Accounting Standards (IPSAS) and the Project Resource Management Regulations (PRMR).

## STAFFING

*Consistent with the Council-approved staff cap*

The first group of ITER Scientist Fellows has started its work to contribute to ITER's top scientific research needs; in parallel the first ITER Project Associates were recruited for their expertise in the areas of assembly, installation and commissioning. Both of these non-staff categories were created by the ITER Director-General as part of a strategy to leverage resources in the Domestic Agencies and the Member fusion communities.

At the end of the year, the ITER Organization employed 740 staff members. Thirty two experts and 38 interns were also employed at ITER, and a fifth recruitment campaign for Monaco Fellows was conducted for appointments beginning in late 2016/2017. An Office of the Ombudsman was established as a dispute resolution mechanism for directly employed staff, and rules concerning rewards for inventors were issued in order to encourage the development of ITER Organization intellectual property.

As set forth in the Staff Regulations, the ITER Staff Committee supports employees in all matters related to their welfare: promoting educational and social activities; meeting regularly with administration representatives to discuss issues with an influence on well-being; and assisting staff with difficulties. Topics of particular consultation in 2016 included flexible work time; objectives setting, performance assessment and incentive measures; and expatriation issues. The Staff Committee also undertook to bring issues relating to the Provence-Alpes-Côte d'Azur International School, where 56 percent of the 710 students attending at the start of the school year were from ITER families, to appropriate forums for discussion.

## EXTERNAL RELATIONS

*Opening the doors to scientific exchange; reaching out to the public*

The ITER Organization signed the first non-Member technical cooperation agreement of its history in September with the Australian Nuclear Science and Technology Organisation (ANSTO), a national research organization representing the Australian nuclear fusion community. Under the terms of the Agreement, Australia can contribute directly to the construction of the ITER machine in limited but important areas and Australian researchers can participate in research collaborations at ITER. Cooperation is envisioned in diagnostics, materials, superconducting technology, and fusion plasma theory and modelling.

The ITER Organization also signed Memoranda of Understanding for technical, scientific or academic cooperation in 2016 with the Universidad Nacional de Educación a Distancia (Spain), the University of Illinois (US), the National Research Nuclear University MEPhI (Russia), the KTH Royal Institute of Technology (Sweden), and the Institute of Plasma Physics Chinese Academy of Sciences (China). (A full list of cooperating entities can be found at the end of this report.)

The third edition of the Monaco-ITER International Fusion Energy Days (MIIFED) was held in conjunction with the annual ITER Business Forum in 2016 to create a single event dedicated to upcoming business opportunities. ITER scientists also exchanged with their peers at fusion science and technology conferences worldwide.

ITER was represented at a number of external events, including the World Nuclear Exhibition (Paris), the Symposium on Fusion Technology (Czech Republic), the IAEA Fusion Energy Conference (Japan), and World Energy Congress (Turkey), the Pacific Basin Nuclear Conference (China), and the ITER/Broader Approach Symposium (Japan).

As part of an updated exhibition stand Communication has developed a portable immersive virtual reality tour of the ITER construction site that is accessible in 2D and 3D versions through the public website. Fifteen thousand visitors visited the ITER site in France in 2016.

ITER's new immersive reality tour makes you feel like you are ON the drone that is documenting ITER construction.

The 18 D-shaped toroidal field coils are among the largest components of the ITER machine. The very first toroidal field winding pack (110 tonnes) is produced by European contractors in October. *Photo: F4E*

# 2016 HIGHLIGHTS **BY DEPARTMENT**

**PROJECT CONTROL OFFICE (PCO)**

*The Project Control Office ensures the coordinated action of project controls, manages the ITER Baseline (scope, schedule, cost, and risk), monitors schedule variation and response actions, performs risk and opportunity analysis, and evaluates the efficiency of management systems.*

The updated long-term schedule presented to the ITER Council in November 2015 (the "reference schedule") was the foundation for the establishment of the ITER Baseline in 2016. The Project Control Office was centrally involved in these efforts, preparing for meetings of the ITER Council and advisory bodies and working to articulate a "staged approach" to plasma operation with respect to the technical challenges and financial constraints of the Members.

**Project progress is controlled and reported on the basis of high-level milestones approved by the ITER Council.**

The methodology and the preparation underpinning the first year of schedule development were validated by an ITER Council Review Group in February and the subsequent extraordinary meeting of the ITER Council; based on this positive result and further recommendations for optimization, a project-wide effort was launched to complete integration activities. In parallel, the ITER Organization and Domestic Agencies worked through several iterations to develop the staged approach to operation – four distinct phases of operation from First Plasma to deuterium-tritium experiments, interspersed with periods of assembly – that reduce funding requirements from the Members for the 2017-2019 period. The staged approach also lowers project risk by focusing on First Plasma and allows for a longer research program between First Plasma and fusion operation.

At the eighteenth ITER Council in June, representatives of the ITER Members endorsed the updated resource-loaded schedule to First Plasma (December 2025) and charged the ITER Organization with extending the integrated schedule through Deuterium-Tritium Operation.

Six months of tightly coordinated effort with the Domestic Agencies ensued to establish the detailed consistency of the full 2016 Baseline within the frame of the staged approach. At two workshops held at ITER Headquarters in July – the Configuration Workshop and the Research Plan Workshop – lists of components were established for each installation phase and need dates defined in full compatibility with the Members' financial constraints and the planned scientific research program. The Configuration Workshop was also the occasion to discuss and resolve identified technical issues and to escalate a small number of top issues, with recommendations, for decision making by the Director-General.

In November, the ITER Council (IC-19) commended the ITER Organization and the Domestic Agencies for the successful development of the updated schedule, the fruit of two years of integrated effort. All Members approved the project schedule and estimated cost including staff resources up to 2025, as well as the indicative schedule and cost baseline up to the start of burning plasma operations (2035) based on the staged approach. The overall project cost was approved *ad referendum*, pending approval through each Member's specific governmental budget process.

Project progress was controlled and reported throughout 2016 on the basis of high-level project or programmatic milestones approved by the ITER Council. Out of 20 ITER Council milestones planned for the year 19 were achieved – with the last delayed by only a few weeks without impact on the schedule. Similar high-level "markers" have now been identified through First Plasma and will continue to be tracked and reported every two months as an important monitoring tool.

To answer to the need for more precise statusing, effective change control and more meaningful trend analysis, the Project Control Office also introduced a new schedule management tool during the year – a simplified Master Schedule. Consistent with the Detailed Work Schedules submitted by the Domestic Agencies in September, the Master Schedule formed the basis of the baseline schedule submitted to the ITER Council. The Detailed Work Schedules are still used to monitor execution at the working level on a daily basis and to provide forecast delivery dates, while the Master Schedule is used to monitor the rate of achievement against commitments. With ten times fewer activities,

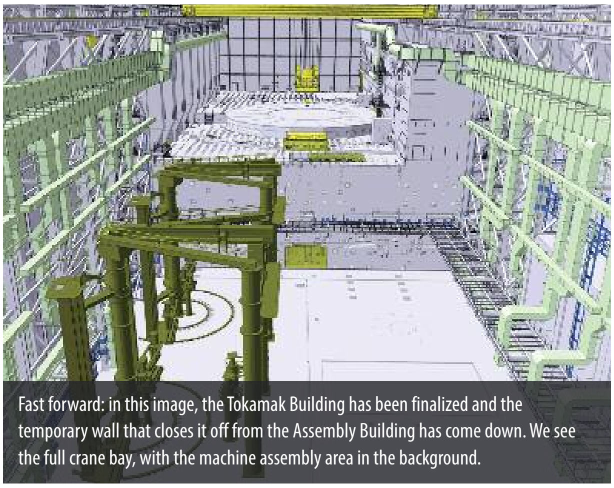
In March, a water detritiation tank supplied by Europe becomes the first plant component to be installed in the Tokamak Complex.

the Master Schedule enables the robust logical sequencing of activities, which in turn permits essential in-month execution monitoring of work progress and "percent complete" statistics.

The ITER Organization's approach to risk and opportunity management continues to mature. Improvements introduced in 2016 through the risk and opportunity action plan include the continued clean up and development of the risk and opportunity register (now accessible to all ITER and Domestic Agency staff); better prioritization; and the adoption of a quantitative approach with the probability of risk and opportunity occurrence and impact calculated in months and euros. The top ten risk and opportunity families, plus response actions, are identified in the register, providing a reasonable snapshot of the risk and opportunity situation up to First Plasma that covers the ITER Organization, the Domestic Agencies, and transversal topics.

In order to drive proactive risk and opportunity management for the project as a whole, the Director-General created the Project Risk & Opportunity Management Committee (PROMC) in April. This independent senior body will enhance line management's capability to manage risks and opportunities by applying a three-tier approach to identifying and prioritizing required response plan actions across the project (highest-level risks and opportunities will be handled by the Executive Project Board, while those classified at a lower-level will be treated at the Configuration Control Board level or by the Departments). Efforts to harmonize the different risk and opportunity management approaches and systems in the ITER Organization and the Domestic Agencies are progressing. A workshop planned in February 2017 will be the opportunity to demonstrate a common understanding on risk and opportunity management methodology, a stable risk register, and response plans in preparation for an independent review by Management Advisory Committee experts.

Building on efforts initiated last year, the Office continues to implement industry-standard project management tools and procedures. The success of a pilot earned value management (EVM) program and the expansion of key performance indicators in 2016 will lead to the implementation of these performance monitoring tools at the ITER Organization next year; the Office is also developing an overall indicator of physical progress. Finally, the Project Management Plan (PMP) is circulating for approval; this near-finalized document will strengthen the ITER Project culture by providing the framework for the implementation of methods, processes, tools and competency development required to successfully project-manage ITER.



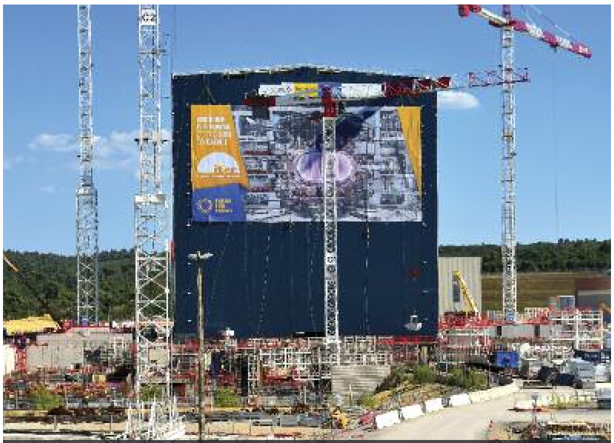
Fast forward: in this image, the Tokamak Building has been finalized and the temporary wall that closes it off from the Assembly Building has come down. We see the full crane bay, with the machine assembly area in the background.

### CENTRAL INTEGRATION OFFICE (CIO)

*The Central Integration Office seeks to maintain overall project coherence while supporting the ITER Director-General in his responsibility as design authority, project integrator and nuclear operator. It regroups under its umbrella the transversal functions of design control and integration; systems engineering; engineering quality control; configuration management; the development and maintenance of information tools (IT); Computer-Aided Design (CAD) resource management and design activities; systems analysis and standards; nuclear and engineering analysis; and documentation and records.*

The teams for design integration and system integration dedicated significant resources during the reporting period to implementing the staged approach into the baseline – identifying the minimum technical configuration required for each phase, flagging outstanding issues, and modifying ITER basic documents to reflect the new project strategy. At the Configuration Workshop mid-year, the Domestic Agencies provided input per system and a common position was established, joint work which contributed to finalizing the technical baseline in time for presentation to the ITER Council in November.

The Design & Construction Integration Division assists plant system and building owners in implementing requirements or change requests in their designs and in resolving key interface issues. In 2016, the baseline configuration for the machine was completed in full compliance with project requirements and manufacturing input – an effort that resulted in the approval of more than 50 models. Remaining questions on port systems integration were addressed as engineers identified the temporary items needed for First Plasma, performed the detailed designs of bioshield plugs, defined the port cell bellow/building sealing requirements, and completed the qualification of the vacuum vessel port plug handling process. In preparation for the launch of the Tokamak assembly



Giant, but not quite to scale: the ITER machine will be 30% larger than what is shown on the poster that adorns the temporary wall of the Assembly Building.

contract, the Division performed tolerance assessments, issued functional tolerance and interface drawings, and held design integration reviews for assembly tooling. The team was also heavily involved in preparing construction technical specifications for mechanical and piping work contracts.

Design & Construction Integration is responsible for coordinating engineering model configuration management at the project level, which includes both baseline and as-built model control. Tolerance requirements were reviewed in 2016 to complete the overall tolerance model and only a few issues now remain to be resolved before the document becomes the reference baseline. The assessment of critical gaps has been completed for the ex-vessel area and nearly completed for the in-vessel area; documents describing the functional step-by-step assembly sequences of main machine systems have been produced; and a proposal to coordinate analysis for transversal tolerance risks was accepted and will be set into place in 2017.

Team members completed the design of concrete civil works for the Tokamak Complex covering all plant systems, penetrations, embedded plates, and fixing building interfaces up to roof level. The construction configuration including roof equipment is expected to be completed by early 2017. The construction design – or the sequence of events that drive the design and realization of buildings – has now been approved level by level and execution designs are progressing. Changes required for improved radiation shielding have been issued as project change requests, the design layout for mechanical and electrical equipment is evolving, and as-built models for near-completed buildings on site (Assembly, Cleaning, and Radio Frequency Heating buildings) were updated to reflect the latest changes and will be issued in 2017. Good progress was also recorded in the engineering integration of the cooling tower zone.

The systems engineering team focuses on verifying the correct flow down of safety and other top-level project requirements in the definition of the systems. Existing safety requirements impacting buildings were clarified during the year for the Tokamak Complex and auxiliary buildings and the integration of specific plant systems was verified through simulation. In order to prepare for future functional design integration reviews, a pilot case was run based on the cryogenic integrated system (cryogenics, magnets, vacuum and thermal shield). CIO is also collaborating with each Domestic Agency to freeze interfaces with importance for First Plasma and place them under configuration control. After an initial collaboration with the US Domestic Agency in 2016, this important effort will be pursued with the six other agencies in order to reduce or mitigate risks along the critical schedule path.

The configuration management process – specifically the level II and level III Configuration Control Boards – has been used with success over the past 24 months to close out a large backlog of project change requests, with the result that the change process is now more stable. The implementation of a project lifecycle management tool (PLM) is also progressing well: when fully implemented this cross-organizational tool will assist the project in collecting, controlling and maintaining approved configurations; producing the as-built regulatory file needed for operation; and managing ongoing maintenance and component replacement activities. Planning is underway on the framework contract, a team has been recruited, and a PLM pilot was run mid-year to support the management of the different plant configurations related to the staged approach.

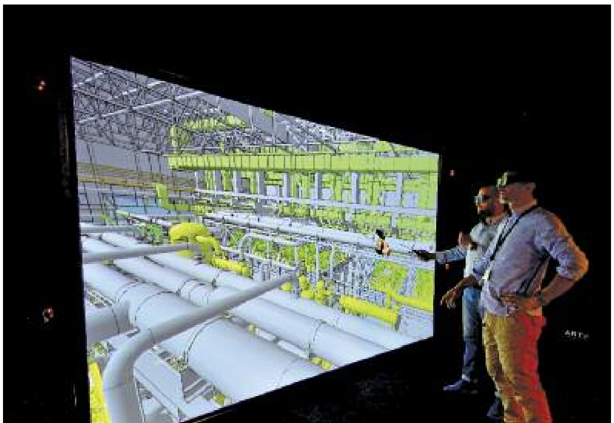
Following the introduction of Project Teams in 2015 and their increased involvement in protection-important activities, the Configuration Management Division has initiated a qualification program for team staff. Procedures for configuration management, design control, quality control, and document control were improved and aligned with the staged approach during the year and a set of safety reference documents (and the processes for controlling them) were defined with the Safety Department. In other highlights, more regular reporting on global design activities was established; the implementation of design control in the supply chain was reviewed in depth; and new tools were introduced and propagated for requirement management.

With quality control now transferred under CIO responsibility, needs were assessed and required resources estimated. The planned approach will be to optimize resources already available for quality control at the Domestic Agencies; to this end, a procedural framework was agreed and requirements for top-level quality and planning documents finalized. The Document Control Section was active in preparing for on-site activities by establishing document control procedures, determining the criteria for handing over engineering documentation packages to the Construction Department, and improving the management of radiographic material and as-built documentation.

The Project Information System Section/Division (IT) continues to manage computer services, databases and networks, telecommunications, and the project's internal and external websites, adding 1,000 new computers to its base in 2016, managing 4,500 video conferences and treating 23,000 user requests. IT oversees some 40 outsourced contracts, seeking the best value for investment, and maintains the ITER Organization's central applications and central infrastructure.

In 2016, the group upgraded the SAP solution for administration, created new applications and interlinks between software programs to reflect business needs, supported the integration of the Construction Management-as-Agent team, and continued to collaborate on the use of the SmartPlant® suite for materials management and construction. Significant resources were also devoted to the development and trial of the PLM project management tool, the reinforcement of cyber security, and the improvement of computing capacity. In October, a protocol for massive data transfer developed in Japan was tested successfully with the participation of ITER IT experts.

In collaboration with IT, the Design Office Division administers the project's CAD infrastructure. In 2016 it supported the technical responsible officers in the execution of the year's full CAD work plan, in particular producing thousands of schematics and drawings in support of construction call-for-tenders. The Office treated requests for support and tickets for data exchange from users at the ITER Organization, the Domestic Agencies and suppliers (650 in all), while continuing to monitor outsourced work packages, CAD earned value measurements, and key performance indicators to ensure the efficiency and quality of the work. The Office moved to set up control groups, enhance quality control, create standardized technical documents, and develop industrial technical plateaus (schematics, drawings, plant design) in support of the tight schedule.



Engineers at ITER use virtual renditions of the machine's systems to verify integration issues, interfaces and assembly sequences.

**The ITER Organization has worked over the past two years to reinforce the transversal functions of engineering integration, configuration control, quality assurance, project control, and human resource management.**

To efficiently support the construction phase, improvements were launched or initiated in the area of multi-CAD usage, advanced drafting capabilities, improved mass production tools, clarified documentation, and PLM support; the new AVEVA plant design suite was also deployed and centrally administered. A workshop hosted in May in China with all Domestic Agencies brought users together in the interest of improving collaboration.

The Analysis Section/Division is charged with structural, seismic, nuclear and electromagnetic analysis in support of project priorities, with emphasis on interfaces and the design integration of the plant in collaboration with the Domestic Agencies. In 2016, team members pursued the definition of interface loads between buildings and equipment in the Tokamak Complex for the sizing of embedded plates; performed calculations to confirm the interface load between the cryostat bellow flanges and the bioshield in accidental conditions; collaborated with the Korean Domestic Agency on the structural analysis of the sector sub-assembly tool and assembly tool group B1; and contributed to the completion of building design by responding to requests for information. Twenty-five additional system load specification reports were finalized, bringing the number on record to 226.

In an important milestone for the project, Division staff completed work begun last year to update design floor response spectra for the Tokamak Complex. These key input documents – critical to the design of all components located in this area – have now been approved as part of the technical baseline. A more accurate model of the building and all internal equipment was developed in close collaboration with the European agency and reconciliation has started to implement changes in the impacted equipment. In parallel, the


Series production is underway in Japan on the building blocks of the toroidal field coils – double pancake windings. Each winding is insulated by glass and polyimide tapes and impregnated with cyanate-ester and epoxy resins to harden the assembly. *Photo: ITER Japan* evaluation of floor response spectra for SL-3-rated seismic events is underway for the Tokamak Complex.

To ensure a consistent and fully integrated nuclear engineering approach in the project, compliant with project and regulatory requirements, the Director-General created a Nuclear Integration Unit in 2016. Staffed with experts from the ITER Organization and the Domestic Agencies and under the functional responsibility of the CIO Department, the Unit was effective immediately – producing a radiation transport model for the buildings of the Tokamak Complex; assessing the issue of toroidal field coil heating; performing nuclear analyses (for example on dust filtering, in-vessel viewing systems, neutral beam cell/neutral beam injection, and equatorial bioshield plugs); creating the first shut-down dose rate maps based on global analysis; and generating nuclear radiation maps to provide a comprehensive view of the potential effect of radiation on Tokamak components. The Unit also works with the Environmental Protection & Nuclear Safety Division on responses to questions from the French nuclear safety authority.

The list of electronics exposed to nuclear radiation was kept current in 2016 to reflect the results of radiation map studies, and basic countermeasures were selected for each system; discussions underway at ITER and with the Domestic Agencies on the standardization of needed radiation hardened electronics will continue into the next reporting period. The Analysis Section/Division also issued a document on the chemical composition and impurity requirements for steels and alloys in ITER – an area formerly missing from the technical baseline.

The ITER electromagnetic integration team created an analysis model for locked and rotating vertical displacement events based on interpretation of results obtained on the European tokamak JET: this electromagnetic analysis model was extensively discussed by fusion community physicists and is considered the best existing interpretation. A global model was completed for the test blanket systems and delivered to users for the detailed analysis of each system.

Large electromagnetic systems (magnet coils, passive structures, power supply, busbars) will benefit from integrated modelling and analysis capabilities made possible by a new tool for operative dynamic simulations, developed using specialized software. The geometrical configuration of the magnetic system source currents was also described during the year in a standardized parametric specification developed from the 3D CAD models for manufacturing design. Finally, the team provided detailed technical documents in support of material procurement, material test certificates, manufacturing reports, technical issues related to welding, and material properties under radiation.

## QUALITY ASSURANCE & ASSESSMENT DIVISION (QAA)

*The Quality Assurance & Assessment Division's objectives are to specify project quality requirements, perform independent assessments and audits on requirement compliance, and coordinate the integrated management system through the Management and Quality Program. The Division ensures that the processes needed for the quality management system are properly established, implemented and maintained; reports to top management on the performance of the quality management system; and works to promote awareness of ITER Organization or stakeholder requirements throughout the organization.*

Strong progress on the central database for processing non-conformities means that this quality assurance management tool will be ready for launch in 2017. Until then, temporary measures were employed during the year to track non-conformities and to alert responsible parties in order to reduce the average duration from detection to closure.

**In order to prepare for the lead role that it will play in the assembly and installation of the ITER machine and plant, the ITER Organization has introduced a new matrixed organization for construction management.**

Through the joint effort of the Quality Assurance & Assessment Division and a specially created Management and Quality Program (MQP) Working Group, the structure of the ITER MQP program has been simplified – resulting in improved logic, clearer hierarchy and ownership, and the elimination of process duplication. During monthly working group meetings, participants carried out a comprehensive review of MQP documents and begin implementing an improvement plan, including the update of more than 200 documents. Two of the three highest level documents – the Project Management Plan and the Quality Assurance Program – are in revision.

Safety & Quality responsible officers from all Domestic Agencies and the ITER Organization met as part of the SQAWG (Safety and Quality Assurance Working Group). Through this forum information is shared on requirements and design conformity, supervision planning and inspections, procurement quality requirements, the non-conformity mechanism, and other safety and quality issues.

During the reporting period, the Division verified the effective implementation of the ITER Organization quality assurance program through 14 Domestic Agency quality audits, and 15 supplier/subcontractor quality audits covering 14 Procurement Arrangements. Through the resulting quality audit reports, improvements and adjustments were obtained in the areas of supplier evaluation, quality audit capabilities, correct application of manufacturing inspection plans and contractual requirements, and improvement in processes, document management and non-conformity declarations.

Throughout the year, the Division's quality responsible officers supported process owners and systems teams in ensuring that the quality procedures are correctly established – a necessary precursor to the correct propagation of safety and technical requirements at all levels of the project.

**SAFETY DEPARTMENT (SD)**

*The Safety Department supports the Director-General in all matters related to environmental protection, nuclear safety, licensing, occupational health and safety, and safety and security. It ensures that safety and security standards are implemented and enforced throughout the ITER Project with all concerned stakeholders in compliance with Host country safety and security regulations.*

An important milestone was reached in July 2016 as the last hold point for building construction was lifted by the French Nuclear Regulator ASN. Related to the construction of neutral beam cells at the L1 level of the Tokamak Building, this was the last hold point before the start of the assembly phase.

**A new Nuclear Integration Unit has been created to promote a fully integrated nuclear engineering approach in compliance with project and regulatory requirements.**

Acting as the representative of the nuclear operator (the ITER Organization), the Environmental Protection & Nuclear Safety Division maintains independent surveillance activities as established in French regulations for Basic Nuclear Installations (INB). This includes interfacing with local, national and international government agencies and entities with respect to safety; reinforcing the control on the chain of contractors/suppliers in conformity with the INB Order; and carrying out surveillance activities in the context of changes in project organization. Regular technical exchanges continue with ASN on the prescriptions related to the demands of the official Ministerial decree that created the ITER INB. At its meeting in August, for example, the ASN director confirmed that the staged approach to assembly is compatible with ITER licensing.

To ensure compliance with French regulations, surveillance plans have been reinforced – in particular

Pouring begins in April for the B1-level basemat of the Tokamak Building in respect of the 2016-2017 ITER Council milestones.

for systems containing protection important components (PICs) and for transverse activities such as calculations, transportation and assembly that may have an impact on safety. The number of declared non-conformities for all systems is rising on par with the increase of work – a situation that reflects the proper identification by contractors of discrepancies, but one that must be managed to avoid backlog in the future. The global management of non-conformities, from detection to closure, has been fine-tuned in order to reduce the number of long-term files. The Department is also supporting the resolution of supplier deviation requests in order to authorize possible modifications without impact on the safety cases of ITER.

In 2016 ASN performed an inspection on the surveillance of external contractors for cryostat manufacturing; three other on-site inspections during the year were focused either on the civil works or the design of support equipment for completing construction. Corrective actions were undertaken by the ITER Organization and the Domestic Agencies in response to ASN requests linked to these inspections. The French Nuclear Regulator continues to monitor the central ITER Organization in order to assess reliability and compliance with the French safety regulations. The modified design of the vacuum vessel pressure suppression system (VVPSS) was submitted to the Regulator in February.

A continuing preoccupation of the Safety Department is to ensure that a safety attitude is embedded throughout the project. In 2016, together with the Central Integration Office, the Department undertook to qualify Project Team staff with respect to applicable nuclear safety regulations and general nuclear safety culture. Workshops were organized to address the distillation of the safety culture across the entire scope of the project, including design and manufacturing; non-conformity management; protection important components, activities and defined requirements; the compliance matrix for safety requirements; manufacturing and inspection plans; release notes; and as-built files. Members of the Department continue to be a regular presence at the public meetings of the Local Information Commission (CLI).

As part of the Safety Department, the Division for Security, Health & Safety is responsible for the protection of people and property, the protection of nuclear materials, the protection of data, and the health and safety of workers. In fulfilling these missions, the Division maintains close relations with security and occupational safety Host state representatives. All occupation health risks are now grouped in a centralized database, which lists the risks according to plant system or machine function and identifies mitigation measures. A tool for the management of chemical products on the ITER site was added in 2016.

The Division also manages general emergency procedures, keeping intervention plans updated for every building, verifying emergency materials on a monthly basis, and organizing occupational safety and security exercises. For the worksite area, induction safety training is managed centrally for all staff and contractors, regardless of employer.

### TOKAMAK ENGINEERING DEPARTMENT (TED)

*The Tokamak Engineering Department is in charge of the design, procurement, acceptance, installation, commissioning, and operation of all core tokamak systems (blanket, divertor, vacuum vessel, cryostat, thermal shields, magnets, in-vessel coils, port plugs and diagnostics, heating and current drive) plus the Test Blanket Module program and system instrumentation. In preparing for the assembly and installation of components on site, the Department coordinates increasingly with the Construction Department and dedicated teams for Tokamak and Tokamak Complex assembly.*

Nine years into the campaign to produce ITER's large superconducting magnet systems, collaboration between the six procuring Domestic Agencies and the ITER Organization continues to produce results: the principal components are on schedule; technical issues are dealt with on a day-to-day basis; and quality control remains a top priority. With the first large magnet – a toroidal field coil from Japan – expected on site in 2019, planning has begun for the assembly phase, as teams work to define specific handling and installation tools, develop installation processes, and finalize magnet/vacuum vessel and magnet/tooling interfaces. At the CEA MIFI magnet infrastructure facilities created for ITER, mockups are planned for assembly process qualification and technical staff training.

The effort to procure 88 kilometres of niobium-tin (Nb3Sn) superconductor for ITER's toroidal field coils came to an end in December as the last unit length left the production line. The fabrication of the final coils – each made up of a conductor winding pack (seven stacked double pancakes) and stainless steel coil case – is now in the hands of Europe and Japan. In a major achievement, Europe completed its first winding pack in October; following final verification, this 110-tonne component will be transferred to the coil manufacturer for cold testing and insertion into a coil case. Headway was also made in Japan, where the first winding pack will be finalized early next year and manufacturers are on schedule to complete the first full set of toroidal field coil cases and intercoil structures. An insert coil built from ITER toroidal field conductor was tested in a specialized facility in Japan under ITER-like conditions. Initial results are under investigation as they show some degradation under prolonged electromagnetic cycling.

The first series element of the poloidal field coil procurement program (a production double pancake) was manufactured in Russia for ITER's smallest poloidal field magnet. Series manufacturing is also slated to begin in China for poloidal field coil #6 and at ITER for coil #5 following the successful qualification of winding, helium inlet and joint welding processes for these coils that are under European procurement. In the on-site facility where Europe will manufacture the four largest coils (#2-5), equipment was installed in 2016 for the later-phase manufacturing steps; in addition, a final contract was awarded for the full fabrication and cold testing process.

A European contractor practices one important step in poloidal field coil manufacturing – the creation of helium inlets in the conductor unit lengths.

Before the start of welding on the cryostat base the team performs a coconut ceremony in the Cryostat Workshop, calling on the protection of Ganesha – "Remover of Obstacles."

A key milestone was reached in the fabrication of the central solenoid magnet as US contractors wound the first production module in April from over 100 tonnes (6,000 metres) of Nb3Sn conductor supplied by Japan; this module will now move on to the month-long heat treatment phase. Work continues in parallel to validate the full fabrication process, with the qualification coil advancing to the resin impregnation station. In other program achievements, commissioning tests were performed on the cold test facility up to 48.5 kA, progress was recorded in first-of-series fabrication for the central solenoid structure (lower keyblocks, tie plates), and Japan finalized 75 percent of total conductor unit lengths.

The ITER correction coils have entered production in China, where the first eight-turn winding was achieved for the bottom coils and tasks to qualify the full manufacturing scope of the bottom coils (joints, coil case, case closure) and the side coils (winding, impregnation, case) progressed through prototyping. A manufacturing readiness review planned next year for the coil cases will trigger the industrial production of these key elements. The first magnet feeder component – a cryostat feedthrough for poloidal field coil #4 – entered fabrication in 2016, while the bulk of other components passed manufacturing readiness reviews and the first high voltage feedthrough prototype was tested successfully. Series production kicked off for high temperature superconductor current leads in 2016 following successful qualification activities.

Two non-superconducting coil systems will be installed inside the ITER vacuum vessel to augment plasma control capabilities. As part of a multiyear R&D program on the design of these in-vessel coils the ITER team completed the re-evaluation of expected electro-magnetic loads, selected the final design of the conductor (circular), contracted with the conductor manufacturer, and completed assessments of preliminary trials on supports and clamps. The mockup of a sliding concept for in-vessel coil supports has been tested at the MIFI magnet facility.

The procurement of three other magnet packages – magnet supports (China), toroidal pre-compression rings (Europe) and magnet instrumentation (ITER Organization) – is also progressing. The first elements of the toroidal field supports were machined and welding has started on struts. Extensive R&D and analysis is underway for the toroidal pre-compression rings that will contribute to reducing the fatigue of the toroidal magnet structures, and a full-size test facility is planned. Finally, the delivery of magnet instrumentation to the coil manufacturers in the Domestic Agencies continues in a timely fashion.

The first welding operations for the ITER cryostat started in the on-site Cryostat Workshop in September following the assembly of the tier-one base segments on a dedicated support frame. By the end of the year specialists had completed the welding of the sandwich base plates under the oversight of the Indian Domestic Agency and non-destructive examination of the welds was underway; six tier-two base segments and a second assembly frame also arrived at ITER. During a visit to the Workshop in July, the French Regulator ASN confirmed the effective management of external contractors and compliance with regulatory provisions.

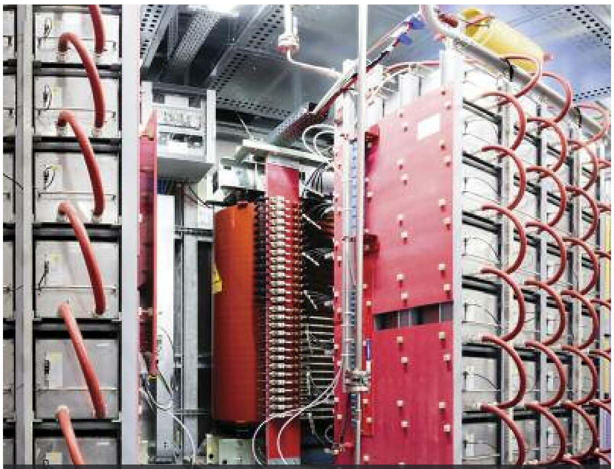
Manufacturing progresses in India on the next part of the cryostat to be assembled – the lower cylinder – and on penetrations for the two lower sections. Procurement milestones were met as well for several cryostat subsystems: a final design review was held for cryostat instrumentation and control; designs and drawings were completed for the heating and diagnostic neutral beam shielding blocks; and the call for nomination for the rectangular bellows is now ready for launch. In 2016, studies were initiated for the temporary storage of completed cryostat sections on the ITER site.

Four ITER Domestic Agencies are involved in the procurement of the ITER vacuum vessel, which comprises not only the nine main vessel sectors (Europe, Korea) but also in-wall shielding (India) and port structures (Korea, Russia). For the main vessel, the manufacturing design is now complete for all sectors plus the port stub extensions; cutting, forming, machining and welding activities are also progressing on the many sub-parts of the four poloidal segments that form each sector. Fabrication activities in Korea are 55 percent complete for sector #6 and 22 percent complete for sector #1; the first T-ribs have been welded to inner shells and the assembly of in-wall shielding blocks will begin next year. In Europe more than two-thirds of flexible housings were completed for sector #5 and large-scale electron beam welding was employed for the first time to realize a poloidal segment sub-assembly. The first activities have begun on sector #4.

A recovery plan was implemented in 2016 to mitigate slippage in the manufacturing and delivery schedule for European vacuum vessel sectors. As part of this plan, the responsibility for sectors #7 and #8 was transferred from Europe to the ITER Organization for fabrication in Korea – a swap that does not modify the overall cost sharing. Other measures include the reinforcement of the European manufacturing consortium through an additional subcontractor and improvements in the way oversight is managed.

Manufacturing is underway on port extensions and stub extensions for the lower and upper ports in Korea and Russia respectively – when completed and tested, these elements will be transferred to the vacuum vessel sector manufacturers for welding onto sectors. As part of the neutron shielding of the vacuum vessel, thousands of in-wall shielding elements are in production in India. The sustainment of the production throughput for these schedule-critical items – needed for the completion of vacuum vessel sectors – is being closely monitored. In Korea, the manufacturing of the vacuum vessel thermal shield has now reached the half-way milestone and other 2016 highlights included the completion of the thermal shield silver coating facility, the qualification of helium leak test procedures, the start of fabrication on the cryostat and support thermal shields, and the close-out of final design reviews for instrumentation and piping manifolds.

The full tungsten divertor is a high-value component and the one that must withstand the highest heat load of the machine. As part of an ongoing effort to minimize the risk of damage or degradation during the operational phase, the question of divertor monoblock shaping was examined by a panel of experts in September. The panel underlined the importance of achieving challenging tolerances in the vertical target region where the plasma strike point is expected and recommended further qualification activities on heat load and tungsten material specifications. The current baseline shaping (toroidal bevel) was retained for the inner vertical target, while a more complex shaping (planar bevel) was preferred for the outer vertical target to protect both the toroidal and poloidal edges. These recommendations will now be addressed by the ITER team and the International Tokamak Physics Activity (ITPA) group on divertor and scrape-off layer physics.



At the PRIMA neutral beam test facility in Italy, a full size ion source – equivalent to the one that will be used on the heating neutral beams at ITER – will be developed on the SPIDER test bed. In 2016, Europe delivers the ion source and extraction grid power supply. *Photo: OCEM ET*

**The first welding and radiographic testing activities for the ITER cryostat begin in a dedicated workshop on site in 2016.**

Two European companies are in the process of realizing full-scale divertor cassette body prototypes and delivery is expected next year after a series of factory acceptance tests. Manufacturing is also underway on prototypes of the divertor dome in Russia, where the ITER Divertor Test Facility is already simulating the demanding heat loads expected during operation in ITER. Small-scale mockups with tungsten monoblocks have been manufactured by three different companies in Europe as part of the pre-qualification phase of the inner target. Following high heat flux testing in Russia, pre-qualified companies will be asked to manufacture a full-scale inner target prototype. A last annual highlight – with direct relevance for the ITER divertor program – was the successful first plasma of the Tore Supra/WEST project in December. Updated with an ITER-like tungsten divertor, WEST will be able to test tungsten technology, acquire data on metal fatigue, and explore the boundary conditions of components in its operational program that kicks off in 2017.

As part of blanket first wall qualification, beryllium-tiled "fingers" designed and manufactured in China performed well in high heat flux tests – an achievement which opened the way for the signature in November of the First Wall Procurement Arrangement with the Chinese Domestic Agency. In other programmatic achievements, planning is underway in China and Korea for the challenging series fabrication of blanket shield blocks and their 200 design variants; Europe is qualifying three first wall suppliers in expectation of a Procurement Arrangement signature next year; Russia is manufacturing a new first wall semi-prototype; and the last activities were carried out to close-out the final design of the blanket


Korea is responsible for manufacturing all vacuum vessel equatorial and lower ports. In 2016, work begins on the first lower port stub extension (pictured) and port extension.
*Photo: ITER Korea*

manifold system. Conceptual design reviews were held for the protective structures that will be temporarily installed inside the vacuum vessel during first-phase assembly (First Plasma protection components) and for operational instrumentation required to monitor the loads on internal components. Finally, the Beryllium Management Committee continues to meet regularly to pursue the safe implementation of beryllium handling and storage at ITER.

It is envisaged that six technological solutions for a tritium breeding blanket system will be operated and tested for the first time in ITER; these solutions are under development now by the ITER Members. Five systems have concluded the conceptual design phase – China's helium-cooled ceramic breeder, Korea's helium-cooled ceramic reflector, Japan's water-cooled ceramic breeder, and Europe's helium-cooled lithium-lead and helium-cooled pebble bed systems – and kick-off meetings have been held to launch the preliminary design phase in both China and Korea. Test Blanket Module (TBM) Leaders are also developing compliance strategies with European regulations on nuclear pressure vessels (ESP/ESPN), preparing for the trilateral agreements that must be signed with the ITER Organization and the Host country on the management of radioactive waste, and harmonizing inputs in view of reporting to the French safety authority in 2017.

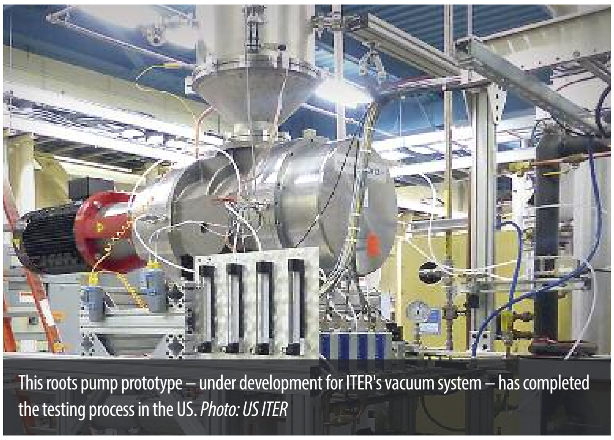
The need dates for the test blanket systems were clarified during the year in relation to the staged approach to assembly. To meet the deadline for the first components due on site – the connection pipes for the test blanket systems – the design was advanced in-house before a contract was concluded for final design. Contracts were also awarded for safety studies on the test blanket module port cells and for RAMI analysis of the port plugs. All Members reported steady progress in the R&D activities carried out in support of the test blanket module program.

In pursuit of the joint tender approach adopted for the procurement of diagnostic port plug structures – the "containers" that will host ITER's port-based diagnostic systems – a common supplier was chosen in October. Eight equatorial and 14 upper port plug structures will be shipped by the manufacturer to the Domestic Agencies for the integration of drawers with diagnostic elements, shielding modules, and diagnostic first walls. In other news, engineering teams are advancing the standardization of port infrastructure looking – in particular – at modular concepts to ease integration and maintenance; work progressed on the development of a prototype generic first wall; and electromagnetic disruption loads were defined for the port plugs in order to move forward with component design and port integration. A Complementary Diagnostic Procurement Arrangement was signed in April with Russia on the port plug structures for lower port 8.

The diagnostics team has clarified diagnostic delivery schedules in line with the ITER assembly phases, adding some new systems in relation to specific First Plasma requirements. System designs are advancing in all ITER Members and the earliest-need diagnostics have entered the manufacturing phase. Completed CER coils (for "continuous external Rogowski" coils) are ready for factory acceptance testing in Europe, mineral insulated cables were produced in Japan for the micro fission chambers, and start of manufacturing is imminent for the outer vessel magnetic coils and the neutron flux monitor for equatorial port 7. R&D activities for technical issues common to many systems, such as loom attachments, welding to the vacuum vessel, mirror cleaning, and the radiation environment, advance constructively and plans are maturing to launch framework contracts in several key program areas such as diagnostic instrumentation and control, remote handling, mirror cleaning and shutter engineering, optical diagnostics, and first wall fabrication.

**The principal ITER magnets – the toroidal and poloidal field magnet systems, the central solenoid, and the correction coils – are all in production.**

Within the new staged approach to ITER operation the second antenna of the ion cyclotron system and associated power supplies has been reintroduced into the construction baseline and budget. Both antennas are to be procured together by the European Domestic Agency as the most economical path forward. The design of the antenna is progressing and a global analysis model has been developed to evaluate the most stringent loads on the components. In other R&D activities Europe tested



This roots pump prototype – under development for ITER's vacuum system – has completed the testing process in the US. *Photo: US ITER* small-size mockups of the Faraday screens, a cold spray copper coating technique was trialled with success on titanium alloy, and tests have started on joining techniques between titanium and stainless steel. The Indian Domestic Agency has developed two prototypes for the system's radio frequency sources and is testing them in order to decide on series fabrication. The US continues to validate the performance of different transmission line subcomponent prototypes, and a plant control system prototype has entered the trial phase in ITER's CODAC lab. The maturing design of the ion cyclotron system has permitted all requirements to be defined for the on-site Radio Frequency Heating Building and construction on that structure has started.

**All planned milestones for the ITER cryogenic system were successfully achieved, including the finalization of most of the components for the liquid helium and liquid nitrogen plants.**

Five Domestic Agencies and the ITER Organization are sharing in the design and procurement of ITER's microwave heating system – electron cyclotron resonance heating. Following lengthy qualification programs, series manufacturing started in 2016 for the microwave sources (gyrotrons) in Russia and Japan, and for the first power supply unit in Europe. Two diamond disks were also successfully produced for the vacuum-tight window that will seal the vacuum vessel but allow the system's electromagnetic waves to reach the plasma. US contractors completed mode purity analysis on the full transmission line and pursued the testing of prototype components; Japan has completed the first prototype body power supply; and India is ready to award its first high voltage power supply contract in 2017. A joint ITER Organization-US ITER team is collaborating with industry to design an isolation shutter valve that can ensure confinement at each transmission line "point of entry" in the buildings.

The PRIMA neutral beam test facility at Consorzio RFX in Padua, Italy, comprises the ion source testbed SPIDER and the full-scale neutral beam injector MITICA. SPIDER is in its final assembly phases and facility commissioning activities have started, including the testing of components procured by Europe (SPIDER vacuum vessel, high voltage deck, gas and vacuum system) and India (beam dump, 100 kV power supply). Integrated commissioning of this test bed can begin once the beam source, the most critical component of the system, is delivered.

For MITICA, the power supply components from Japan have been installed and the first set of voltage holding tests is planned early next year. The high voltage bushing is also expected soon. Europe has awarded a preparatory contract for the MITICA beam source, with three potential suppliers undertaking manufacturing designs.

To lay the groundwork for the heating and diagnostic neutral beams at ITER, a preliminary design review was held for the largest all-metal valve ever designed – the absolute valve that will connect each neutral beam injector in the neutral beam cell to the vacuum vessel. Preparation is underway for the signature of the European Procurement Arrangement that covers the heating neutral beam vessels, passive magnetic shielding, active correction coils, and front-end components. A proposal has been made to install the large captive components for a third neutral beam injector during early construction in order to maintain an important potential for flexibility in the operation of the ITER facility should an upgrade be decided.

In advance of the operation of the neutral beam test facility, the half-size ion source ELISE (IPP Garching, Germany) is producing results that are very important to optimizing source performance and proving the concept of large-scale negative ion caesiated sources. Important advances have been made in resolving high power arcing issues that will allow operation at ITER-relevant power parameters. The experimental program for 2017 will concentrate on high power discharges with a focus on controlling co-extracted electrons in deuterium discharges.

The Indian Domestic Agency is developing a test facility for the components and the design of the diagnostic neutral beam for ITER. The vacuum vessel has been installed and manufacturing is now underway on the diagnostic neutral beam source and, more recently, diagnostic neutral beam line components.

The US Domestic Agency is testing electron cyclotron waveguide performance at Japan's QST, the National Institute for Quantum and Radiological Science and Technology. The electron cyclotron system is one of three external heating systems at ITER. *Photo: US ITER*

**PLANT ENGINEERING DEPARTMENT (PED)**

*The Plant Engineering Department provides a fully qualified range of services and facilities for the operation of the ITER Tokamak. PED is responsible for the design, procurement, installation, and testing of electrical and power supply distribution, cooling water, cryogenics, vacuum, fuel cycle and remote handling, as well as the management of radioactive materials, radioactive waste, and dismantlement. In the construction organization established for the assembly and installation phase, the Department also coordinates with the Construction Management-as-Agent project manager and forms the basis for the dedicated team for plant installation.*

The Plant Engineering Department adjusted its internal organization in 2016 to prepare for a ramp-up of plant installation activities expected next year as access becomes available to the Site Services Building, the magnet power conversion area, and the zones for cryogenics and cooling. A newly created Field Engineering Installation Division now forms the basis for the construction team for plant installation, defined as "balance of plant" installation works (worksites 3, 4 and 5) and beyond (i.e., busbar and multi-process line installation). The new Division will interact closely with systems owners in the engineering divisions as well as the Construction Management-as-Agent contractor as it carries out in-field engineering support and surveillance in the areas of electrical systems, mechanical, and piping. The first activities are already underway.

All planned milestones for the ITER cryogenic system were successfully achieved in 2016. Manufacturers have finalized most of the components of the liquid helium and liquid nitrogen plants and shipped 1,500 tonnes of material; construction of the cryoplant buildings and infrastructure progresses on site; and the procurement of the cryodistribution system advances in India, where contractors have tested the performance of the prototype torus cryolines, launched fabrication of liquid nitrogen cryolines, and advanced to the final engineering design phase on the warm lines, cryolines and cryodistribution boxes. To maximize efficiency in the management of on-site assembly sequences, part of the Indian scope (Group-X cryolines) has been transferred to the ITER Organization. All scope holders (European and Indian Domestic Agencies plus the ITER Organization) now meet regularly in the context of the new Cryogenic Project Team as this widely distributed plant system transitions from design and manufacturing to the construction and commissioning phase.

The task force for the re-design of the vacuum vessel pressure suppression system completed its work in 2016 and the new configuration was endorsed in a preliminary design review. The design is now under review by the Agreed Notified Body, and studies continue to confirm mitigation possibilities for the risk of hydrogen explosion and to validate the efficiency of steam condensation in the new strategy. Four vapour suppression tanks for this important system – designed to protect the ITER vacuum vessel from over pressurization caused by the loss of coolant from the in-vessel components – are now on order to respect schedule milestones.

Japan is supplying the high voltage power supplies and the high voltage bushing (pictured) for MITICA, a full-scale ITER neutral beam injector under construction at the PRIMA neutral beam test facility in Italy. *Photo: ITER Japan*

The Tokamak Cooling Water System (TCWS) Division at ITER continues efforts to optimize the machine's primary heat removal system. The design of the systems needed for First Plasma is progressing – including those features added to support the new design of the vacuum vessel pressure suppression system – and a final design review is expected next year. Value engineering confirmed that the TCWS can manage increased loads on the vacuum vessel up to 32 MW, and the preliminary design of in-cryostat vacuum vessel and divertor/blanket heat transfer systems was completed and transferred to a subcontractor for final design. Quality audits were conducted by the US Domestic Agency and the ITER Safety Department and both were passed successfully. Fabrication has started for the first batch of nuclear-grade stainless-steel piping and fittings in the US, Germany and India; delivery to the ITER site of at least one batch per year between 2017 and 2021 is planned.

The design and fabrication of the secondary cooling circuits under Indian scope advanced during the reporting period, with final design reviews held successfully for the heat removal system in April and the component cooling/chilled cooling water systems in September. Factory acceptance tests took place for the ozonator package, and manufacturing readiness reviews were held for a number of other packages including

These test stands at the Efremov Institute in Russia are ready to receive key elements of the ITER power supply and superconducting magnet protection system for testing in 2017. *Photo: ITER Russia*

cooling towers, stainless steel seamless pipes, pressurizers, chillers and heat exchangers. Regular shipments of cooling water piping were received in 2016, including the Lot 1A captive pipe spools needed for early installation. The European Domestic Agency, which is responsible for on-site infrastructure, has begun preparing for first-phase buried pipe installation and is advancing civil work on the site of the cooling towers and basins.

ITER will require electrical power in two forms: DC current for plasma operations (through the coil power supply system and the pulsed power electrical network, PPEN) and AC current for the industrial auxiliaries such as the cryoplant and buildings (through the steady state electrical network, SSEN). Through sustained shipments from procuring parties China, Europe and the United States, ITER's main warehouse facility now houses rows of electrical components for both networks as over 90 percent of SSEN and 80 percent of PPEN material has now been received on site. Factory acceptance tests have been completed on the balance of SSEN power distribution components and deliveries should be completed next year; fabrication and testing is also progressing well on coil power supply system and pulsed power distribution components. All three massive PPEN transformers were shipped by China and installation activities on site have started. Electrical distribution will be the first ITER plant system to enter into production, with the planned energization of one portion of the SSEN network early in 2017.

The Plant Engineering Department continues to share its electrical engineering expertise project-wide, supporting plant system responsible officers; carrying out electrical simulations and stress test analyses; reviewing allocation of requirements and commissioning plans; and assisting the Domestic Agencies. Input was provided to the construction team for electrical distribution on site – scope which covers the electrical switchyard civil works as well as the low and medium voltage load centres that are distributed among the buildings. Technical documents for energy contracts, electricity transport, operation and maintenance, and electrical measurements were prepared as part of the lead-up to testing, commissioning and operation.

Procurement is underway for ITER's coil power supply and distribution system following a multiyear qualification and testing program that validated the robustness of system design. China plans to ship five poloidal field AC/DC converter units in 2017 plus the first reactive power compensator, which has been successfully tested with the instrumentation and control (I&C) integration kit provided by the ITER CODAC team. Korea has completed testing on the first correction coil AC/DC converter unit and the converter transformers for the correction and vertical stability coils; Russia continues the series manufacturing and delivery of switching network components; contractors completed the conceptual design of the in-vessel coil busbars; and seismic tests were carried out on the fast discharge resistors for the toroidal field coils. Globally, the integration of the coil power supply system was improved in 2016 through the optimization of interfaces and all on-site installation sequences were confirmed with the procuring Domestic Agencies.

Advanced planning continues for the installation of cable trays in ITER buildings and underground galleries. Cable tray execution drawings were issued for first-need areas and others are in the final review process; the time required for the generation of cable diagrams was also reduced through a semi-automatic program developed in house. The location of cable trays for the 400 kV substation was confirmed and the first material was installed for the SSEN bays that will be brought on line early next year. To guarantee the functionality of safety-related cables, the thickness of wrapping material around cable trays was calculated in relation to fire hazard; test campaigns were also held to qualify equipment submitted to static magnetic field and the results were submitted to the French Nuclear Regulator.

A contract awarded by Europe in 2016 for the supply of the cask and plug system means that all four in-vessel remote handling systems are now in the hands of industry. To identify common technological challenges and promote standardization, the Department invited engineers from the suppliers to interact with system owners and designers at a technical workshop held on site in November.

Procuring parties Europe, Japan and the ITER Organization worked together to redefine the need dates for remote handling equipment in relation to the staged approach to construction. This re-baselining exercise resulted in significant cost savings through the elimination of one tool that had been under consideration (the multi-purpose deployer) and the increased functionality of the blanket remote handling system. Projects were initiated with ASIPP (China) and CCFE/RACE (UK) for the development and testing of mockups for remote handling, tooling, and component refurbishment; contracts have also been established for support in the design, development and planned operation of the remote handling transfer casks and systems planned for the ITER Hot Cell. A conceptual design review was successfully held for the maintenance and decontamination facilities that will be necessary for remote handling equipment.

Work is underway to complete the conceptual design of the Hot Cell Complex (facility and processes) by the end of 2017; to this end, a large number of integration, design and safety activities have been launched. A consortium was chosen for the design of the building, multiple contracts were signed for process development (radwaste cutting station, liquid radwaste evaporator, tritium removal furnace, laboratory, in-vessel component maintenance), and a framework contract was launched for the safety analysis of the Hot Cell Facility. The joint ITER Organization/Agence Iter France working group continues to think ahead to the issues of radwaste management and waste disposal in France. A workshop was held to raise awareness on decommissioning issues that must be incorporated today in the design of systems (handling, licensing issues) and collaboration has started with France's permanent waste repository ANDRA on storage issues such as packaging and acceptance criteria. A beryllium facilities working group was also created to develop technical options for a beryllium storage area and

Accurate dimension control is applied from component fabrication to final assembly at ITER. Optical metrologists are already a common sight as they measure the as-built locations of the systems.

management building in order to pre-assemble the first wall components (water-cooled tiles) to be installed in the vacuum vessel in full respect of regulatory requirements.

The Tritium Plant is essentially a nuclear gas processing plant – receiving deuterium-tritium-helium gases, removing impurities, separating isotopes and helium, and returning gases back to the fuelling systems – but the scale and processing demands of ITER make system

**Electrical distribution will be the first ITER plant system to come on line, with the planned energization of one portion of the steady state network next year.**

designs challenging. The systems for storage and delivery, isotope separation, and analytics are the subject of ongoing design and R&D studies; the tokamak exhaust processing system has advanced to the preliminary design phase; and progress on the design of captive piping for the atmosphere detritiation system means that installation in the Tokamak Complex can be envisioned in the near term. The atmosphere detritiation system is entering the final design phase and key studies have been completed on the efficiency of scrubber column tritiated water collection. Six of the largest tritiated water storage tanks for the water detritiation system were installed in the basement of the Tokamak Complex and progress was made on both the safety analysis of Tritium Plant equipment and the atmosphere detritiation qualification plan, which was presented to the Regulatory body.

The conceptual engineering of ITER's fuelling system is also progressing. The US is testing a dual nozzle for the pellet injection system capable of delivering two types of fuelling pellets, while in China – following the final design review – the gas distribution manifold system is transitioning to the manufacturing readiness review phase. The engineering design of a disruption mitigation system based on hybrid shattered pellet injection for deuterium-tritium operation and massive gas injection for non-active operation advances in the US. Studies are underway on port integration and support, and a task agreement was signed to study shattered pellet injection as a disruption mitigation technique at the European tokamak JET.

All ITER vacuum systems are progressing to manufacturing: the assembly of finalized torus pre-production cryopump components is underway; vacuum auxiliary system flanges are ready to ship from the US; testing has been concluded on the cryoviscous compressor and a roots pump prototype; design and build activities have started for the all-metal scroll


The Tokamak assembly pit is visible through the open end of the Assembly Hall. When the building over the pit is completed, the assembly cranes will travel back and forth delivering their loads.

pumps; and testing continues on dust filtering. The Procurement Arrangement covering cryopumps for ITER's heating and diagnostic neutral beam systems as well as for the MITICA neutral beam test stand was signed with Europe in June.

As part of a standardization program that will make all-metal ultra-high valves available at reduced prices, a first production batch was received from the manufacturer for testing. The procurement of vacuum pipework has been launched following the award of a contract in April, and a small batch of seamless stainless-steel piping has already been received for inspection. Contracts kicked off for the manufacture of a full-size rig to test the sealing of the equatorial ports and test blanket module flanges, and for the manufacturing of double metallic seals.

### CONSTRUCTION DEPARTMENT (CST)

*The Construction Department ensures that all ITER facilities are designed and built according to ITER Organization requirements; manages transport, logistics and materials management services; and plans, organizes and executes assembly-phase works on the ITER site until turnover to the operation teams for start-up and commissioning. CST works closely with the engineering departments to receive the necessary specifications and documents for construction, the Environmental Protection & Nuclear Safety Division to implement processes and procedures that ensure compliance with French nuclear regulations, and the European Domestic Agency in relation to the detailed design and construction of the buildings and site infrastructure. The Department also coordinates with the Construction Management-as-Agent project manager and dedicated teams for Tokamak machine and Tokamak Complex assembly and installation.*

A major milestone was achieved in June with the selection of the Construction Management-as-Agent (CMA) – the contractor that will provide key support to the ITER Organization during the integration and assembly of the components delivered by Members. The CMA will coordinate and supervise on-site work in support of the ITER Organization construction teams managing the assembly/installation contracts for the entire site and bring best industry practice to bear in all processes, services and systems.

The arrival of the first CMA team on site and subsequent contract kick-off meeting came as part of a more general reorganization of construction management as the ITER Organization prepares for an increased role in site activity. The new organizational matrix introduced in September integrates the CMA contractor in the ITER construction team, clarifies oversight responsibilities, and – while preserving functional units – creates integrated construction teams to focus on three geographical areas related to: a) Tokamak machine assembly; b) systems installation in the Tokamak Complex; and c) conventional plant installation. Each of the teams integrates resources from engineering departments and offices as well as the Domestic Agencies and the CMA team in order to capture the working knowledge of components and systems that has accumulated across the project and to ensure the integrated organization of assembly and installation activities in specific zones on site.

In the new reorganization, the Tokamak Assembly Division has become the basis for the integrated team for Tokamak machine assembly and, as such, has full responsibility for all assembly-related activities in the Tokamak Pit as well as the Assembly Hall and Cleaning Facility (worksite 1). In 2016, the group revisited the tendering strategy for machine assembly with an eye to lowering the inherent risk of long-term, large-sized contracts. Component interfaces were also scrutinized to ensure compatibility with installation procedures and tooling; toroidal field coils, for example, interface with both the sector sub-assembly tool and the in-pit support tool. Metrology teams have been dispatched to manufacturing sites in the ITER Members to record the as-built dimensions of large machine components in fabrication and to verify tolerances.

**A major milestone is achieved in June with the selection of the Construction Management-as-Agent that will provide key support to the ITER Organization during the assembly phase.**

The development of purpose-built tools for ITER assembly activities continues in Korea, where the first of two sector sub-assembly units is being assembled and a final design review was held for other phase-one tools. Tooling packages under the direct responsibility of the ITER Organization also progressed: the qualification of the tools and equipment that will be required for vacuum vessel in-pit welding is on schedule and the first feasibility simulations on full-scale sector and port mockups is set to begin; development continues on in-vessel access and handling systems; and the conclusion of a major framework contract in 2016 will allow the CST Department to move forward with the auxiliary tools needed for early machine installation activities.

The Tokamak Complex Division focuses on the installation of Tokamak Complex systems through the integrated construction team charged with worksite 2. In 2016, construction package proposals were drawn up in support of the upcoming award of major Tokamak

Complex installation contracts; these packages also transfer important constructability information to the CMA contractor. By thoroughly reviewing installation sequences up to First Plasma, the Division identified captive equipment that might be needed by Tokamak Complex systems at a later phase and specified the temporary infrastructure needed to optimize assembly activities. In interaction with design and engineering teams, the Domestic Agencies and the CMA contractor, the Division seeks to increase the efficiency of assembly execution through its knowledge of sequences, access, and systems installation methodology.

**Work on ITER's main scientific facility – the Tokamak Complex – is now evolving at or above platform level.**

The Construction Management Division forms the core of the new Construction Management and Coordination Team, with responsibility for the coordinated procedures for the tendering and management of construction contracts between the ITER Organization and suppliers. In 2016 the Division developed an optimized assembly procurement strategy that is compatible with the updated project schedule and that, while dividing the work into manageable packages, takes interfaces between work areas into account. Nine contracts are planned to cover all first-phase assembly and installation activities. As part of preparation activities, the Division has developed a code of safe practice in radiographic testing that is applicable to contractors and staff alike. The CST Department as a whole benefitted in 2016 from interaction with the European organization CERN on its experience with the assembly and installation of large scientific instruments. A workshop held at ITER in September will be followed up next year by a visit of the ITER construction assembly teams to CERN.

Due to an increase in workers and number of shifts on site, the pace of building and infrastructure construction accelerated in 2016 under the oversight of the European Domestic Agency. Two elements of the Tokamak Complex are now clearly visible above platform level – the concrete bioshield, whose basement and ground (L1) levels are in place, and the Diagnostics Building, whose exterior walls are completely framed out at L1 level. Work also proceeds to complete the lower levels of the Tritium and Tokamak buildings in order to make them available for early-access assembly activities in 2018; the installation of the first captive components in the basement of the Tritium Building (six detritiation tanks supplied by Europe) and the completion of the B1 basemat of the Tokamak Building were among the milestones achieved. Progress was made on the final design and interfaces of the cryostat bearings, which is an important prerequisite to starting civil work on the concrete crown that will support the cryostat at B2 level.

The 60-metre-tall ITER Assembly Building has been equipped with handling cranes capable of lifting 1,500 tonnes and dressed out in polished steel cladding – with the exception of the west wall, where a temporary cover is in place until the completion of the Tokamak Building. Eight other building projects are also underway: European contractors completed the site service and cleaning facilities; erected the skeletal structures of the cryoplant and the building for radio frequency heating; launched excavation and preparatory work on the sites of magnet power conversion and cooling towers; and advanced the underground technical galleries and electrical switchyard infrastructure. The first transformer was installed on the platform for the pulsed power electrical network in October and three other beds are ready.

In addition to hundreds of conventional loads, 23 highly exceptional load convoys reached ITER in 2016 including those for the massive beams for the Assembly Hall cranes, large cryoplant components and segments of the ITER cryostat. As part of planning for the increased deliveries – and increased staff – expected in the years ahead, the Facilities, Logistics & Materials Division oversaw the completion of a new access road to ITER's largest storage warehouse, as well as a 200-person office building and parking lot for construction staff. Two new warehouse areas will be added on site, an off-site warehouse – managed by ITER's global logistics provider – is foreseen for bulk components, and an agreement signed with the Host Organization CEA will provide additional local storage for some of the extensive cooling water piping expected from India.

The bioshield already rises over 20 metres, as construction teams advance on the third of six levels, L1.

**SCIENCE & OPERATIONS DEPARTMENT (SCOD)**

*The Science & Operations Department supports ITER construction and operation in all matters related to physics performance and plasma control requirements, the assessment of plasma-related specifications for engineering systems, and the development of operational and research plans for the exploitation phase. The Department is also in charge of the systems and infrastructure required for machine and facility operation, in particular those related to central instrumentation and control, and plans for the operation, maintenance and inspection of all ITER plant systems.*

The Department welcomed the first ITER Scientist Fellows in 2016 – a group of approximately 20 scientists nominated by the ITER Members to contribute to ITER's high-priority research needs for three years. Although remaining based at their home institutions, the Fellows are collaborating closely with the SCOD team on targeted annual goals.

Work has begun to review the major elements of the ITER Research Plan in relation to the proposed staged approach to assembly. At a week-long event in July, fusion science experts from the Members and ITER Organization/Domestic Agency staff clarified the research objectives for each operational phase in relation to the availability of technical systems; these initial efforts will be pursued in 2017 following the full endorsement of the staged approach by the ITER Council.

The key remaining physics design issue for the ITER tungsten divertor – monoblock front surface shaping in the high heat flux areas – has advanced through the coordinated efforts of the SCOD Department, the International Tokamak Physics Activity (ITPA), and worldwide experiments. At a dedicated workshop in September, the ITER design solution to protect leading edges from the glancing incidence of plasma was demonstrated to be satisfactory from an engineering and physics point of view.

A new graphical interface improves the experience of SOLPS-ITER, which has become the most widely used plasma boundary modelling tool in the fusion community. The user base has expanded considerably, with 120 registered users and all ITER Members represented. The understanding of material migration and fuel retention also continues to evolve – with recent simulations of diffusion trapping kinetics (used to match desorption measurements made on beryllium deposits extracted from JET) confirming that outgassing is much slower than previously anticipated. The implications of these results for the use of divertor hot gas baking as the primary fuel recovery tool are being evaluated.

The understanding of tungsten accumulation was advanced through particle transport simulations that predicted low tungsten accumulation during stationary

The first batch of all-metal, ultra-high vacuum valves is received in May for testing in the ITER vacuum lab. Approximately 250 of these critical components will be employed on the machine.

phases and a larger, though avoidable, accumulation during transient phases; these results were then confirmed in experiments carried out on operational tokamaks. The control of edge localized modes (ELMs) by magnetic perturbation is also under investigation to support the design of the ELM coil system. New results from advanced modelling have confirmed that ELM control will be required for both low-energy plasmas (for impurity control) and high-energy plasmas (for divertor protection), and that the number of electromagnetic cycles to which the coils will be subjected can be substantially reduced compared to previous evaluations.

The first fully integrated core-to-edge-plus-divertor modelling was completed for the Q=10 scenario, including fuelling requirements and up/down ramping. Scientists also completed an integrated code suite for the evaluation of fast particle losses/power fluxes associated with the ELM coil control application under ITER's Integrated Modelling and Analysis Suite (IMAS), with initial results showing small particle losses for neutral beam injection. ITER's integrated modelling capabilities continue to grow as specific modelling suites from the Members' fusion communities are adapted to the IMAS framework.

The preliminary design review for the ITER plasma control system, held in November, focused on First Plasma and subsequent pre-fusion power phases in hydrogen and helium, but with sufficient kinetic (especially density) control and adequate protection against disruptions. The design of this system – responsible for controlling plasma parameters during a plasma shot – can now advance to the next stage. The physics basis for disruption mitigation strategies continues to progress and the engineering design of the system is maturing in the US for hybrid shattered pellet injection and massive gas injection concepts. Plans to install a shattered pellet injector at JET will allow this technique to be tested in an environment similar to ITER. One of the most challenging issues will be to understand how the formation of high energy electrons (runaway electrons) can be reliably suppressed during disruptions.

Design activities are advancing for the three pillars of the ITER control system – conventional control (CODAC), central interlock (machine protection) and central safety (nuclear and occupational). The central safety system has entered the final design phase; manufacturing has started on the central interlock system following a successful final design review; and the understanding of machine protection functions has evolved through a series of meetings with system responsible officers. The qualification of components for the nuclear safety control system continues by means of electromagnetic and seismic testing.

**The ITER Organization welcomes the first ITER Scientist Fellows in 2016 – a group of approximately 20 experts nominated by the ITER Members to contribute to the project's high-priority research needs.**

To ensure the integration of over 200 local plant instrumentation and control (I&C) systems into the central system and guarantee inter-operability, the ITER Organization makes standardized software (CODAC Core System) and hardware (integration kits) available to developers in the Domestic Agencies and ensures user support and training. Half of all integration kits have now been distributed; two additional versions of the CODAC Core System were released in 2016; and training is offered on site or in the form of on-line video. To prepare for the arrival of the first plant I&C systems, planning has started for network infrastructure and the local control rooms that will be required until the ITER Control Building becomes available. The first version of CODAC Operation Applications – software that supports central coordination, automation, configuration and data handling – was released, and development will continue in support of integrated commissioning and operation.

The prototyping of I&C systems also contributes to readying parts of the control system architecture for implementation at ITER. ITER control software was integrated with state-of-the-art visualization tools from the JET data analysis group in a trial that helped to validate interconnecting diagnostic and control systems, and a plant I&C system for a neutron diagnostic has been shipped to the Russian Domestic Agency for extensive evaluation.

The skeletal structure of the Radio Frequency Heating Building is now visible up against the northern side of the Assembly Hall.

The Operation Management Section continues to lay the groundwork for the commissioning and operation phases. In 2016, it delivered high-level strategy documents on the ITER maintenance program, beryllium management, concept of operations, and human and organizational factors; it also began drafting the ITER Operations Handbook and formed a team to focus on the strategy – and schedule – for commissioning. The Section has reviewed existing RAMI analysis reports with an eye to identifying gaps, and verified the compliance of plant system maintenance and inspection requirements against project and safety requirements.

At a workshop in April, over 50 experts from the ITER Organization, the Domestic Agencies and industry discussed the future development of an ITER plant simulator that – in mimicking the behaviour of the two dozen plant systems that make up the installation – will help to validate foreseen operational scenarios and serve as a training platform for future operators. A contract was signed in December for the development of technical specifications. SCOD is also launching an ITER Operations Network in preparation for the operations and maintenance phase by inviting operations experts from other facilities to share their experience. The first nominations are expected in 2017.

The ITER Organization has been a contracting party to the International Energy Agency (IEA) Technology Collaboration Programme on Co-operation in Tokamak Programmes (CTP-TCP) since 2012; in 2016 the Department chaired the CTP-TCP Executive Committee for a second consecutive year and was successful in piloting the proposal for an extension for a further five years from mid-2017. SCOD scientists published 70 papers as leading author or co-author in refereed journals; ensured the representation of ITER science at fusion and control conferences worldwide; and mentored fusion trainees from the ITER internship program, the European DC PhD program, and the Monaco-ITER Postdoctoral Fellowship program that is now in its fifth cycle.

**FINANCE & PROCUREMENT DEPARTMENT (FPD)**

*The Finance & Procurement Department is charged with sound financial and budget management, the preparation and management of the annual and lifecycle budgets, the presentation of the annual ITER Organization accounts, the preparation of in-kind Procurement Arrangements, and the placement of in-cash contracts and task agreements through competitive process.*

In 2016, the Budget Management Section worked closely with the Project Controls Office to finalize resource estimates in accordance with the revised project schedule and to submit an updated baseline to the Members for the construction phase. It closely monitored and reported on the implementation of the 2016 ITER Organization commitments, payments, and income budgets, overseeing the execution of fully 93 percent of the commitments budget and 86 percent of the payments budget.

In addition to these budgets, the Reserve Fund continues to be maintained as a tool for addressing cost impacts due to changes in scope or design within the ITER Organization or Domestic Agencies. The use of this common account is closely monitored and reported to the Central Team Management Board and the ITER Council. The regular verification of commitments, invoices and other financial transactions; small-value purchase orders and invitation letters; and suspense transaction management also contribute to sound financial management at the ITER Organization.

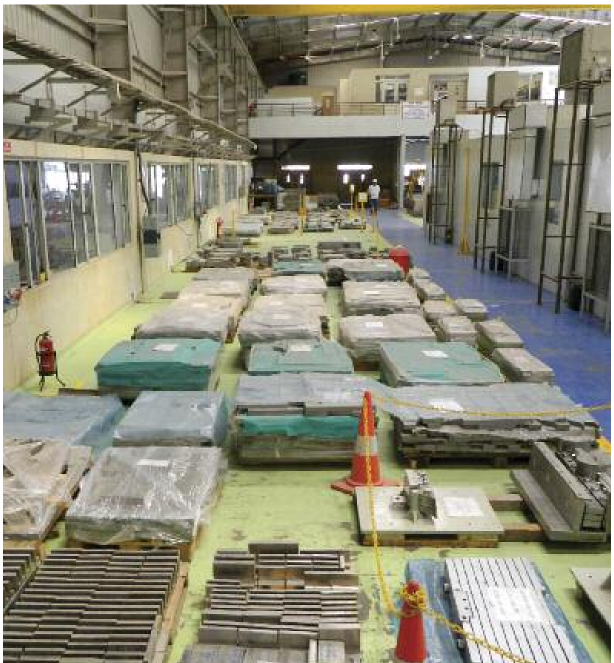
The Accounting & Treasury Section produced the 2015 Financial Report, which includes the 2015 Financial Statements, on which the Financial Audit Board – composed of independent auditors nominated by the seven Members – issued an unqualified audit opinion in April 2017, noting the proactive initiatives taken to improve accountability and transparency in financial management, contract administration and budgetary control. The expert group also conducted another audit in September that covered the trial balance for the period from 1 January to 30 June. During 2016, the Treasury team managed to realize a financial income of EUR .98 million, which represents an average rate of return of 0.59 percent of the daily available cash balance (invested only in secured deposits). In comparison, the average 2016 Eonia® (Euro OverNight index Average) index was -0.32 percent.

Recommendations from the Financial Audit Board are tracked through a computer application until solutions are validated and implemented.

Since 2007, the ITER Organization has signed a total of 108 Procurement Arrangements for the delivery of components, systems and buildings with the Domestic Agencies, representing 90.86 percent of the project's in-kind allocated value. In 2016, the Department assisted in the finalization and signature of two Procurement Arrangements, one Complementary Diagnostic Procurement Arrangement, and several transfer-of-scope agreements from the Domestic Agencies to the ITER Organization.

The ITER Organization awarded the ten-year Construction Management-as-Agent contract in June for Tokamak and support system assembly and installation. Several other major contract awards were concluded as a result of close collaboration with the Domestic Agencies, including arrangements for the common procurement of diagnostic port plug structures and the extension of the Logistics Service Provider framework contract. Further strategic contract signatures achieved within deadline in support of the project include those for vapour suppression tanks (manufacturing design and procurement); sector sub-assembly tools; purpose-built tools and equipment; and Hot Cell Complex engineering services.

The Procurement & Contracts Division is closely involved in preparations for the award of three major assembly and installation packages for mechanical, electrical and tokamak works. In general, it can be said that procurement activities and challenges are increasing in complexity as the ITER Project prepares for the installation of the machine and plant. Procurement & Contracts is moving toward a more strategic function through a leading role in the construction procurement strategies.



More than half of the space between the double walls of the vacuum vessel will be taken up by in-wall shielding blocks designed to protect ex-vessel components from neutron radiation. Indian contractors are producing over 9,000 elements. *Photo: ITER India*

Tooling and testing activities are underway to prepare for the fabrication of ITER's second-smallest poloidal field coil (PF6) in China on behalf of the European Domestic Agency. *Photo: ITER China*

**HUMAN RESOURCES DEPARTMENT (HRD)**

*The Human Resources Department contributes to ITER Organization strategic and operational goals by implementing a fully integrated human resources service. The Department develops the overall strategy and policies for human resource management, manages the staffing plan in relation to organizational needs and forecasts, carries out a wide range of staff services (recruitment, training, appraisal, salary, travel and social insurance), and contributes to strengthening project and managerial culture.*

Recognizing that the human resource function is a key factor for project success, the ITER Organization is implementing a comprehensive action plan based on the Director-General's Action Plan of 2015, and that takes into account further recommendations made in February 2016 by the ITER Council Review Group. The Department answered to several audits during the year and reported to the ITER Council on the implementation of reforms and the course of planned improvements for 2017.

As part of this effort the Human Resources Department has developed a new recruitment strategy, proactively working with the Domestic Agencies to improve the balance in representation of the Members, promoting recruitment outreach through platforms such as LinkedIn, and reworking job offer descriptions to encourage the widest possible application pool. The Department also proposed revised measures to increase the attractiveness of the ITER Project Associate scheme, which was created to leverage qualified resources from the ITER Members. The first ITER Project Associates were successfully recruited from Member countries and institutions in 2016 and other applications are under consideration; in the coming years, 150 to 200 ITER Project Associates are expected to contribute to the Project, in particular in the areas of assembly, installation and commissioning.

Other 2016 developments include the recruitment of a new Head of Department, the introduction of ombudsmen to assist in the resolution of eventual work-related conflicts and disputes, and the reorganization of the Ethics Committee to reflect the cultural diversity of the staff. Internal Administrative Circulars on missions and travel/removal expenses were revised to improve efficiency and cost effectiveness; the staff functionalities of the administrative portal SAP were expanded; and policies on annual performance review, rewards/recognition and service steps (now called seniority steps) were updated.

Dialogue with the Staff Committee – including via working groups and formal consultation – was conducted on issues that impact the day-to-day environment for staff. Among the priorities in 2016 were: flexible time; objectives setting, performance assessment and incentive measures; expatriation issues; sports and cultural opportunities; external activities; and international school-related matters.

Recruitment in 2016 was consistent with the ITER Council-approved staff cap, as the Department managed 162 appointments (of which 32 were ITER Organization staff members appointed through internal or external competition), 30 departures, and 32 contract renewal decisions. For 182 posted vacancies, Human Resources received 5,156 applications through the ITER Domestic Agencies and conducted 879 interviews. As of 31 December 2016, the ITER Organization employed a total of 740 staff members, including 5 postdoctoral researchers funded under the Monaco-ITER Partnership Arrangement and 25 staff funded by the US Domestic Agency for work on the tokamak cooling water (23) and vacuum (2) systems. The Department managed 32 expert contracts and an increasing number of student interns (38) through more targeted promotion of the internship program. Training sessions organized in security, design planning, nuclear safety culture, and managerial, scientific and technical skills benefitted 1,100 attendees during the year.

**The MIIFED/IBF event in February offers 600 participants from industry an overview of upcoming contract opportunities related to the assembly and installation phase of the project.**

As part of its mission to support social dialogue within the Organization, the Human Resources Department maintained the dialogue with the Staff Committee, coordinated the activities of the Advisory Board on Pension and Social Insurance and, where necessary, the Committee for Health & Safety. The Department also represented the ITER Organization in its relations with the French administration (labour inspectorate, social security).

The February Monaco-ITER International Fusion Energy Days attract a large number of participants with a program organized around industrial opportunities at ITER.

## CABINET (CAB)

*The Cabinet supports the Director-General in all matters related to the management of the ITER Organization and in his global responsibility as Chief Executive Officer and Chair of the cross-decisional Executive Project Board. CAB liaises with official bodies and partner government organizations and assists the Director-General in his external and international interactions. Through its Legal Affairs and Communication offices, CAB also provides legal advice to the Director-General and develops and maintains a comprehensive internal and external communication strategy.*

The Cabinet structures its work between the strategic and administrative support of the Director-General and the Deputy Directors-General. Its scope includes legal and communication affairs; contact with external stakeholders; document preparation and editing of input documents to the ITER Council and its advisory bodies; follow-up of internal decisions and interdepartmental projects; and the monitoring of follow-up actions and recommendations from the ITER Council, the Management Advisory Committee, the Science and Technology Advisory Committee, the Management Assessor, and high-level independent review groups. At the request of the Director-General, the Cabinet can work on strategic issues for the Organization as decision-making support.

**The bulk of the Action Plan proposed to the ITER Council by the Director-General at the start of his mandate in March 2015 has effectively been implemented.**

The Cabinet participates in a number of key committees (procurement assessment, crisis management, budget advisory, intellectual property, publications, export control) and organizes the top project meetings at the executive level, namely: the biweekly Central Team Management Board for ITER Organization senior executive managers (both decision and information meetings); the Executive Project Board that is attended by top ITER Organization and Domestic Agency management; and the regular Joint Project Coordination weeks.

ITER's largest components arrive at the Mediterranean port of Fos-sur-Mer and are transported by barge to the starting point of the ITER Itinerary. From there, they have 104 kilometres to travel to the site. *Photo: © ITER Organization - Emmanuel Bonici*

In 2016 the team assisted in the continued daily implementation of the Director-General's Action Plan: supporting the project-wide effort to finalize the 2016 Baseline, following through on actions to reform the management of human resources, and aiding in the deployment of a new organizational matrix for construction oversight.

Cabinet staff also provided general assistance in the management of the Director-General's agenda, helping to prepare for internal and external meetings as well as institutional and VIP events and visits to the ITER Organization.

## COMMUNICATION (COM)

*Within the Cabinet of the Director-General, Communication works to elevate the public's understanding of fusion energy, raise awareness of the project, and showcase ITER construction and manufacturing progress. Through targeted initiatives in internal communication COM is also invested in strengthening the work environment – helping to develop a strong project culture, facilitating the flow of information, and supporting implementation of Director-General's Action Plan. Finally, COM maintains strong ties to Member State agencies and external collaborators in the fusion community through the development of sustainable and collective actions.*

Communication propels the strategic activities that are designed to elevate the public visibility of the ITER Project and increase awareness of ITER's mission, goals and status. The group maintains the public website and the project's presence on social media; issues publications (the weekly *ITER Newsline*, brochures, an annual photo book, *ITER Mag*, press releases, the Annual Report); makes up-to-date audio visual material available for the widest possible distribution; handles press and media relations; manages an on-site Visitors Centre and public visits to the construction site; and pilots ITER participation at conferences and exhibitions. Plans are underway to conduct future global media campaigns as an additional way to elevate public awareness of the ITER Project mission and progress.

In February, Communication helped to organize the joint MIIFED/IBF* industrial event, which attracted nearly 600 international participants with a focus on upcoming contract opportunities related to the assembly and installation phase of the project. ITER was represented at a number of external events, including the World Nuclear Exhibition (Paris), the Symposium on Fusion

ITER . . . a story waiting to be told. International TV crews are a regular feature on the ITER construction site.

Technology (Czech Republic), the IAEA Fusion Energy Conference (Japan), the World Energy Congress (Turkey), the Pacific Basin Nuclear Conference (China), and the ITER/Broader Approach Symposium (Japan). As part of an updated exhibition stand, Communication developed a portable immersive virtual reality tour of the ITER construction site that is also accessible in 2D and 3D through the public website.

Among the dozens of media crews received throughout the year, Communication hosted a Canadian documentary team for several weeks at ITER Headquarters – part of more than three years of filming and research to create a 90-minute documentary on fusion and ITER that is planned for release in 2017. International journalists were also invited to attend a dedicated two-day media event in October. Communication held one Open Doors Day event in 2016; participated in the organization of the annual ITER Games and ITER Robots contests; and – in collaboration with Agence Iter France and the European Domestic Agency – received 15,000 visitors on site.

Communication supported the Director-General in his role as primary ambassador for the project, helping him to prepare for a number of high-visibility presentations and appearances. These included an invitation to appear before a subcommittee of the US House of Representatives; the hosting of many ministerial delegations (ITER Member or non-Member representatives) including a ministerial delegation from Iran and return visit to Iran; and the visits of HSH Prince Albert II of Monaco, the Director General of the International Atomic Energy Agency, and members of the European Parliament. More generally, Communication maintains a database of presentations for general audiences and is developing a "Speakers Bureau" capable of representing the project in external venues in complement to what is already handled by ITER management.

The first all-staff meeting of the year, held in the on-site Cryostat Workshop, was also the occasion to update the ITER staff photo. A number of other initiatives contributed to enriching the work environment, including the introduction of a dedicated training and site visit for newcomers, the hosting of external lecturers, and a celebratory event for ITER Organization/Domestic Agency staff and contractors in December. Planning is underway for the roll out of information screens in high traffic areas, on the re-make of the internal website Buzz, and on a regular COM email that will share news of internal interest across the ITER Project.

Communication continues to cultivate strong relationships with designated communication points of contact in each Domestic Agency and in the wider fusion community. The group issues the periodic *Director-General Newsletter* with the support of Domestic Agency colleagues, communicates regularly through in-person or video meetings, and organizes an annual ITER communicators meeting at Headquarters.

* Monaco-ITER International Fusion Energy Days/ITER Business Forum

### LEGAL AFFAIRS (LGA)

*Within the Cabinet, Legal Affairs advises the Director-General, the departments, and the governing bodies of the ITER Organization such as the ITER Council, the Management Advisory Committee and the Test Blanket Module Program Committee. Regular counsel is provided by Legal Affairs on the interpretation and implementation of the ITER constitutive agreements (the ITER Agreement, the Agreement on Privileges and Immunities, and the Headquarters Agreement).*

In 2016, questions pertaining to international cooperation with Members – and also the possibility of cooperation with non-Members – were addressed, including particular support for the conclusion of the first non-Member Cooperation Agreement with the Australian Nuclear Science and Technology Organisation.

Legal Affairs pursued the management of nuclear liability issues, and was involved in several other complex project issues – helping to prepare for component transfers of responsibility between the Domestic Agencies and the ITER Organization; supporting the negotiation of agreements with the French power transportation authority RTE; and advising on strategic ITER construction contracts, worksite coordination documents, and administrative authorizations on the worksite.

The legal team contributed to the protection of ITER Organization interests by handling the correct implementation of the privileges and immunities of the ITER Organization with national authorities – negotiating, for example, the recognition of exemption for value added tax (VAT) for the ITER Organization and the Domestic Agencies, or the exemption of customs taxes, anti-dumping taxes, and electricity taxes. This type of issue is increasing in frequency with the arrival of components and/or their transportation between Members.

Extensive support was provided on visa and work permit issues for contractors and Domestic Agency staff members in order to prevent delay in contract execution. Legal Affairs also interfaced with the labour inspectorate and the French administration to clarify the administrative requirements for work on the construction site and in order to secure the social protection of workers.

In 2016 Legal Affairs was responsible for drafting and negotiating 19 agreements, 9 license agreements, numerous non-disclosure agreements, and 30 Memoranda of Understanding. It managed insurance claims and insurance-related matters, and reviewed ITER Organization contracts prior to signature by the Director-General.

Legal Affairs provided advice on the French laws and regulations to be observed by the ITER Organization in application of Article 14 of the ITER Agreement relative to public health, safety, licensing and environmental protection, in particular concerning working conditions on site and the management of beryllium handling and storage issues. Legal Affairs is a participant to meetings of the ITER Beryllium Management Committee and the Beryllium Working Group.

Legal Affairs managed litigation cases in close collaboration with the Human Resources Department, and provided support and advice in the establishment of the ombudsman process, activities of the ethic committee, the update of the ITER Project Associate scheme, and social security issues. Specific in-house training sessions were organized on the legal framework specific to the ITER Organization, the status of international civil servants, and intellectual property in order to raise staff awareness. Legal Affairs also introduced a new income tax assistance program for staff.

Legal Affairs coordinated the implementation of the legal framework for intellectual property within the ITER Organization through the Intellectual Property Board, advising line management and technical responsible officers on publications, contracts, Procurement Arrangements, non-disclosure agreements, and communication. Rules concerning rewards for inventors were issued in order to encourage directly employed staff members to develop ITER Organization intellectual property; this new policy proposes awards for inventions that become the subject of a patent application, or developments that engender a royalty-paying licensing agreement. At the annual meeting of ITER Organization/Domestic Agency contact persons for intellectual property, chaired by the ITER Legal Advisor in November, participants worked to encourage the widest appropriate dissemination of intellectual property generated in the course of activities for ITER.

As part of the semi-prototype qualification program in China for enhanced heat flux first wall blanket panels, pairs of beryllium-tiled "fingers" (pictured) have undergone testing at a dedicated facility in Russia. *Photo: ITER China*

**INTERNAL AUDIT (IAS)**

*The work of the Internal Audit Service is aligned to the business, financial and operational risks of the ITER Organization and audits are conducted according to a comprehensive risk-based plan that is updated periodically. The annual risk assessment exercise that was carried out in 2016 by IAS was comprehensive, and covered 92 major processes of ITER Organization departments and divisions – including the Cabinet, Human Resources, Finance & Procurement, Construction, the Design Office, IT, Document Control and Project Control.*

The results of the annual risk assessment exercise carried out by IAS were submitted to external auditors (the Financial Audit Board) as input for their audit planning. IAS also cooperated with the Financial Audit Board auditors during their audit assignments at ITER.

In 2016, IAS audited the accounting of assets, pre-paid assets, and depreciation for the 2016 ITER Organization Financial Statements. Other important topics of audit included mission travel; the system of levy and computation of common facilities, services and amenities; operations pertaining to facilities management; suspense operations; and purchase and disposal of IT hardware.

IAS performed advisory services as requested periodically by management and carried out important assignments related to human resource matters, budget for salaries, and procurement issues. IAS also held workshops to impart knowledge and skills to staff of the Financial Control Office on matters relating to computation and accounting of liabilities and provision, and routinely advised the Head of Office with the aim to further enhance the adequacy and effectiveness of control functions at the ITER Organization. Similarly, in collaboration with ORAP, IAS verified the effective implementation of MQP process simplification following a reduction-of-bureaucracy effort carried out last year.

Lastly, IAS followed up on the implementation status of its recommendations, of which a large number were addressed and implemented during the reporting period by line management. At year end, more than 40 of the IAS audit recommendations had been implemented by line departments, leading to savings of resources for the ITER Organization and/or to augmentation of revenue. Of these, the most significant in terms of cost savings were amendments to the contract for canteen facilities and modifications in procedures for the purchase of IT hardware.

### ITER COUNCIL SECRETARIAT (ICS)

*The ITER Council Secretariat supports the activities of the ITER Council, providing secretarial services to the Council and its subsidiary bodies such as the Management Advisory Committee (MAC), the Council Preparatory Working Group (CPWG), and the Financial Audit Board in accordance with the Rules of Procedure of the ITER Council.*

In 2016, the ITER Council met for an Extraordinary Meeting in April, for its Eighteenth Meeting in June and its Nineteenth Meeting in November. The Management Advisory Committee met twice: in May (MAC-21) and in October (MAC-22). The ITER Council commissioned reviews by the ITER Council Working Group on the Independent Review of the Updated Long-Term Schedule and Human Resources (ICRG), and the ITER Council Study Group on the Implementation of ITER Governance. The ICS also supported the Financial Audit Board in relation to its 2016 financial audit activities and the 2015 Management Assessment.

### EXTERNAL RELATIONS & ACTION PLAN IMPLEMENTATION OFFICE (ORAP)

*The ORAP Office provides support to the Director-General in all matters related to cooperation and coordination with the Members and their relevant domestic institutions, as well in the simplification of Management & Quality Program procedures as foreseen in the Director-General's Action Plan.*

In 2016, the External Relations & Action Plan Implementation Office worked in close collaboration with ITER Members to organize the Director-General's visits abroad, arrange meetings with senior government officials and parliament members, and prepare presentations, for appearances at international conferences.

The Office organized the Director-General's visits to China, India, Japan and Russia and prepared the necessary briefing documents; it also supported the Head of Communication by organizing visits to China, India, Japan and Korea, providing detailed background information and analysis, and liaising on questions of communication strategy. ORAP was charged with correspondence relating to three high-level Member delegations that were received at ITER Headquarters outside of ITER Council meetings.

Cooperation with the Australian organization ANSTO is envisioned in a number of strategic areas, including diagnostics, materials, superconducting technology, and fusion plasma theory and modelling.

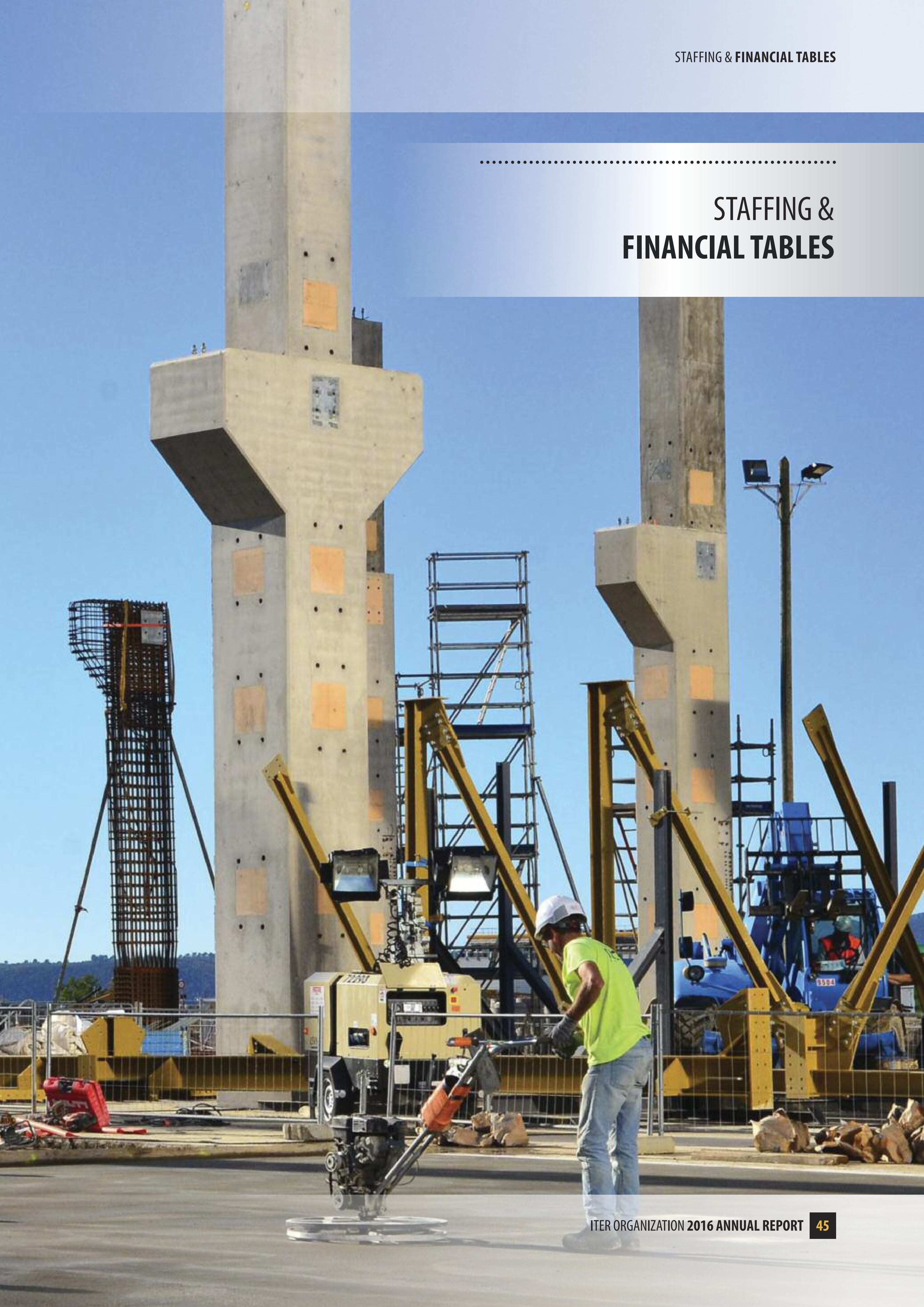
The Office, in collaboration with Internal Audit (IAS), monitored and assessed the implementation of recommendations for simplifying/optimizing Management & Quality Program procedures and Internal Administrative Circulars as approved by the Central Team Management Board. This was consequent to the simplification/optimization exercise that was carried out by IAS and ORAP in the previous year. The Office also promoted the balanced representation of all Members within the Staff Committee and supported the Domestic Agencies in the recruitment of highly qualified candidates for ITER Organization positions.

**The ITER Organization signs the first non-Member technical cooperation agreement of its history in September with the Australian Nuclear Science and Technology Organisation, ANSTO.**

In close cooperation with the Legal Affairs and its contracted immigration expert, ORAP contributed to drafting work permit application procedures for Member employees and communicated intensively inside and outside the organization on visa-work permit procedures and requirements. The Office organized a workshop on work permit and social contributions for relevant ITER Organization staff and coordinated with the Welcome Office of Agence Iter France to ensure prompt and efficient visa services to all ITER staff members. The Office also liaised with a provider of work permit services to facilitate administrative formalities for Domestic Agency contractors.

Support was provided for human resource matters, such as clarifying the work of the new ombudsmen in conjunction with the Staff Committee, Human Resources and Communication, and participating in discussions on changes to be implemented in the ITER Organization policy for awards, the Code of Conduct, and others.


On a zone not far from the Tokamak Complex, contractors have started to erect the infrastructure of the ITER cryoplant – 5,400 m² of covered buildings plus a large exterior area for the storage of helium and nitrogen in liquid and gaseous forms.



# STAFFING & **FINANCIAL TABLES**

# STAFFING TABLES

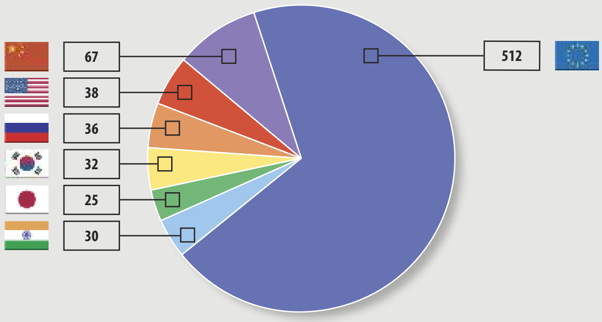
## Staff by Member as at 31 December 2016

| Staff by Member | 31/12/2014 | 31/12/2015 | 31/12/2016 |
|---|---|---|---|
| China | 50 | 55 | 67 |
| European Union | 412 | 446 | 512 |
| India | 19 | 22 | 30 |
| Japan | 29 | 25 | 25 |
| Republic of Korea | 33 | 32 | 32 |
| Russian Federation | 30 | 30 | 36 |
| United States of America | 36 | 32 | 38 |
| **Total** | **609*** | **642**** | **740***** |

* Includes 6 Monaco Postdoctoral Fellows and 16 TCWS staff.

** Includes 5 Monaco Postdoctoral Fellows and staff funded for work on the TCWS (24) and on the vacuum system (1).

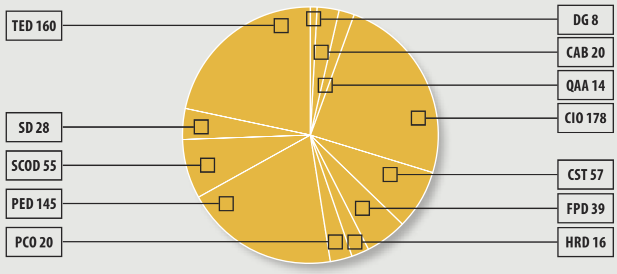
*** Includes 4 Monaco Postdoctoral Fellows and staff funded for work on the TCWS (23), the vacuum system (2), and the safety control system for nuclear (1).




## Staff by Department as at 31 December 2016

| Staff by Org. Unit* | Professional & Higher | Support | TOTAL |
|---|---|---|---|
| DG | 7 | 1 | 8 |
| CAB | 10 | 10 | 20 |
| QAA | 6 | 8 | 14 |
| CIO | 80 | 98 | 178 |
| CST | 49 | 8 | 57 |
| FPD | 15 | 24 | 39 |
| HRD | 7 | 9 | 16 |
| PCO | 15 | 5 | 20 |
| PED | 95 | 50 | 145 |
| SCOD | 46 | 9 | 55 |
| SD | 19 | 9 | 28 |
| TED | 123 | 37 | 160 |
| **TOTAL** | **472** | **268** | **740** |

* For the full names of organizational units, see pages 15 to 43.




# FINANCIAL TABLES

*Amounts in thousands of Euro*

## Commitments Execution – Cash And Short-Term In Kind (Task Agreements And Secondments)*

| Budget Headings | | Total Commitment Appropriations 2016<br>1 | De-commitments and Transfers of previous years' Total Commitments<br>2 | Total Actual Commitments 2016<br>3 | Unused Commitment Appropriations carried forward to 2017<br>4 = 1 + 2 - 3 |
|---|---|---|---|---|---|
| Title I | Direct Investment (Fund) | 158,242 | 9,583 | 153,121 | 14,704 |
| Title II | R&D Expenditure | 3,682 | 88 | 2,431 | 1,339 |
| Title III | Direct Expenditure | 167,127 | 3,754 | 157,742 | 13,139 |
| **TOTAL COMMITMENTS** | | **329,051** | **13,424** | **313,294** | **29,181** |

* Excluding Reserve Fund

## Payments Execution – Cash And Short-Term In Kind (Task Agreements And Secondments)*

| Budget Headings | | Total Payment Appropriations 2016<br>1 | Total Actual Payments 2016<br>2 | Unused Payment Appropriations carried forward to 2017<br>3 = 1 – 2 |
|---|---|---|---|---|
| Title I | Direct Investment (Fund) | 96,817 | 75,250 | 21,568 |
| Title II | R&D Expenditure | 6,776 | 5,958 | 818 |
| Title III | Direct Expenditure | 173,332 | 145,887 | 27,445 |
| **TOTAL PAYMENTS** | | **276,926** | **227,096** | **49,831** |

* Excluding Reserve Fund

# FINANCIAL TABLES (CONTINUED)

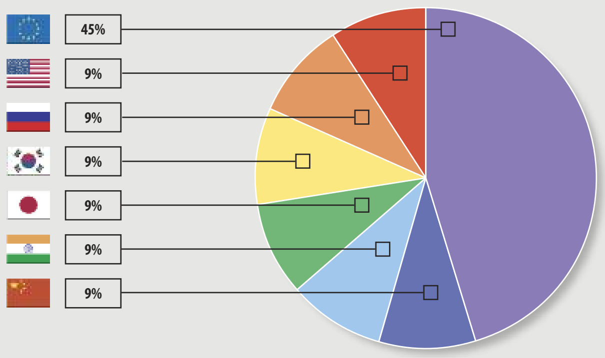
## Cumulative Position Statement by Member as at 31 December 2016

| | Contributions in Cash (cash and short-term in kind) | | Contributions in Kind (Procurement Arrangements) | | Total Contributions | |
|---|---|---|---|---|---|---|
| Euratom (*) | 735,581 | 45.42% | 362,838 | 31.11% | 1,098,419 | 39.43% |
| People's Republic of China | 147,215 | 9.09% | 137,093 | 11.76% | 284,309 | 10.21% |
| Republic of India | 147,264 | 9.09% | 62,616 | 5.37% | 209,880 | 7.53% |
| Japan (*) | 147,215 | 9.09% | 319,950 | 27.44% | 467,166 | 16.77% |
| Republic of Korea | 147,119 | 9.08% | 102,440 | 8.78% | 249,559 | 8.96% |
| Russian Federation | 147,215 | 9.09% | 115,954 | 9.94% | 263,169 | 9.45% |
| United States of America | 147,941 | 9.13% | 65,251 | 5.60% | 213,192 | 7.65% |
| **Total** | **1,619,551** | | **1,166,142** | | **2,785,693** | |

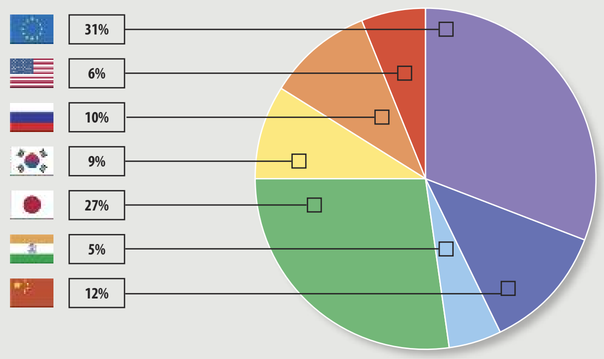
(*) Cumulative credits granted to Japan include a contribution from the European Union corresponding to IUA 110,597 amounting to EUR 184.97 million (including IUA 40,062 for deliverables achieved in 2016) for procurements for which the procurement responsibility has been transferred to Japan within the framework of the transferred procurement responsibilities from Euratom to Japan.

*These tables show tabulations in thousand/million Euros which could cause minor differences due to rounding.*

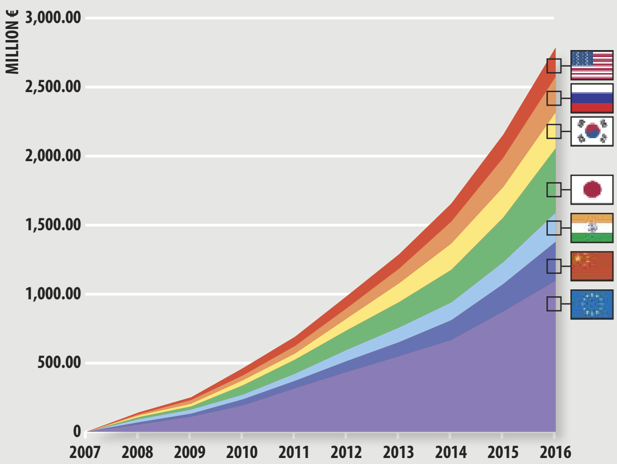
## Contributions In Cash (Cash and Short-Term In Kind)



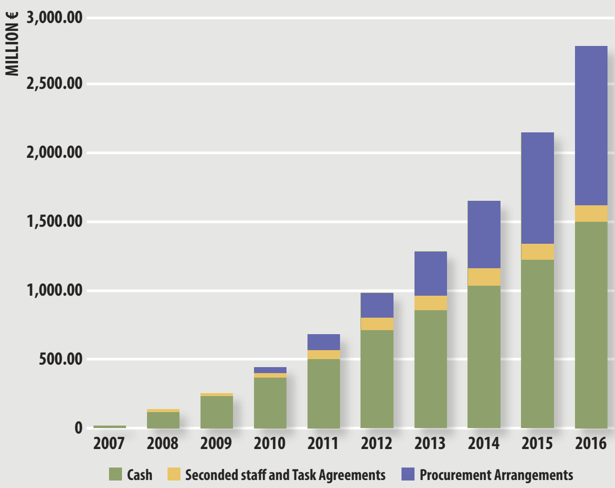

## Contributions In Kind (Procurement Arrangements)




## Cumulative Position by Member




## Deferred Contributions




The pace of deferred contributions related to the achievement of Procurement Arrangement milestones (in purple) continued its increase in 2016 (compared to 2015), reflecting an acceleration of construction and component fabrication activities.

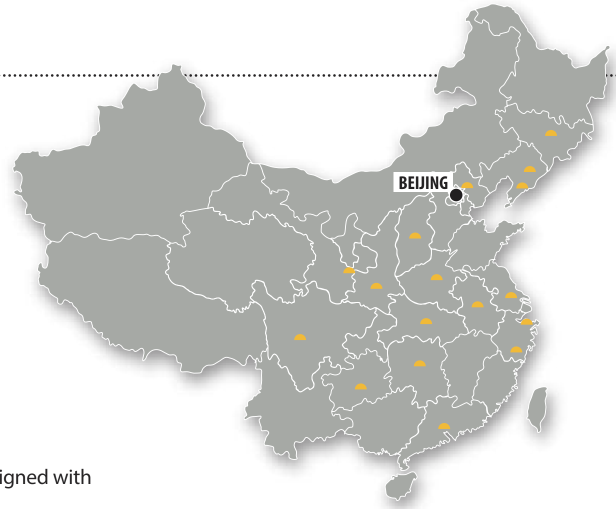

Welding and non-destructive examination activities are underway in the Cryostat Workshop for the first major component of ITER assembly – the 1,250-tonne cryostat base.

# DOMESTIC AGENCY **PROCUREMENT HIGHLIGHTS**

**PROCUREMENT HIGHLIGHTS KEY**

- R&D and manufacturing milestones
- Major contracts
- ITER Organization-Domestic Agency milestones
- Completed package

The figures on the following pages are adjusted annually for changes in credit value due to Procurement Arrangement Refinements (PAR) and Additional Direct Investments (ADI) related to Project Change Requests. Please note that 2016 figures supersede all previously published figures.

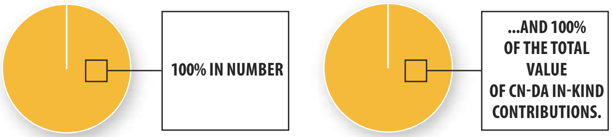



## ITER CHINA (CN-DA)

www.iterchina.cn

## PROCUREMENT ARRANGEMENTS*

**Fourteen PAs signed since 2007 representing…**




77 design or fabrication contracts related to ITER procurement have been signed with laboratories and industry.

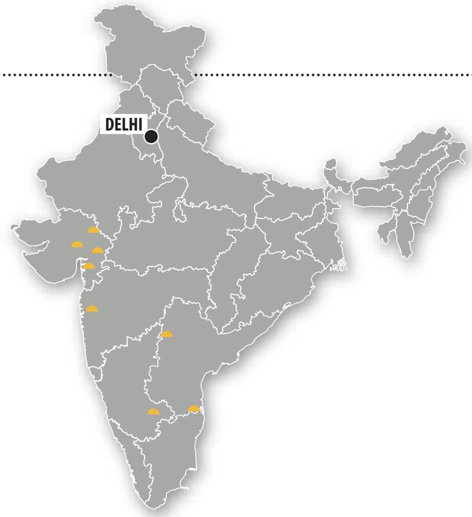
| CHINESE PROCUREMENT HIGHLIGHTS IN 2016 | % OF ITER SYSTEM PROCURED BY CHINA |
|---|---|
| **MAGNET SYSTEMS** | |
| ***Toroidal Field Conductor*** | 7.5% |
| ■ All 11 conductor unit lengths completed and delivered (IC milestone) | |
| ***Poloidal Field Conductor*** | 65% |
| ■ All conductor fabrication completed for PF5 and PF2 (IC milestone) | |
| ■ 6 of 16 PF3 unit lengths produced | |
| ■ 8 of 16 PF4 unit lengths produced | |
| ■ 9 conductor unit lengths delivered to EU-DA at ITER site | |
| ***Magnet Supports*** | 100% |
| ■ MRRs completed for gravity supports and poloidal field supports; some manufacturing underway | |
| ***Feeders*** | 80% |
| ■ Five MRRs successfully held, including for HTS current leads, coil terminal box (CTB/TS), and cryostat feedthrough | |
| ■ Qualification completed for poloidal field HTS current lead prototype; series production started | |
| ■ Start of fabrication on first cryostat feedthrough for poloidal field coil 4 | |
| ***Correction Coils*** | 100% |
| ■ Contract signed for remaining manufacturing scope | |
| ■ Bottom correction coil in fabrication | |
| ■ Full-size U-shaped bottom correction coil case fabricated with satisfactory results | |
| ■ Qualification prototypes progress for full manufacturing scope of bottom and side coils | |
| ***Correction Coil and Feeder Conductors*** | 100% |
| ■ All correction coil and feeder conductors manufactured and delivered in 2016 | |
| **POWER SYSTEMS** | |
| ***Pulsed Power Electrical Network (PPEN)*** | 100% |
| ■ All voltage transformers delivered to IO site | |
| ■ Second batch of breakers, disconnectors, and current transformers delivered | |
| ■ 3 main transformers delivered | |
| ***AC/DC Converters*** | 55% |
| ■ Successful FAT and delivery for first set of rectified transformers | |
| ***Reactive Power Compensation*** | 100% |
| First reactive power compensation (RPC) and harmonic filtering (HF) units manufactured | |
| RPC and HF units installed at ASIPP-ITER platform for integrated tests | |
| **BLANKET** | |
| ***Blanket First Wall*** | 12.6% |
| ■ High heat flux tests successfully passed on first-wall finger pairs for semi-prototype | |
| ■ Enhanced Heat Flux Blanket First Wall Procurement Arrangement signed in November | |
| ***Blanket Shield Block*** | 50.2% |
| ■ Deep-hole drilling on full-scale prototype completed in December | |
| ■ First hot helium leak test facility manufactured and under commissioning | |
| **FUEL CYCLE** | |
| ***Gas Injection System*** | 100% |
| ■ Contract signed for manifold manufacturing | |
| ■ Preliminary design of gas valve boxes ongoing; some physics requirements fixed as design input | |
| ***Glow Discharge Cleaning*** | 100% |
| ■ Preliminary design of temporary/permanent electrodes ongoing | |
| **DIAGNOSTICS** | |
| ***Diagnostics*** | 3.22% |
| ■ Final design of neutron flux monitor (equatorial port 7) ongoing; FDR for support frame held | |
| ■ PDR held for radial x-ray camera | |
| ■ Preliminary design of equatorial port 12 integration ongoing | |
| ■ Preliminary design of remaining neutron flux monitors ongoing | |

**Abbreviations • ANB** Agreed Notified Body • **CDR** Conceptual Design Review • **DA** Domestic Agency • **FDR** Final Design Review • **I&C** Instrumentation & Control • **IO** ITER Organization • **IC** ITER Council • **FAT** Factory Acceptance Tests • **MIP** Manufacturing & Inspection Plans • **MRR** Manufacturing Readiness Review • **PA** Procurement Arrangement • **PDR** Preliminary Design Review

* Does not include Complementary Diagnostic Arrangements.

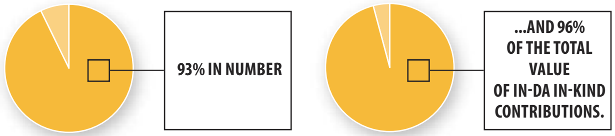
# ITER INDIA (IN-DA)

**www.iter-india.org**




## PROCUREMENT ARRANGEMENTS*

**Fourteen PAs signed since 2007 representing…**




20 design or fabrication contracts related to ITER procurement have been signed with industry and R&D organizations.

**INDIA PROCUREMENT HIGHLIGHTS IN 2016** — **% OF ITER SYSTEM PROCURED BY INDIA**

**CRYOSTAT**

***Cryostat*** — *100%*
- Final segments of tier-1 base section delivered (IC milestone); start of tier-1 sub-assembly (fabrication/welding) and testing activities on site
- Manufacturing and FAT of tier-2 base section components completed; components delivered to Cryostat Workshop
- Progress on fabrication activities for lower cylinder tier-1 components in India
- FDR held for cryostat I&C
- Agreement reached to transfer vacuum vessel pressure suppression system (VVPSS) to IO

**CRYOGENIC SYSTEMS**

***Cryolines & Cryodistribution*** — *100%*
- PDRs held for cryolines (Lot Y3, Lot X4, parts of Lot Y4 and Y5); and warm lines (Lots W1 and W2)
- PDR and FDR completed for cryoplant termination cold box (CTCB) of cryodistribution system
- PDRs held for auxiliary cold box and thermal shield cooling system for cryodistribution
- Manufacturing started for CTCB components
- FDRs held for cryolines (Lot Y1, Lot X3, parts of Lots Y4 and Y5) and warm lines (Lot W1) and completed for cryolines (Lot Y1, Lot Y2)
- MRRs held for cryolines (Lot Y1, part of Lot Y2)
- Manufacturing and FAT completed for second prototype cryoline; successful installation and testing at IN-DA lab
- Start of manufacturing for Group Y cryoline components

**HEATING & CURRENT DRIVE SYSTEMS**

***Diagnostic Neutral Beam (DNB) Power Supply and Beam Line*** — *100%*
- Beam source manufacturing in progress; beam line component fabrication initiated
- Vacuum vessel installation at DNB test facility at advanced stage; high voltage deck in manufacturing
- Test facility technical activities (data acquisition and control system design, radio frequency experiment in vacuum, cryocooler-based cryopump experiment) ongoing
- DNB acceleration grid power supply (AGPS) installed and commissioned at IN-DA lab
- Manufacturing initiated on 25-metre transmission line components for IN-DA lab
- Solid state high frequency (1 MHz) power source in development

***Neutral Beam Test Facility (NBTF) Components (beam dump & 100 KV power supply)*** — *2%*
- Successful FAT and shipment for components of SPIDER AGPS (transformers, switch power supply modules); installation at NBTF well advanced

***Ion Cyclotron Radio Frequency (RF) Power Sources*** — *100%*
- Mismatch transmission line system tested at low power and installed with diacrode-based RF amplifier to conduct ITER-like test scenarios
- Diacrode-based system (1.5 MW) tested with stringent specifications for the first time
- Assembly and integration of tetrode-based system completed at IN-DA laboratory; high-power operation initiated as per ITER specifications
- Industrial prototype high voltage power supply operated continuously for site acceptance campaigns of diacrode and tetrode sources

***Ion Cyclotron Heating & Current Drive RF Power Supply (8 out of 10)*** — *44%*
- 3 MW radio frequency high voltage power supply successfully operated at ITER parameters

***Electron Cyclotron High Voltage Power Supply*** — *30%*
- Development and test activities ongoing

***Electron Cyclotron RF Gyrotrons (2 out of 24)*** — *8%*
- Activities ongoing for test facility development at IN-DA laboratory
- Procurement activities initiated for test gyrotron and waveguide set for test laboratory
- Development activities ongoing for auxiliary systems and services (prototype of ITER deliverable) to establish the test facility

**COOLING WATER SYSTEMS**

***Heat Rejection System, Component Cooling Water System, Chilled Water System*** — *100%*
- FDR conducted for heat rejection system, component cooling water system, and chilled water system H2
- MRRs completed for cooling towers, stop log gates, self-cleaning filters, stainless steel seamless pipes, ozonation system, pressurizer, water cooled chillers, and plate-type heat exchangers
- Lot 1 piping delivered (IC milestone); continued fabrication and delivery of piping
- Manufacturing and FAT completed for ozonation system

**VACUUM VESSEL**

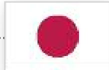
***In-wall Shielding Block Assemblies*** — *100%*
- Manufacturing and FAT completed for two vacuum vessel sectors (5 and 6)
- Manufacturing and FAT completed for the IWS support ribs and lower brackets of two vacuum vessel sectors (5 and 6)
- Batches shipped to EU-DA and KO-DA
- IWS component fabrication ongoing for vacuum vessel sectors 4 and 1

**DIAGNOSTICS**

***Diagnostics*** — *3.1%*
- First-phase PDR held for XRCS-survey sight tube
- Most components for conventional X-ray source and optical setup procured and tested for IN-DA lab
- Fast-scanning Fourier transform spectrometer received at IN-DA lab after successful FAT; preliminary design and prototype works underway for electron cyclotron emission
- First phase system integration review completed for upper port integration

**Abbreviations** • **ANB** Agreed Notified Body • **CDR** Conceptual Design Review • **DA** Domestic Agency • **FDR** Final Design Review • **I&C** Instrumentation & Control • **IO** ITER Organization • **IC** ITER Council • **FAT** Factory Acceptance Tests • **MIP** Manufacturing & Inspection Plans • **MRR** Manufacturing Readiness Review • **PA** Procurement Arrangement • **PDR** Preliminary Design Review

* Does not include Complementary Diagnostic Arrangements.

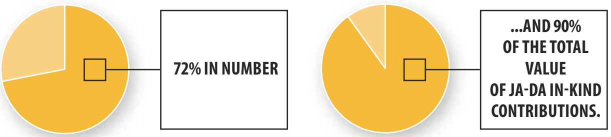


## ITER JAPAN (JA-DA)

**www.fusion.qst.go.jp/english/iter-e/iter.html**


### PROCUREMENT ARRANGEMENTS*

**Thirteen PAs signed since 2007 representing…**




Over 800 design or fabrication contracts related to ITER procurement have been signed with industry since 2007.

**JAPANESE PROCUREMENT HIGHLIGHTS IN 2016** — **% OF ITER SYSTEM PROCURED BY JAPAN**

**MAGNET SYSTEMS**

***Toroidal Field Conductor*** — *25%*
- All conductor unit lengths completed in 2014

***Toroidal Field Magnet Windings (9 out of 19)*** — *47%*
- Double pancake stacking of the first coil successfully performed
- Toroidal field coil series production underway

***Toroidal Field Magnet Structures*** — *100%*
- Material procurement and coil structure series production underway
- Segments of first outer case section successfully connected

***Central Solenoid Conductor*** — *100%*
- 37 conductors (six 613 m and thirty-one 918 m) manufactured, corresponding to 75% of required material
- 31 unit lengths shipped to US-DA, cumulative (63%)

**HEATING & CURRENT DRIVE SYSTEMS**

***ITER & Neutral Beam Test Facility (NBTF) High Voltage Bushing*** — *100%*
***and accelerator*** — *33%*
- HV bushing and 1MV high-voltage test performed; shipping has started

***Neutral Beam Power Supply System for ITER and NBTF*** — *59%*
- All five DC generators now shipped and installed
- Transmission lines 1 and 2 installed
- DC filter, high voltage deck HVD2, and short circuit device shipped
- Transmission link 3 fabricated
- Installation work performed at NBTF

***Electron Cyclotron Radio Frequency (RF) Power Sources (8 gyrotrons out of 24)*** — *33%*
- Fabrication of two out of eight gyrotrons completed
- Contracts awarded for mirror optical units and cooling manifolds
- Final design of anode and body power supply underway

***Electron Cyclotron Equatorial Launcher*** — *71%*
- Millimetre wave mockup test completed
- Final design of equatorial launcher underway

**REMOTE HANDLING**

***Blanket Remote Handling System*** — *100%*
- Contract awarded for package #2 (rail deployment equipment)

**DIVERTOR**

***Outer Target*** — *100%*
- High heat flux testing of full-tungsten prototype plasma-facing units completed at RF-DA test facility (IC milestone)
- Discussion of Project Change Request related to design change to full-tungsten target (including financial issues) underway
- Amendment of Divertor Outer Target Procurement Arrangement due to this design change in provision

**TRITIUM PLANT**

***Atmosphere Detritiation System*** — *50%*
- Progression of detritiation system qualification activities; performance test of modified water distributor completed
- Joint JA-DA/ITER Organization procurement activities proceeding

**DIAGNOSTICS**

***Diagnostics*** — *14.2%*
- Manufacturing of mineral-insulated cables for micro fission chambers completed
- Contract awarded for prototyping and final design of edge Thomson scattering system, poloidal polarimeter, and divertor impurity monitor
- PDR closed for poloidal polarimeter
- PDR closed for edge Thomson scattering

**Abbreviations** • **ANB** Agreed Notified Body • **CDR** Conceptual Design Review • **DA** Domestic Agency • **FDR** Final Design Review • **I&C** Instrumentation & Control • **IO** ITER Organization • **IC** ITER Council • **FAT** Factory Acceptance Tests • **MIP** Manufacturing & Inspection Plans • **MRR** Manufacturing Readiness Review • **PA** Procurement Arrangement • **PDR** Preliminary Design Review

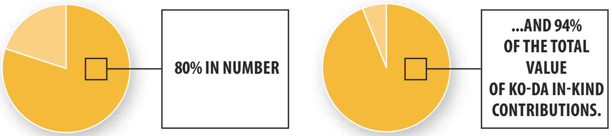
* Includes Complementary Diagnostic Arrangements.

# ITER KOREA (KO-DA)

www.iterkorea.org


## PROCUREMENT ARRANGEMENTS*

**Eight PAs signed since 2007 representing…**




143 design or fabrication contracts related to ITER procurement have been signed with universities, laboratories and industry since 2007.

**KOREAN PROCUREMENT HIGHLIGHTS IN 2016** — **% OF ITER SYSTEM PROCURED BY KOREA**

**VACUUM VESSEL**

***Main Vessel (2 of 9 segments)*** — *21.25%*
- Agreement signed with IO for fabrication of sectors #7 and #8
- Fabrication activities underway for Sector 6 (55% completed) and Sector 1 (22% completed)

***Equatorial Ports*** — *100%*
- Neutral beam port stub extension and in-wall shielding manufacturing launched
- Manufacturing design ongoing for neutral beam port extension

***Lower Ports*** — *100%*
- Lower port stub extension and port extension manufacturing underway

**BLANKET**

***Blanket Shield Block*** — *49.82%*
- Preparing to award contract for shield block material procurement and manufacturing

**POWER SYSTEMS**

***AC/DC Converters*** — *37.27%*
- AC/DC converter (CCS-1) manufacturing completed
- AC/DC converter (CCU-1) and converter transformer (VS1-1) FAT completed
- Master controller manufactured for toroidal field coil power supply system

***In-Vessel Coil Power Supply (busbars)*** — *100%*
- Design issues reviewed and configuration improvements implemented

**MAGNET SYSTEMS**

***Toroidal Field Conductor*** — *20.18%*
- All conductor unit lengths completed in 2014 and delivered to JA-DA

**THERMAL SHIELD**

***Vacuum Vessel Thermal Shield and Cryostat Thermal Shield*** — *100%*
- Final design for thermal shield manifold and instrumentation approved
- Manufacturing drawings of lower cryostat thermal shield (LCTS) cylinder and support thermal shield (STS) approved; manufacturing of LCTS cylinder and STS started
- Vacuum leak test system constructed

**ASSEMBLY TOOLING**

***Machine Assembly Tooling*** — *100%*
- Start of assembly for first vacuum vessel sector sub-assembly tool (SSAT) for factory acceptance tests
- Start of manufacturing on SSAT #2
- FDR completed for first batch Group B2 tools

**TRITIUM PLANT**

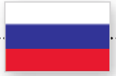
***Tritium Storage & Delivery*** — *82.09%*
- Storage and delivery system full scale getter bed design completed
- Storage and delivery system process flow diagram under development
- Tritium inventory calorimetry, helium 3 recovery process development ongoing

**DIAGNOSTICS**

***Diagnostics*** — *3.16%*
- PDRs closed for vacuum ultra-violet (VUV) spectrometers and neutron activation system (NAS) transfer lines
- Ongoing prototype test of VUV spectrometer and NAS on KSTAR
- Development and testing of key components (DeMi system for first mirror protection, pipe feedthrough, rotary-type mechanical feedthrough …)

**Abbreviations** • **ANB** Agreed Notified Body • **CDR** Conceptual Design Review • **DA** Domestic Agency • **FDR** Final Design Review • **I&C** Instrumentation & Control • **IO** ITER Organization • **IC** ITER Council • **FAT** Factory Acceptance Tests • **MIP** Manufacturing & Inspection Plans • **MRR** Manufacturing Readiness Review • **PA** Procurement Arrangement • **PDR** Preliminary Design Review

* Does not include Complementary Diagnostic Arrangements.

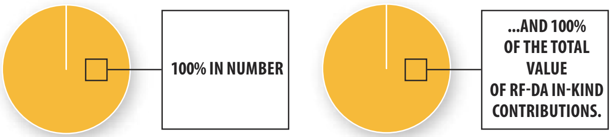



# ITER RUSSIA (RF-DA)

www.iterrf.ru

## PROCUREMENT ARRANGEMENTS*

Twelve PAs signed since 2007 representing…




Over 800 design or fabrication contracts related to ITER procurement have been signed with industry since 2007.

## RUSSIAN PROCUREMENT HIGHLIGHTS IN 2016 — % OF ITER SYSTEM PROCURED BY RUSSIA

### POWER SYSTEMS

***Switching Network, Fast Discharge Units, DC Busbar and Instrumentation*** — *100%*

- FDR-2 held for switching network resistors and power cables
- Second group of busbars, flexible links, rigid inserts, busbar boxes and supports manufactured, tested and delivered
- Prototypes of fast discharge unit resistor and fast make switch subjected to type testing
- Quality assurance documents uploaded and approved by IO, including new versions
- Engineering analyses completed and uploaded; R&D test reports issued
- Materials and components for future production purchased
- Manufacturing started on future deliveries

### MAGNET SYSTEMS

***Toroidal Field Conductor*** — *19.3%*

- All conductor unit lengths completed and delivered to EU-DA in 2015

***Poloidal Field Conductor*** — *20%*

- Final conductor sample (PFRF4) tested at SULTAN
- Two unit lengths for PF1 conductor manufactured and accepted by IO

***Poloidal Field Magnet No.1*** — *100%*

- First double pancake (of 8) wound

### BLANKET

***Blanket First Wall*** — *40%*

- Set of enhanced heat flux first wall fingers with beryllium armour manufactured and successfully tested
- New equipment prepared for induction brazing of beryllium armour to first wall panel
- Deep drilling technological process successfully developed and tested on enhanced heat flux first wall beam

***Blanket Module Connectors*** — *100%*

- Pre-qualification tests completed for CuCrZr/316L bonded joint (diffusion bonding or HIP); post-HIP heat treatment procedure under development
- AS/LF coatings: first-phase pre-qualification program for plates completed; next step is performing experiments with coated bolts

### DIVERTOR

***Dome*** — *100%*

- Catia model of dome developed for full tungsten divertor; supporting analysis carried out on new design
- Update MIPs for full-scale new-design dome prototype
- Qualification of manufacturing process for dome
- Lower-level MIPs created for manufacture of dome prototype plasma-facing unit tiles
- RF-DA design review for inner particle reflector plate plasma-facing units

***Plasma-Facing Component Tests*** — *100%*

- High heat flux test campaign completed for plasma-facing units of full-scale full-tungsten prototype
- Modernization of ITER Divertor Test Facility (new manipulator, independent cooling of electron gun)
- Test report on high heat flux tests submitted for divertor outer vertical target full-scale tungsten prototype

### VACUUM VESSEL

***Upper Ports*** — *100%*

- Series production continues on upper port components
- Final assembly and successful pressure and leak testing of the first upper port stub extension (PSE12)
- Participation in technical project management matters

***Port Plug Test Facility*** — *100%*

- Designing and updating of Port Plug Test Facility for nuclear test stands continued for FDR finalization

### DIAGNOSTICS — *17%*

- Diagnostic amendment signed for Lower Port Plug 8
- Procurement description completed for Upper Port Plug 7

### HEATING & CURRENT DRIVE SYSTEMS

***Electron Cyclotron Radio Frequency Power Sources (8 gyrotrons out of 24)*** — *33%*

- First Russian gyrotron set manufactured

**Abbreviations • ANB** Agreed Notified Body • **CDR** Conceptual Design Review • **DA** Domestic Agency • **FDR** Final Design Review • **I&C** Instrumentation & Control • **IO** ITER Organization • **IC** ITER Council • **FAT** Factory Acceptance Tests • **MIP** Manufacturing & Inspection Plans • **MRR** Manufacturing Readiness Review • **PA** Procurement Arrangement • **PDR** Preliminary Design Review

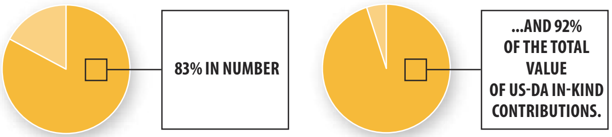
* Does not include Complementary Diagnostic Arrangements.

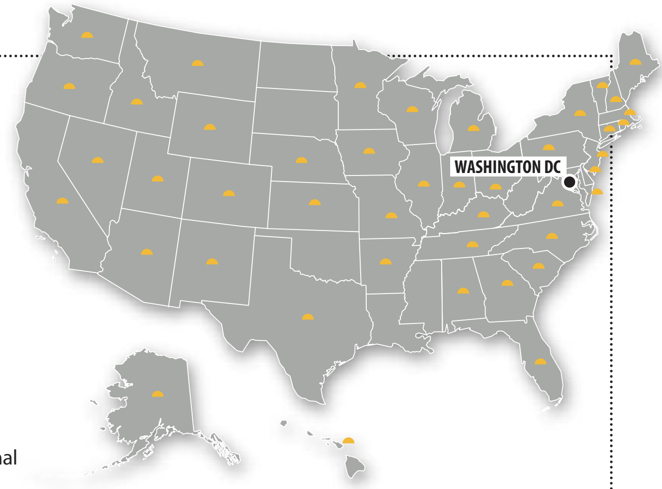
## US ITER (US-DA)

**www.usiter.org**

### PROCUREMENT ARRANGEMENTS*

**Fifteen PAs signed since 2007 representing…**




The US has awarded over 600 contracts to US industry, universities, and national laboratories in 44 states plus the District of Columbia since 2007.

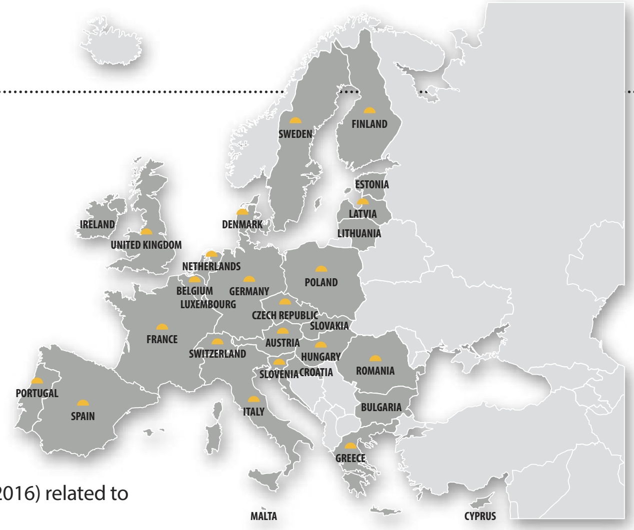
| US PROCUREMENT HIGHLIGHTS IN 2016 | % OF ITER SYSTEM PROCURED BY THE US |
|---|---|
| **COOLING WATER SYSTEM** | |
| ***Tokamak Cooling Water System (TCWS)*** | 100% |
| ■ Preparation for First Plasma FDR underway | |
| **MAGNET SYSTEMS** | |
| ***Central Solenoid Modules, Structure and Assembly Tooling*** | 100% |
| ■ Completed winding of first module (IC milestone) | |
| ■ Completed vacuum pressure impregnation and turn insulation of mockup coil | |
| ■ Wound hexapancakes 4 and 5 for module 2 | |
| ■ Commissioned 9 of 10 fabrication work stations | |
| ■ Last two contracts (of 7) for structures pending | |
| ■ Completed lower key block assembly #1 | |
| ■ Manufactured first article tie plate | |
| ■ Advanced fabrication of assembly platform | |
| ■ Completed MRR for lifting fixture | |
| ***Toroidal Field Conductor*** | 8% |
| ■ Completed first 760-metre unit length by second integrator (IC milestone) | |
| ■ Completed all conductor unit lengths; 7 of 9 deliveries completed to the EU-DA | |
| ■ Toroidal field insert coil testing underway | |
| **DIAGNOSTICS** | |
| ***Port-Based Diagnostic Systems*** | 14% |
| ■ Residual gas analyzer final R&D report completed | |
| ■ Development test stand for motional stark effect mirror cleaning technology in progress | |
| ■ Assembly underway for low field side reflectometer telescope test rig | |
| **HEATING & CURRENT DRIVE SYSTEMS** | |
| ***Ion Cyclotron Transmission Lines*** | 88% |
| ■ Preparation for FDR on Radio Frequency Building components | |
| ■ Fabrication of rotary joint test articles underway | |
| ***Electron Cyclotron Transmission Lines*** | 88% |
| ■ Proof-of-concept tests completed at QST Japan | |
| ■ Basic ordering agreement contract signed for fabrication of transmission line switches | |
| **FUEL CYCLE** | |
| ***Vacuum Auxiliary and Roughing Pump Stations*** | 100% |
| ■ Delivery to ITER of vacuum test stand components | |
| ■ Flanges ready to ship to ITER site (IC milestone) | |
| ■ Further testing of cryoviscous compressor completed | |
| ***Pellet Injection System*** | 100% |
| ■ Pellet injection cask and system design ongoing | |
| ■ Continued fabrication of fuel recirculation loop test unit | |
| ■ Dual gun nozzle test unit in development | |
| ■ Fabrication underway on latest iteration of twin screw extruder test unit | |
| ***Disruption Mitigation System*** | 100% |
| ■ Contract finalized for installation of shattered pellet injection unit on JET | |
| **TRITIUM PLANT** | |
| ***Tokamak Exhaust Processing System*** | 88% |
| ■ Preliminary design contributions continued under IO Task Agreement | |
| **POWER SYSTEMS** | |
| ***Steady State Electrical Network*** | 75% |
| ■ Delivery of power transformers to ITER site (IC milestone) | |
| ■ Delivery of 6.6 kV switchgear to EU-DA | |
| ■ 28 out of 35 planned shipments completed | |
| ■ Contract awarded for fabrication of reactive power compensators | |
| ■ Full contract scope now awarded | |

**Abbreviations** • **ANB** Agreed Notified Body • **CDR** Conceptual Design Review • **DA** Domestic Agency • **FDR** Final Design Review • **I&C** Instrumentation & Control • **IO** ITER Organization • **IC** ITER Council • **FAT** Factory Acceptance Tests • **MIP** Manufacturing & Inspection Plans • **MRR** Manufacturing Readiness Review • **PA** Procurement Arrangement • **PDR** Preliminary Design Review

* Includes Complementary Diagnostic Arrangements.

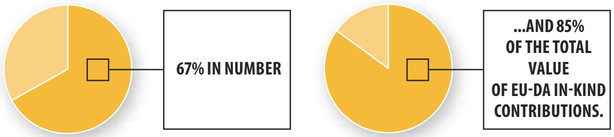
## FUSION FOR ENERGY (EU-DA)

**www.fusionforenergy.europa.eu**




### PROCUREMENT ARRANGEMENTS*

**Thirty-three PAs signed since 2007 representing…**




The EU has awarded 595 research, design or fabrication contracts (89 in 2016) related to ITER procurement to universities, laboratories and industry since 2007.

### EU PROCUREMENT HIGHLIGHTS IN 2016 — % OF ITER SYSTEM PROCURED BY THE EU

**BUILDINGS**

***Building Construction, Tokamak Pit Excavation and Drainage, Ground Support Structure, Seismic Isolation Pads*** — 100%
- Anti-seismic bearings completed in 2012
- Start of B1 civil works in Tokamak Building (IC milestone); two basement levels complete at year end
- Erection of main cranes in Assembly Building (IC milestone); auxiliary cranes also installed
- Work on bioshield reached L1
- Started on L2 level of the Diagnostics Building
- Six water detritiation tanks installed in Tritium Building (IC milestone)
- Progress on Cryoplant, Site Service Building, Cleaning Facility, RF Heating Building, and technical galleries
- Start of work on cooling tower and magnet conversions zones

***Architect Engineer Services*** — 100%
- Construction design submitted for Tokamak Building (L3, L4, L5), Tritium Building, and Diagnostics Building

***ITER Headquarters*** — 53.5%
- Headquarters building completed in 2012

**MAGNET SYSTEMS**

***Toroidal Field Conductor*** — 20.18%
- All conductor unit lengths completed and delivered

***Toroidal Field Magnet Windings (10 out of 19)*** — 53%
- Completion of first toroidal field winding pack (IC milestone)
- 62 of 70 radial plates manufactured
- Series production underway: 62 double pancakes wound; 56 heat treated; 53 transferred to radial plates; 30 impregnated

***Pre-Compression Rings*** — 100%
- Qualification slices manufactured; material room temperature tests initiated
- Backup contract signed for manufacturing route based on alternative technology

***Poloidal Field Conductor*** — 18%
- All conductor unit lengths completed and delivered in 2016

***Poloidal Field Magnets No. 2-6*** — 100%
- On-site facility (PF2-5): contract signed for full fabrication and cold testing process
- Progress in tooling installation and commissioning
- Turn insulation qualification completed
- First-layer dummy double pancake winding completed for PF5
- Qualification activities underway for helium inlets/joints
- Facility in China (PF6): progress in tooling installation and commissioning
- PF6 qualification activities underway (turn insulation/dummy joint)
- PF6 dummy double pancake winding completed

**HEATING & CURRENT DRIVE SYSTEMS**

***Power Supply Heating Neutral Beam*** — 35%
- Site acceptance tests completed for SPIDER ion source power supplies
- FAT completed for MITICA high voltage deck and bushing
- FDR held for MITICA acceleration grid power supplies
- FDR held for MITICA grounded related power supplies

***Neutral Beam Test Facility (NBTF) Components*** — 64.7%
- SPIDER components finalized: vacuum vessel, ion source handling tools, high voltage deck, transmission line
- SPIDER vacuum and gas injection system installed; on-site acceptance tests initiated
- Manufacturing of all main sub-assemblies for MITICA vacuum vessel completed
- Installation of MITICA cooling towers and heat exchangers completed

***Neutral Beam Assembly, Testing, Active Compensation & Correction Coils*** — 100%

***Neutral Beam Source and High Voltage Bushing*** — 41%

***Neutral Beam Pressure Vessel, Magnetic Shielding*** — 100%

***Ion Cyclotron Antenna*** — 60%
- Testing of copper coating on titanium alloy completed
- Testing of Faraday screen mockups completed
- Development of Ti-SS rotary friction welding signed

***Electron Cyclotron Control System*** — 100%
- Framework contract signed for set-up and operation of high power testing facility
- First contracts and Task Orders for facility set-up and I&C development

***Electron Cyclotron High Voltage Power Supply*** — 62%
- FAT start on first power supply unit

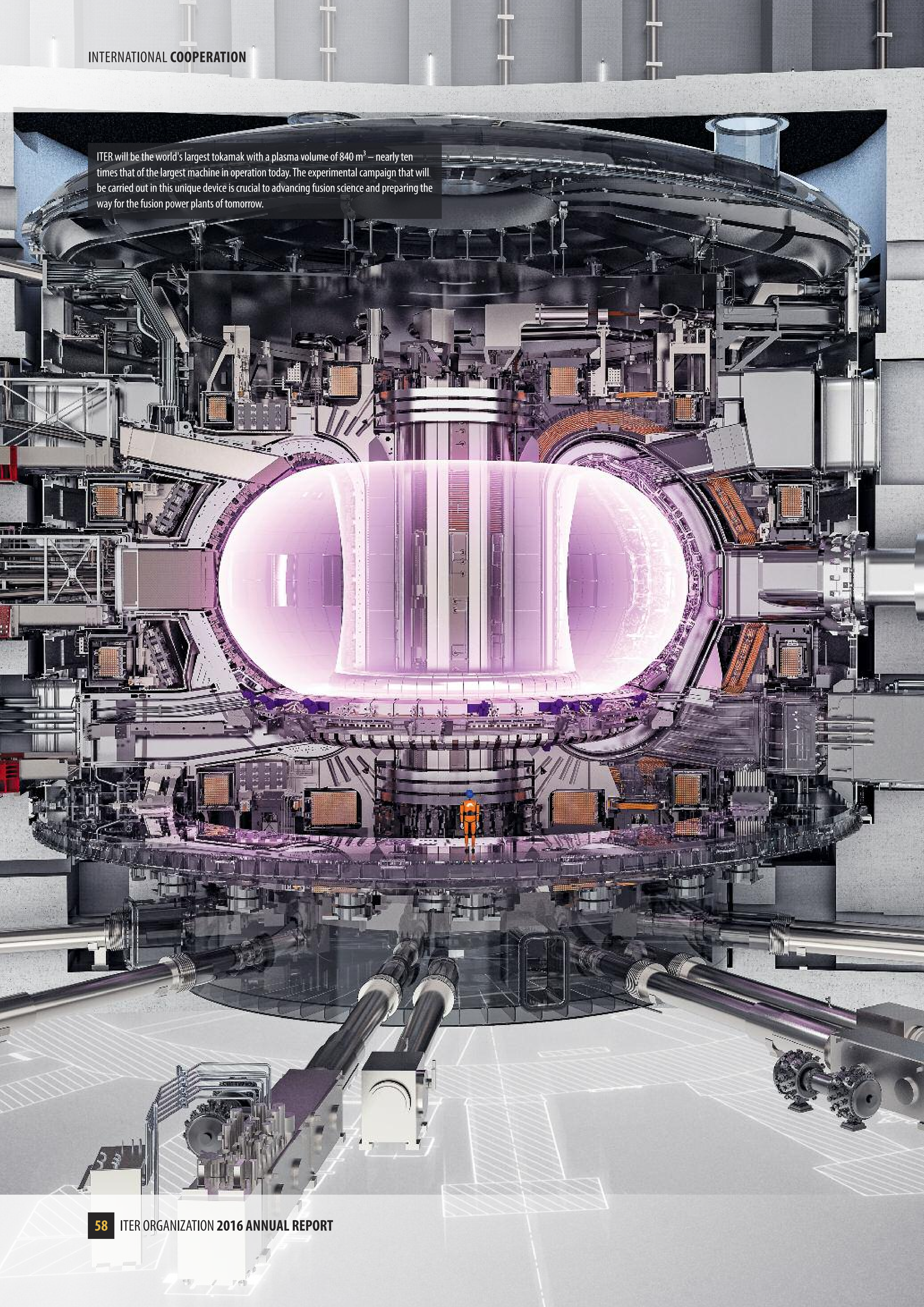
***Electron Cyclotron Upper Launchers*** — 76%
- Prototyping and testing completed: copper cuffs brazed on diamond discs
- Design specification for upper launcher isolation valve prototype completed
- Task Order for conceptual design of upper launcher cooling system signed; intermediate design report delivered

**Abbreviations • ANB** Agreed Notified Body • **CDR** Conceptual Design Review • **DA** Domestic Agency • **FDR** Final Design Review • **I&C** Instrumentation & Control • **IO** ITER Organization • **IC** ITER Council • **FAT** Factory Acceptance Tests • **MIP** Manufacturing & Inspection Plans • **MRR** Manufacturing Readiness Review • **PA** Procurement Arrangement • **PDR** Preliminary Design Review

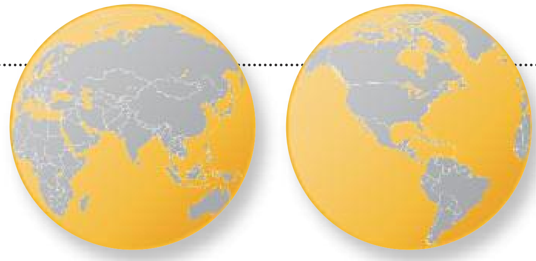
| EU PROCUREMENT HIGHLIGHTS IN 2016 | % OF ITER SYSTEM PROCURED BY THE EU |
|---|---|
| ***Electron Cyclotron Radio Frequency (RF) Power Sources (6 gyrotrons out of 24)*** | *25%* |
| ■ Long-pulse prototype 1 MW gyrotron manufactured and successfully tested in short-pulse regimes | |
| ■ Cryogen-free gyrotron magnet manufactured; FAT completed | |
| **VACUUM VESSEL – MAIN VESSEL (5 OF 9 SEGMENTS)** | **55%** |
| ■ Responsibility for sectors #7 and #8 transferred to IO | |
| ■ Stainless steel forgings produced for sectors 5 (100%); 4 (90%); 3 (46%); 2 (11%); and 9 (5%) | |
| ■ Stainless steel plates produced for sectors 5 (100%); 4 (100%); 3 (100%); 2 (95%); and 9 (90%) | |
| ■ Fabrication initiated for vacuum vessel sector 4 | |
| ■ Consortium central engineering team co-located in Chieti, Italy | |
| ■ Reinforcement of vacuum vessel consortium through an additional main subcontractor, ENSA | |
| **DIVERTOR** | |
| ***Inner Vertical Targets*** | *100%* |
| ■ First stage pre-qualification for additional suppliers completed with successful manufacture and high-heat-flux testing of representative mockups | |
| ***Cassette Body and Assembly*** | *100%* |
| ■ Welding of sub-assemblies and structures completed | |
| ***In-Vessel Divertor Remote Handling Equipment*** | *100%* |
| ***Divertor Rail*** | *100%* |
| **BLANKET** | |
| ***Blanket First Wall*** | *47.4%* |
| ■ Manufacture of two reduced-scale first wall prototypes completed | |
| ■ Successful high-heat-flux testing of two qualification first wall semi-prototypes | |
| ***Blanket Cooling Manifolds*** | *100%* |
| **REMOTE HANDLING** | |
| ***In-Vessel Divertor Remote Handling System*** | *100%* |
| ■ Technology validation tests underway | |
| ■ New design of central cassette validated through fully remote installation at the Divertor Test Platform (DTP2) | |
| ***Cask and Plug Remote Handling System*** | *100%* |
| ■ Contract signed for supply of cask and plug remote handling system | |
| ■ Analysis of existing conceptual design plus requirements and interfaces initiated | |
| ***Neutral Beam Remote Handling System*** | *100%* |
| ■ Preliminary design activities for first priority items started | |
| ***Common technologies*** | *100%* |
| ■ Successful radiation assessment of CMOS-based camera subsystems up to 1 MGy | |
| ■ Design of radiation tolerant front-end ASICs (application-specific integrated circuits) with BISS communication bus started | |
| ■ Stage 1 of development for GENROBOT framework software for equipment controllers | |
| ***In-Vessel Viewing System*** | *100%* |
| ■ Initial scope evaluation signed | |
| ■ Progress in optics, metrology design and R&D completed | |
| **POWER SYSTEMS** | |
| ***Steady State Electrical Network (SSEN) and Pulsed Power Electrical Network (PPEN): Detailed System Engineering Design*** | *100%* |
| ■ Detailed assembly and installation design approved for SSEN and PPEN | |
| ***Engineering Design and Installation*** | *100%* |
| ■ First PPEN transformer installed in its pit | |
| ***Emergency Power Supply*** | *100%* |
| ***SSEN Components*** | *25%* |
| **FUEL CYCLE** | |
| ***Front End Cryo-Distribution: Warm Regeneration Lines*** | *100%* |
| ■ FDR package accepted | |
| ■ Final design of warm regeneration lines approved | |
| ***Front End Cryo-Distribution: Front End Cryopump Distribution*** | *100%* |
| ***Cryopumps, Torus (6) and Cryostat (2)*** | *100%* |
| ***Cryopumps, Neutral Beam*** | *100%* |
| ■ Procurement Arrangement for heating and diagnostic neutral beam system cryopumps signed in June | |
| ***Leak Detection*** | *100%* |
| **TRITIUM PLANT** | |
| ***Water Detritiation System*** | *100%* |
| ■ Six water detritiation system tanks installed in Tritium Building (IC milestone) | |
| ■ Contract signed for holding and feeding water detritiation system tanks | |
| ■ Delivery of preliminary design package to IO | |
| ***Hydrogen Isotope Separation System*** | *100%* |
| **CRYOPLANT** | |
| ***Cryoplant: LN2 Plant and Auxiliary Systems*** | *50%* |
| ■ First liquid nitrogen refrigerator equipment FAT completed (IC milestone) | |
| ■ Quench tanks delivered | |
| **DIAGNOSTICS** | |
| ***Diagnostics*** | *25%* |
| ■ Continuous External Rogowski (CER) coil fabrication completed | |
| ■ Environmental and gamma-irradiation testing completed for 32 optical component types | |
| ■ Call for tender launched for manufacturing design and build-to-print drawings and specifications | |
| ■ System-level design completed for radial neutron camera; prototyping of diamond detectors started | |
| ■ Opto-mechanical layout for wide-angle viewing system produced | |
| ■ System-level design completed for plasma position reflectometer and collective Thomson scattering | |
| ■ Conceptual design of high-resolution neutron spectrometer completed | |
| **RADIOACTIVE MATERIALS** | |
| ***Waste Treatment and Storage*** | *100%* |
| ***Radiological Protection*** | *100%* |

**Abbreviations** • **ANB** Agreed Notified Body • **CDR** Conceptual Design Review • **DA** Domestic Agency • **FDR** Final Design Review • **I&C** Instrumentation & Control • **IO** ITER Organization • **IC** ITER Council • **FAT** Factory Acceptance Tests • **MIP** Manufacturing & Inspection Plans • **MRR** Manufacturing Readiness Review • **PA** Procurement Arrangement • **PDR** Preliminary Design Review

* Includes Complementary Diagnostic Arrangements.



ITER will be the world's largest tokamak with a plasma volume of 840 $m^3$ – nearly ten times that of the largest machine in operation today. The experimental campaign that will be carried out in this unique device is crucial to advancing fusion science and preparing the way for the fusion power plants of tomorrow.



# INTERNATIONAL COOPERATION

The following entities have signed Cooperation Agreements with the ITER Organization as of 31/01/2017.

## INTERNATIONAL ORGANIZATIONS

| | |
|---|---|
| CERN (European Organization for Nuclear Research) | **Switzerland** |
| ERIC (European Spallation Source European Research Infrastructure Consortium) | **Sweden** |
| IAEA (International Atomic Energy Agency) | **Austria** |

## NATIONAL LABORATORIES

| | |
|---|---|
| Commissariat à l'Energie Atomique et aux Energies Alternatives, CEA | **France** |
| Dutch Institute for Fundamental Energy Research, DIFFER | **Netherlands** |
| Forschungszentrum Juelich GmbH, Institut fuer Energi und Klimaforschung, FZJ | **Germany** |
| Institute of Plasma Physics of the Academy of Science of the Czech Republic, IPP-Prague | **Czech Republic** |
| Institute for Plasma Research, IPR | **India** |
| Institute of Plasma Physics Chinese Academy of Sciences, ASIPP | **China** |
| Karlsruhe Institute of Technology, KIT | **Germany** |
| Max-Planck-Institut für Plasmaphysik, IPP | **Germany** |
| National Fusion Research Institute, NFRI | **Korea** |
| National Institute for Fusion Science, NIFS | **Japan** |
| United Kingdom Atomic Energy Authority, UKAEA-CCFE | **United Kingdom** |

## UNIVERSITIES

| | |
|---|---|
| Seoul National University | **Korea** |
| The Eindhoven University of Technology, TU/e | **Netherlands** |
| The National Research Nuclear University (Moscow Engineering Physics Institute MEPhI) | **Russia** |
| Universitad Carlos III de Madrid (UC3M) | **Spain** |
| Université Aix-Marseille | **France** |
| University of Beihang (BUAA) | **China** |
| University of Durham | **United Kingdom** |
| University of Genoa (Department of Electrical, Electronic, Telecommunications Engineering and Naval Architecture, DITEN) | **Italy** |
| University of Ghent (Ughent) | **Belgium** |
| University of Illinois | **United States** |
| University of Keio | **Japan** |
| University of Kyoto | **Japan** |
| University of Liverpool | **United Kingdom** |
| University of Ljubljana | **Slovenia** |
| University of Manchester | **United Kingdom** |
| Universidad Nacional de Educación a distancia (UNED) | **Spain** |
| University of Oxford | **United Kingdom** |
| University of Pisa (Department of Civil and Industrial Engineering) | **Italy** |
| University of Rome-Sapienza | **Italy** |
| University of Tohoku (School of Engineering) | **Japan** |
| University of Science and Technology of China (USTC) | **China** |
| USTC School of Nuclear Science and Technology (SNST) | **China** |
| Università degli studi di Palermo (UNIPA) | **Italy** |
| University of Strathclyde | **United Kingdom** |
| University of York | **United Kingdom** |

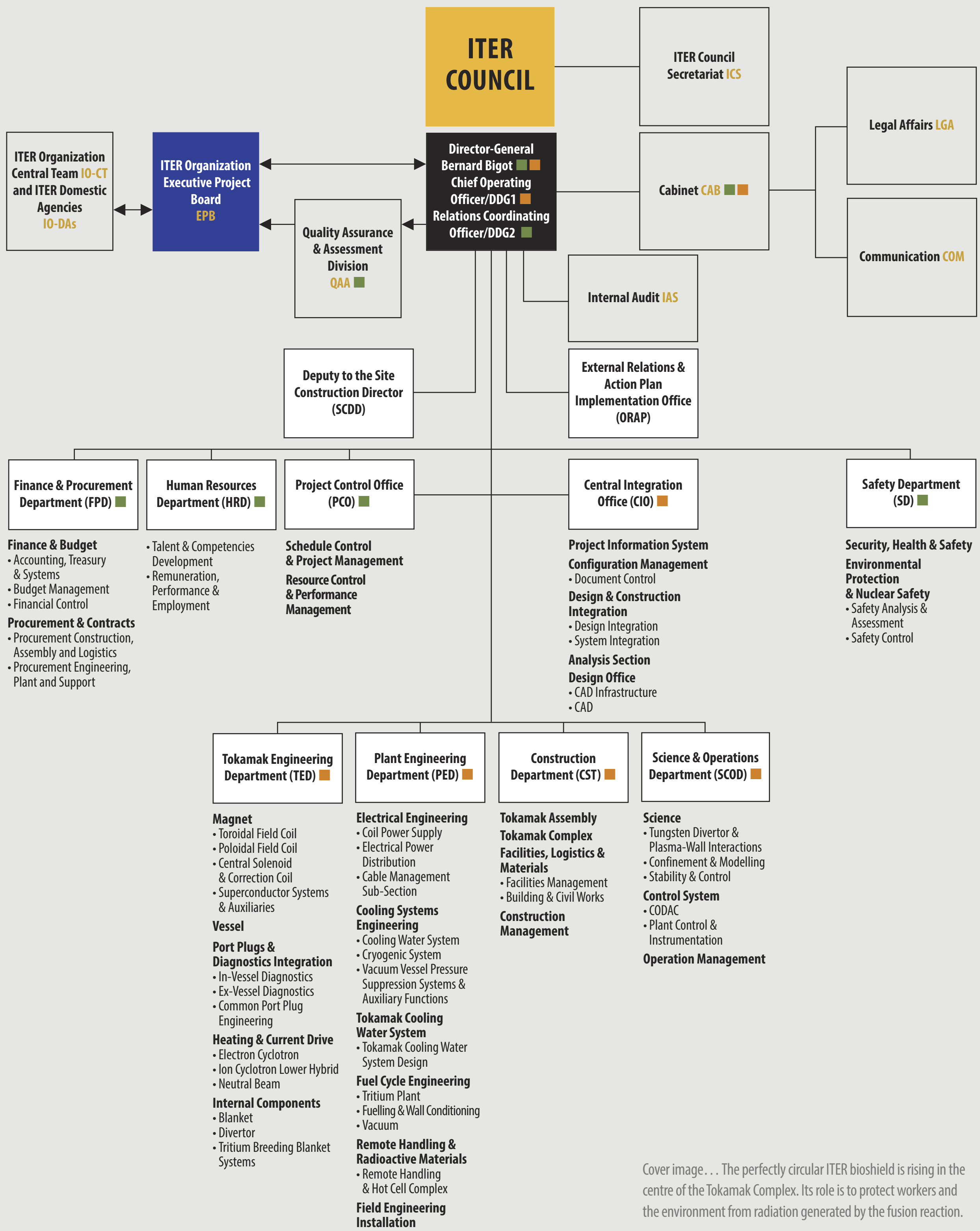
## NATIONAL SCHOOLS

| | |
|---|---|
| Ecole Centrale de Marseille (ECM) | **France** |
| Politecnico di Milano | **Italy** |
| Politecnico di Torino (PoliTo) | **Italy** |
| The Royal Institute of Technology (KTH) | **Sweden** |

## NON-ITER MEMBERS

| | |
|---|---|
| Principality of Monaco | **Monaco** |
| Australian Nuclear Science and Technology Organisation (ANSTO) | **Australia** |

## ITER ORGANIZATION




Cover image… The perfectly circular ITER bioshield is rising in the centre of the Tokamak Complex. Its role is to protect workers and the environment from radiation generated by the fusion reaction.

Towering 60 metres above the construction site, the ITER Assembly Building was equipped in 2016 with its main and auxiliary handling cranes and dressed out in polished steel cladding.

china eu india japan korea russia usa

ITER Organization Headquarters
Route de Vinon-sur-Verdon
CS 90 046
13067 St. Paul-lez-Durance Cedex
France



www.iter.org