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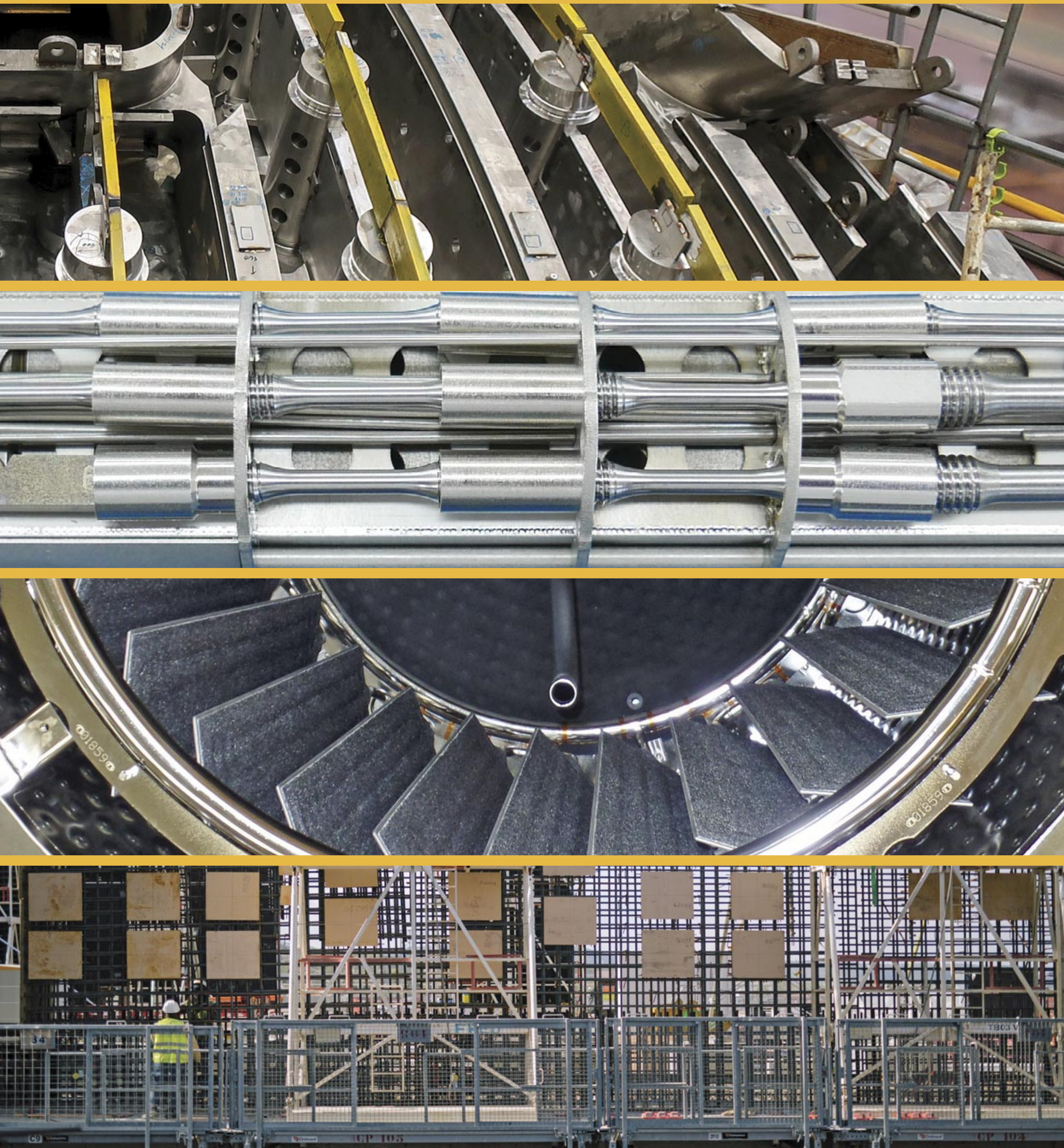
ITER ORGANIZATION 2017 ANNUAL REPORT



The year at a glance

February
- First assembly phase tender launched (early Tokamak Pit works)
- Canadian documentary on fusion and ITER *Let There Be Light* premieres

March
- First transformer "energized" in preparation for connection to French grid
- ITER Business Forum attracts 1,000 participants

April
- Series fabrication begins in on-site Poloidal Field Coils Winding Facility

May
- First Open Doors Day of the year
- ITER Robots competition, sixth edition

June
- 20th ITER Council recognizes strong progress in step with Baseline 2016
- Inauguration of the ITER stand at World's Fair in Astana, Kazakhstan
- Cooperation Agreement signed with Kazakhstan's National Nuclear Center
- Equipment installation begins in the ITER cryoplant

September
- ITER Games: seventh annual
- Two-day media event for international journalists
- Installation starts on first large tool of the Assembly Hall

October
- 750 visitors at ITER's 11th Open Doors Day
- First magnet system component reaches ITER (feeder segment)

November
- 21st ITER Council confirms steady, measurable progress
- ITER is at the United Nations Climate Change Conference (COP23)
- 50% completion milestone on road to First Plasma
- The ITER Organization turns 10

December
- 27 of 29 planned ITER Council milestones achieved since 2016
- First toroidal field coil case passes fitting tests in Japan
- First production unit of the vacuum vessel procurement program (one poloidal segment) achieved in Korea
- Magnet Power Conversion buildings: ready for equipment
- 13,000 people pass through the ITER Visitor Centre in 2017
- 18 highly exceptional convoys travel along the ITER Itinerary in 2017

In the Tokamak Complex, thousands of embedded plates will be used to anchor tanks, piping, cable trays, feeders and diagnostics. Plate density is so high in some areas that it creates the illusion of stars ...

ITER ORGANIZATION
2017 ANNUAL REPORT

From a research organization with just a few dozen employees on site ten years ago, the ITER Organization has evolved into a large and dynamic international community of engineers, scientists, planners and builders focused on realizing and operating the world's largest fusion device.

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The ITER bioshield provides a perfectly circular "well" for machine assembly. The 30-metre-tall structure will be finalized early next year after a two-and-a-half-year effort.

Foreword from the Chair of the ITER Council

I began my term as ITER Council Chair at the beginning of 2016 as the ITER Organization and the Domestic Agencies were finalizing all of the elements of the updated long-term project schedule. This comprehensive baseline schedule, which details all of the steps on the way to achieving Deuterium-Tritium Operation in 2035, was subsequently approved by all ITER Members during the ITER Council's Nineteenth Meeting in November 2016. Today, it forms the basis for oversight work carried out by the Council on ITER Project performance.

Each project actor, within its respective roles and responsibilities, is making every effort to respect the updated Baseline schedule and resource requirements. The Council receives a report every other month on progress against high-level project milestones in addition to a set of highly detailed reports and indicators twice a year in advance of its regular meetings. This meticulous reporting allows the ITER Council – composed of senior representatives from every ITER Member – to fulfil its role as the governing body of the ITER Organization.

Over the course of the last two years the Council has worked to streamline the governance of the project, reducing duplication in the functions of its subsidiary bodies and committees with the aim of avoiding undue burden in the charges made to the ITER Organization and the Members and increasing the overall efficiency of project execution.

At the same time, to keep pace with increasing complexity as ITER moves into the machine assembly phase, the Council has carried out in-depth independent reviews focusing on specific areas of management that are critical to project success. Performed by the Management Advisory Committee (MAC) with involvement of additional experts, these reviews help to validate performance and contribute insight that can be used to the project's advantage, in complement to the biennial Management Assessment mandated by the ITER Agreement. Two in-depth reviews were carried out in 2017 on risk management and the freezing of the design interfaces, and a third is planned next year on configuration management.

As I conclude my term as ITER Council Chair I can only commend the project-wide ITER team under the leadership of the Director-General as well as the ITER Council and its subsidiary bodies for the continuous collaboration and hard work that has contributed to putting the ITER Project on a path to success. Performance is now steady and measurable; substantial gains have been made in effective, efficient decision-making, cost containment, systems engineering, adherence to project commitments, and organizational reform; and improved risk management practices permit the identification and mitigation of challenges in critical path areas. These achievements are founded on the continuous strong commitment of the ITER Members, for which we are all grateful.

In 2017 the project celebrated the tenth anniversary of the implementation of the ITER Agreement and the establishment of the ITER Organization. Before that amount of time comes to pass again, the project will be celebrating First Plasma. You have my best wishes for complete success.

Won Namkung
St. Paul-lez-Durance
July 2018

Creating the many layers of a poloidal field coil is an intricate business. In this facility on site, European contractors are completing the second double pancake for poloidal field coil #5.

Foreword from the Director-General

An intense three-year period of institutional reform is drawing to a close, as measures to implement a clear decision-making process, reduce bureaucracy, strengthen the collaboration between ITER Organization and Domestic Agency teams, develop strong safety and project cultures, and introduce state-of-the-art tools for systems engineering, project control, risk management, and quality assurance have been implemented one after the other.

That the ITER Project is in a stronger position as it heads into the machine assembly phase has been confirmed by a number of external reviews since 2016:

- The report by the ITER Council Independent Review Group (April 2016), which validated the project's schedule as "challenging but technically achievable";
- The US Department of Energy's report to Congress on "U.S. Participation in the ITER Project" (May 2016), which recommended that the United States remain a participant in the project in view of "recent performance" and "improved prospects";
- ITER Council In-Depth Independent Reviews in 2017 validating the ITER Organization's approach to risk analysis and management and to the freezing of design interfaces for First Plasma systems, structures and components;
- A Communication by the European Commission in June 2017 ("EU Contribution to a Reformed ITER Project") expressing confidence that the project was back on track;
- The 2017 ITER Management Assessment conducted by Japan;
- The interim report from the US National Academies of Sciences, Engineering and Medicine on A Strategic Plan for U.S. Burning Plasma Research (December 2017) that concluded that "The only existing project to create a burning plasma at the scale of a power plant is ITER."
- The statement by the European Council of Ministers (April 2018) mandating the Commission to approve the new ITER Baseline;

These conclusions are encouraging with regards to the capacity of the ITER Organization and the Domestic Agencies of the seven ITER Members to build the challenging ITER machine and make it available for the scientific and engineering fusion world community on schedule, on cost and to specification.

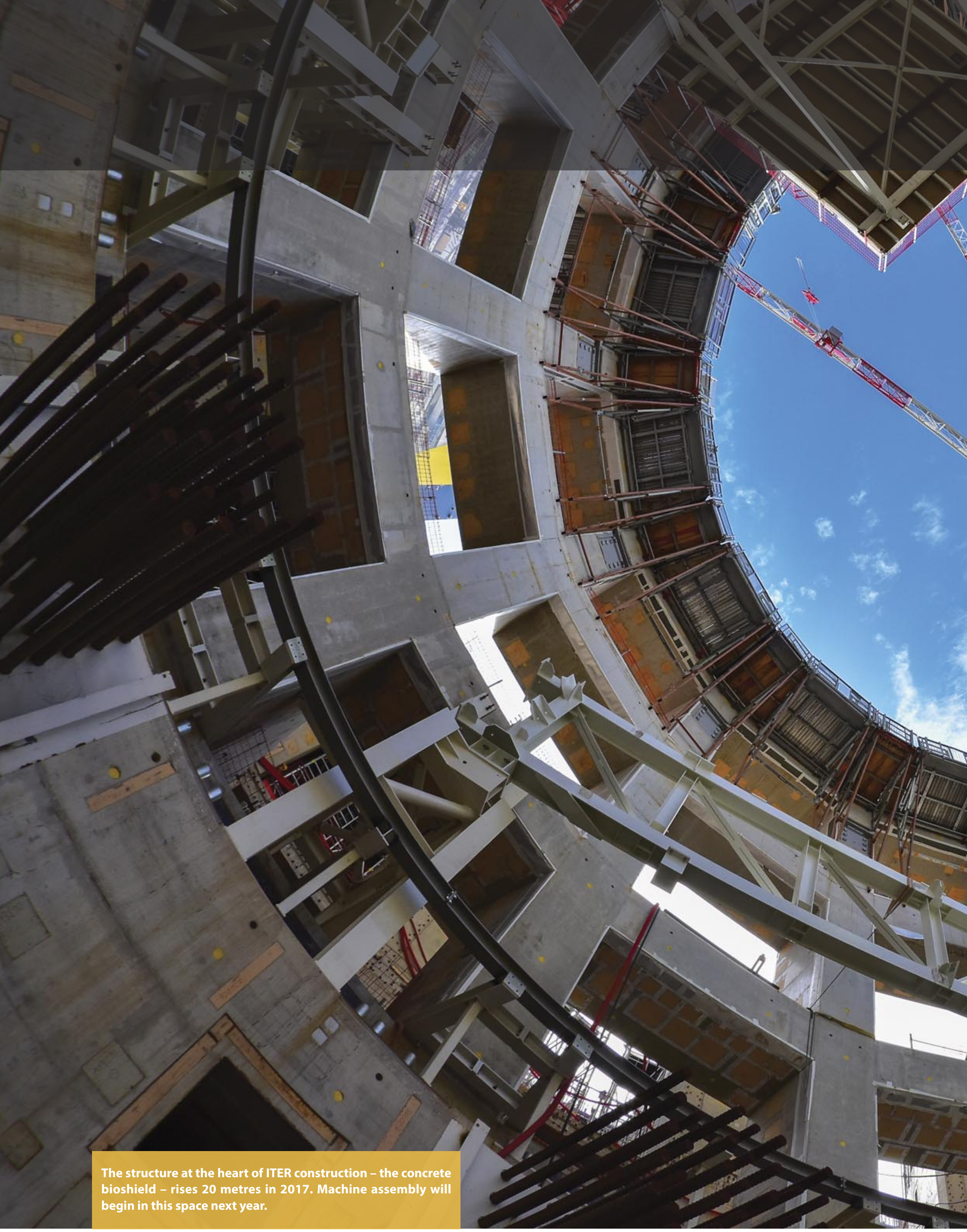
The ITER Project has systems in place that allow us to be proactive in our response to challenges that we foresee as well as agile in our response to new issues as they arise. Our risk identification and risk management practices are now on par with those of other large, complex undertakings; we are implementing industry-grade product lifecycle management; and adherence to the Baseline schedule and cost is tracked monthly. We have proposed a Revised Construction Strategy to the ITER Council, which has been accepted, to mitigate some of the risks already identified by project control tools.

In the upcoming phase of project execution we will see an increased workload for staff related to assembly and installation works on the ITER construction site, as the ITER Organization publishes calls for tender for the principal assembly /installation contracts and plans in detail for systems commissioning. In addition to adjusting and expanding our internal construction organization, direct hires are now supplemented by the ITER Project Associate recruitment scheme that allows institutes from the Members who have signed Memoranda of Understanding with the ITER Organization to send their employees on assignment to the project in specific-need areas.

From a research organization with just a few dozen employees on site ten years ago, the ITER Organization has evolved into a large and dynamic international community of engineers, scientists, planners and builders focused on realizing and preparing for the operation of the world's largest fusion device.

We will continue to strive to maintain the confidence of our stakeholders as we implement the design, manufacturing, construction, delivery, assembly and installation tasks on the road to First Plasma with joint commitment and dedication.

Bernard Bigot
St. Paul-lez-Durance
July 2018



The structure at the heart of ITER construction – the concrete bioshield – rises 20 metres in 2017. Machine assembly will begin in this space next year.

EXECUTIVE SUMMARY

In three years, the Action Plan initiated under ITER Director-General Bernard Bigot has improved the efficiency of technical decision-making, increased the coordination of the ITER Organization and the Domestic Agencies, led to the finalization of system and component designs on the critical path, and created a project culture conducive to delivering on commitments.

A strong sense of ownership and responsibility is being shown by all project participants as the tasks leading to First Plasma in 2025 are executed in factories, laboratories and offices on three continents. The schedule is challenging, but achievable. According to the stringent metrics measuring project performance, the 50 percent completion mark to First Plasma was passed in December and the rhythm is accelerating.

By ratifying the ITER Agreement in November 2007, the representatives of the ITER Members signed into existence "the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project." Member support continues to be crucial today, ten years later, as the countdown to First Plasma begins in the world's largest fusion device.

ORGANIZATION

On track for success

The updated project schedule and overall project cost – Baseline 2016 – is the compass by which the project is managed and controlled. Representing the fastest technically achievable schedule to First Plasma, the Baseline also respects the financial constraints of the ITER Members by planning a four-staged approach, with alternating periods of assembly and operation, up to full Deuterium-Tritium Operation. The Members have agreed to the Baseline 2016 schedule; as a result, the ITER Project is now armed with a detailed roadmap for the manufacturing, testing, delivery, assembly, installation and commissioning of the ITER facility.

ITER management reports every second month to the ITER Council on the schedule performance of the ITER Organization and Domestic Agencies against this Baseline, as well as on progress in the achievement of high-level milestones, the status of key performance indicators, and mitigation strategies for top project risks. For the 2016-2017 period 27 of 29 programmed milestones were effectively completed, with two others postponed without impact to the schedule for achieving First Plasma in 2025.

Transport convoys along the ITER Itinerary are a regular sight in Provence.

All recommendations from the 2015 Management Assessment and the 2016 ITER Council Independent Review Group (ICRG) on the proposed updated long-term schedule have been translated into concrete actions. The external review and validation of project management performance is an ongoing process, however, and in 2017 the ITER Council mandated in-depth independent reviews in two areas that are critical for project control – the management of risks and opportunities, and design interface freezing. In both cases, the reviews validated progress and techniques while also providing suggestions for continued improvement. The Council also convened the 2017 ITER Management Assessment focused on the preparedness of the organization to deliver the project successfully. The results were reported to the ITER Council in November and an action plan in response to recommendations is already underway.

Member representatives convened at the project site for ITER Council meetings on 21-22 June (IC-20) and 15-16 November (IC-21), each time noting that project actors were maintaining strong collaboration and performance. The Management Advisory Committee (MAC) met in advance of each ITER Council session and the Science and Technology Advisory Committee (STAC) met once in 2017 to provide support and informed analysis for strategic issues; in addition, a special video session of the MAC was held in June to focus on key issues and risk and resolution strategies.

BASELINE

Staying the course

At its Nineteenth Meeting (IC-19) in November 2016, the ITER Council approved the updated Level-0 Overall Project Schedule, underpinned by a resource-loaded Master Schedule, through to First Plasma by December 2025 and onward to the start of Deuterium-Tritium Operation by 2035. It approved the Overall Project Cost ad referendum, as individual Members seek approval of project costs through respective governmental budgetary processes.

Through intensive collaboration and coordination the ITER Organization and the Domestic Agencies are executing the project within the schedule and cost of Baseline 2016. Physical progress statistics demonstrate performance stability throughout 2017.

- A large push was made during the year to close out design changes (project change requests) and to freeze the interfaces for First Plasma systems, structures and components – both areas which can negatively impact schedule performance if not managed to the highest standards;
- Significant progress has been made in the ITER Organization /Domestic Agency risk and opportunity management policy and, based on the recommendations of the MAC In-depth Independent Review, further enhancements are underway;
- Project control capacity has matured through a number of state-of-the-art systems. The Master Schedule allows project management to monitor physical progress and compare achievement against planned performance, providing heightened visibility and early warning for issues and opportunities;

- The routine expansion of the original set of monitoring milestones proposed to the ITER Council permits the rolling-wave monitoring of strategic-level achievements;
- Project Team Steering Committees have been created to enhance common best practices among the Project Teams for buildings, the vacuum vessel, and cryogenics;
- The revised Project Management Plan (PMP) and updated Quality Assurance Program (QAP) were both released during the year in support of the project's objective-focused management culture.

Two key issues could affect the on-time achievement of First Plasma: identified delay in the completion of the Tokamak Building and potential delay in the delivery of the vacuum vessel sectors. To mitigate these, the ITER Organization has applied a step-wise approach to determine, from a technical perspective, the manner in which the assembly and installation works under its responsibility can be adapted to maintain the overall schedule envelope. The resulting risk mitigation strategy – the Revised Construction Strategy – proposes tighter coordination, increased parallel activity, and optimized assembly sequencing that, while affecting some pre-agreed ITER Council milestones, will preserve the key dates of torus completion in September 2022, cryostat closure in December 2024 and First Plasma in December 2025.

Specifically, the Revised Construction Strategy brings all installation activities in the critical Tokamak Complex area under the coordination of the ITER Organization, including building services falling under the scope of the European Domestic Agency's TB04* contract for mechanical and electrical installation works. Instead of planning sequential installation activities in the Tokamak Complex – first TB04 building services, and then the installation of machine components and systems by ITER Organization contractors – the transfer of TB04 installation activities to the ITER Organization through the partial novation of the contract allows significant time to be saved by facilitating early access for ITER contractors and allowing the most efficient integrated assembly sequences to be developed to avoid clashes, dismantling and/or rework.

Other provisions in the Revised Construction Strategy call for a sector-by-sector (instead of triplet) approach to the in-pit welding of the vacuum vessel – allowing for more flexibility in the welding sequences and a heightened level of co-activity in the area – and the further transfer of installation scope from the Domestic Agencies to the ITER Organization for highly integrated Tokamak Complex equipment such as cryogenic lines and electrical busbars.

At its meeting in November the ITER Council endorsed this optimized approach to assembly as a way to maintain First Plasma 2025 within the overall schedule and cost of Baseline 2016. The ITER Organization is now pursuing a detailed "bottom-up" analysis of the technical and scheduling proposals (including revised milestones) and finalizing transfer-of-scope agreements for all concerned Domestic Agencies in time for formal consideration and review by the ITER Council in June 2018.

** Tender Batch 04 (TB04) for HVAC, fire protection, liquid and gas utilities, and electrical power distribution.*

A pre-production cryopump is finalized and delivered to ITER in 2017 after a four-year development program in Europe. Six of these pumps will create the ultra-high vacuum that is imperative to initiating plasma in the vacuum vessel.

LICENSING

Safety first

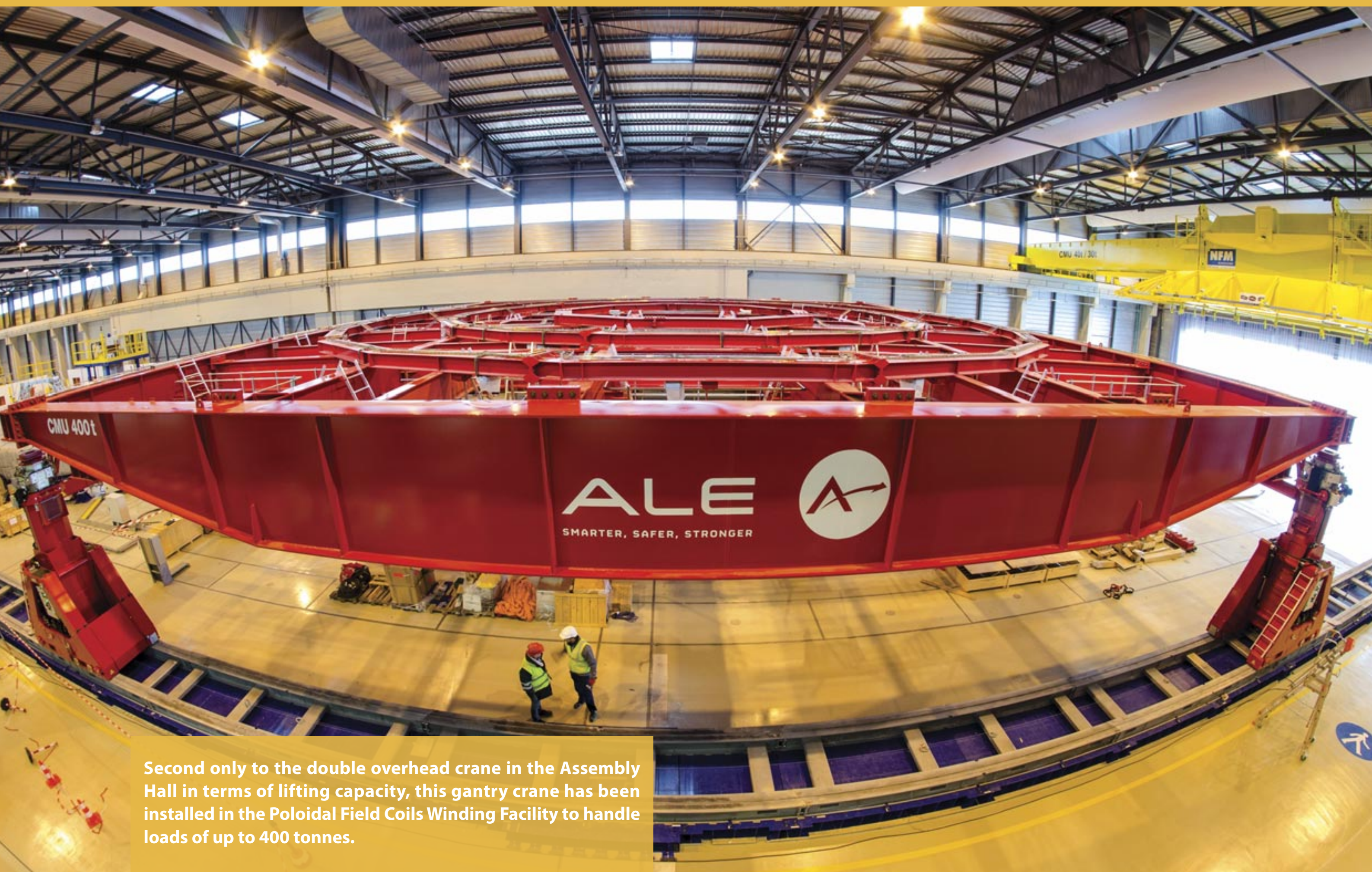
ITER was authorized in 2012 as a Basic Nuclear Installation in France *(Installation Nucléaire de Base, INB)* based on an in-depth technical examination of its design characteristics. Now, the project will have to go through similar regulatory steps to be authorized to assemble the machine, and later to operate.

In 2017 frequent exchanges took place with the French Nuclear Safety Authority (ASN) on the project's staged plan for assembly and operation between 2025 and 2035, an approach that was deemed compatible with the licensing procedure. An update of the preliminary safety report is underway to reflect all changes in the facility's design since the original report was submitted in 2010; before the end of 2019, the ITER Organization must also prepare a detailed safety file to respond to the ASN hold point for the authorization of machine assembly.

ASN performed an inspection in 2017 of the European Domestic Agency's surveillance organization for external contractors, as well as two on-site inspections on building construction. In-house surveillance activities were reinforced during the year in the areas of building construction and the manufacturing of the vacuum vessel, which both fulfil protection-important safety functions. The project's nuclear safety culture is maturing, as the ITER Organization uses workshops and trainings to promote the respect of defined requirements, a collaborative attitude, and correct behaviour. Workshops were organized during the year on the INB Order, nuclear pressure vessel regulations, radiation protection, confinement basic principles, and protection-important activities and components.

Finally, a network has been created to ensure the proper application of European and French pressure equipment (PE) and nuclear pressure equipment (NPE) regulations project-wide. The network will be in charge of advising technical departments, supervising equipment storage, managing requests for exemption, and demonstrating the compliance of ITER pressure equipment such as the cooling water or test blanket system piping with current directives.

ITER's heat rejection infrastructure is under construction now (pictured: the tall columns of the hot basin).



Second only to the double overhead crane in the Assembly Hall in terms of lifting capacity, this gantry crane has been installed in the Poloidal Field Coils Winding Facility to handle loads of up to 400 tonnes.

MANUFACTURING

Readying First Plasma systems and components

As the 2017 reporting period came to an end, the ITER Organization calculated the level of design completion for First Plasma components and systems at 93.9 percent, and the level of construction and manufacturing completion at 55.3 percent based on ITER Unit of Account value credits. Aggregated physical work progress achieved – covering not only design and construction/manufacturing, but also delivery, assembly and installation (total work scope to First Plasma) – is 51.5 percent.

The ITER Domestic Agencies are working to respect project "need dates" for the major components of the upcoming assembly period – the cryostat (India), the vacuum vessel (Europe, Korea, Russia, India), the final magnet assemblies (China, Europe, Japan, Russia, United States), and the thermal shield (Korea) – in accordance with the Revised Construction Strategy. The first major deliveries are expected in 2019, in particular the first toroidal field coil from Japan and the first vacuum vessel sector and corresponding thermal shielding from Korea; these elements will be assembled on the vacuum vessel sector sub-assembly tool beginning in August 2019 in the Assembly Hall. The Vacuum Vessel Project Team Steering Board is closely tracking progress on the vacuum vessel sectors and corresponding in-wall shielding elements (which are inserted between the double walls of the sectors during fabrication) to identify and mitigate any schedule risks.

As manufacturing progresses on all superconducting magnet systems, the first engineering resources have been moved from the technical departments to the Tokamak Assembly Division to prepare for the installation phase. The first magnet element – a feeder component – was delivered in October and other feeder, support and tooling elements are expected soon. Complex toroidal field coil case issues have been resolved through the newly created Superconducting Magnet Coordination Group and the first large-scale coil case fitting trials were successfully conducted late in the year to within gap tolerances of less than a millimetre. The bulk of deliveries for the ITER magnet system are expected over the next three years.

The fabrication of the ITER cryostat is proceeding on schedule in India (segment fabrication) and at ITER (section assembly). Installation activities have started on site for electrical distribution, coil power supply, and the cryoplant. A first-of-series cryopump – the pre-production vacuum cryopump – was received on site in 2017 for testing.

Longer-term development activities are underway for components needed during the second assembly phase. The principal components of the ITER divertor and blanket have reached the full-scale prototyping phase. The tritium breeding blanket program is now in the preliminary design phase, with all ITER Members participating either in the proposed technological solutions, or in R&D activities. Design and development activities are also proceeding according to schedule for remote handling systems and the ITER Hot Cell and Tritium Plant.

R&D

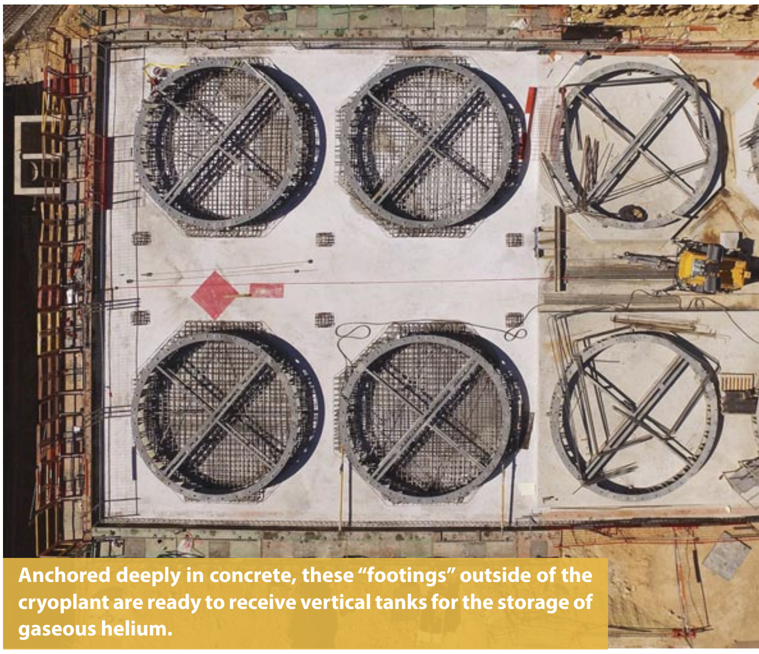
Involving outside experts in system development

R&D in support of the ITER Research Plan is coordinated with the Member science communities through the International Tokamak Physics Activity (ITPA) and the ITER Organization Scientist Fellow network, with particular focus on plasma-wall interactions, confinement and modelling, and stability and control. Experts from the community continue to play an active role in the improvement of integrated modelling capabilities and the infrastructure of the IMAS tool (Integrated Modelling and Analysis Suite), a framework to support the development of sophisticated modelling workflows for ITER.

Experts from the ITER Members are joining the ITER Organization in a task force on disruption mitigation; this machine protection system – triggered automatically as disruptions occur during plasma pulses – is key to ensuring the reliable and successful operation of ITER. Based on plans laid out at a workshop in March, the task force will work to further develop the baseline concept for disruption mitigation (shattered pellet injection) while also exploring alternative approaches.

Through technical cooperation agreements the ITER program is progressing on a number of research fronts, including robotics (with the UK Atomic Energy Authority's RACE facility), Doppler imaging (through the first Implementing Agreement of the ITER-ANSTO Cooperation Agreement with Australia's Nuclear Science and Technology Organisation), and the assembly of magnet components (at the MIFI lab located at the French Alternative Energies and Atomic Energy Commission's Cadarache facility).

Finally, commissioning is set to begin at SPIDER, the negative ion source test bed at the ITER Neutral Beam Test Facility in Padua, Italy. Experience on the operation of this prototype source – as well as on the full injector MITICA (planned in 2022) – will prepare for the installation and operation of the neutral beam heating system at ITER.



Anchored deeply in concrete, these "footings" outside of the cryoplant are ready to receive vertical tanks for the storage of gaseous helium.

The latest figures are in: 128,000 people have visited the ITER site since work began in 2007. This year, 13,000 people passed through the ITER gates.

FINANCE

Managing the budget, seeking cost savings

The annual commitments, payments, and income budgets of the ITER Organization are composed of cash and in-kind procurement activities. In addition to these budgets, a Reserve Fund is maintained to implement design changes necessary to complete the construction of ITER, and an "Undistributed Budget" has been developed in order to mitigate residual cost risks within the ITER Organization.

In 2017 commitments were closely monitored from purchase request through contract signature, and payments, credits, and cash closely tracked, resulting in the effective execution of 90 percent of planned commitments and 83 percent of planned payments during the reporting period.

The final total of commitment appropriations for 2017 was EUR 521.9 million, of which EUR 29.6 million was held in the Reserve Fund and EUR 34.8 million was in Undistributed Budget. During the year, commitments of EUR 409.1 million were made, leaving a balance of unused commitment appropriations for distributed budgets of EUR 48.0 million to be carried forward to 2018. The payment appropriations for 2017 were EUR 532.8 million, including EUR 140.0 million in the Reserve Fund and EUR 46.4 million in Undistributed Budget. Of this amount, EUR 287.8 million was paid or credited, leaving a balance of unused distributed payment appropriations of EUR 58.8 million. Financial income of approximately EUR 0.78 million was earned over the course of the reporting period.

The members of the Financial Audit Board conducted their on-site audits during the year and confirmed that the ITER Organization 2016 Financial Report presented fairly, in all material respects, the financial position of the ITER Organization as of 31 December 2016, its financial performance, and its cash flows for the year in accordance with the International Public Sector Accounting Standards (IPSAS) and the Project Resource Management Regulations (PRMR).

Since 2007 the ITER Organization has signed a total of 110 Procurement Arrangements for the delivery of components, systems and infrastructure with the Domestic Agencies, representing 92.59 percent of the project's in-kind allocated value.

STAFFING

A growing team

The distribution of human resources across the organization continues to evolve, as the project transitions from design to construction. Concerted efforts are also underway to encourage qualified candidates from under-represented Members to join the ITER staffing pool. Recruitment in 2017 was consistent with the ITER Council-approved staff cap, bringing the number of directly hired staff to 825 at the end of the year. Two other non-staff recruitment schemes – Scientist Fellows and ITER Project Associates – help to fill the project's need for specialized talent by allowing experts from the Members' science, technological and industrial communities to contribute to the project. Thirty-seven experts and 35 interns were also employed in 2017.

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 2017 included flexible work time; rewards and recognition, benefits, and expatriation issues. The Staff Committee also undertook to bring issues relating to the Provence-Alpes-Côte d'Azur International School, where 62 percent of the 753 students attending at the start of the school year were from ITER families, to appropriate forums for discussion.

EXTERNAL RELATIONS

Widening the ITER circle

Following an agreement with Australia in 2016, the ITER Organization signed the second non-Member technical Cooperation Agreement of its history in June 2017 with the National Nuclear Center of the Republic of Kazakhstan. The Agreement opens the way to the exchange of technical experts, access to Kazakhstan's research reactors for materials testing, and the development of diagnostics for ITER.

The ITER Organization also signed Memoranda of Understanding for technical, scientific or academic cooperation with the University of Bologna and the University of Rome (Italy); the University of Kyushu (Japan); the University of Peter the Great St. Petersburg Polytech (Russia); Columbia University and the University of California, Los Angeles (United States). A full list of cooperating entities can be found at the end of this report.

The ITER Project was represented at a number of external events, including the United Nations Climate Conference (COP-23) in Bonn, Germany, and the 27th IEEE Symposium on Fusion Engineering (SOFE 2017) in Shanghai, China. A 110-square-metre exhibition on ITER was also present for three months at the 2017 World's Fair in Astana, Kazakhstan, to present the potential of fusion energy to the public through a series of multimedia tools, models, and displays. Thirteen thousand people visited the ITER site in 2017.

2017 CONSTRUCTION UPDATE

Members of the public are introduced to the complexity of ITER during an Open Doors Day event in October.

BUILDINGS

Just over 40% complete

Ten years after preparatory work began on the project site in southern France, the construction of ITER buildings is progressing through contracts issued by the European Domestic Agency for specific work packages. In July, the halfway point was reached in the largest civil works contract – TB03 – for the construction of the Tokamak Complex and eight other buildings.

Counting all the structures, infrastructure and technical areas needed for facility start-up in 2025, work is just over 40 percent complete. Two more years will be necessary to finish the Tokamak Building and ensure overhead crane availability for the major lifts of the machine assembly phase (target date: March 2020). Partial access, however, will be possible in 2018 for the first component integration activities in the basement.

The skyline of the Tokamak Complex evolved considerably in 2017 as the walls of the Tritium, Tokamak and Diagnostic buildings rose to L1, L2 and L3 levels respectively. Large openings visible in the northern wall of the structure correspond to the elevator shaft for the cask and plug robotic system that will ferry components needing refurbishment or replacement to the Hot Cell. In December pouring was underway for the second-to-last concrete segment of the circular bioshield, nearly completing this six-level, 30-metre-tall structure that has been under construction since 2015.

Inside the bioshield, contractors have begun to place the complex rebar arrangements for the radial walls of the cryostat crown, which will support the cryostat from below. Because the rebar-to-concrete ratio in this area is the densest of ITER construction, a constructability study is underway in the form of full-scale mockup on the worksite that reproduces a 20-degree crown segment plus two radial walls. Eighteen spherical bearings for the cryostat crown have entered industrial production and are on schedule for delivery next year.

Early access to the Assembly Hall was granted to the ITER Organization in August for installation activities related to the vacuum vessel sector sub-assembly tools; by the end of the year the floor anchoring system and the first segments had been installed. Full load testing was successfully completed for the 50-tonne and 750-tonne overhead cranes in 2017 and the smaller cranes (plus the facility's large doors) are now under the responsibility of the Facilities, Logistics & Materials Division. European contractors working under the TB04 mechanical and electrical works contract were also active in the building, providing good practice in large-scale co-activity for the different actors of the ITER Organization and European construction management teams.

Structural work ended on the ITER cryoplant in 2017 and 5,400 m^2 of covered buildings were turned over to the ITER Organization. Three helium cold boxes and 18 compressor units plus auxiliary equipment were installed under the coordination of ITER's Construction Management-as-Agent contractor, and preparations are underway to prepare for the positioning of 11 large gas/liquid storage tanks in the open-air storage area. The twin buildings for magnet power conversion also advanced significantly as the main structures were completed and the first transformer units were placed on foundations adjacent to the buildings.

Cooling pipe installation began in the Site Services Building, before the works were suspended to allow for the finalization of the civil structures designed to support the chillers and pumping systems. Strong progress was also recorded in the cooling tower zone to the north of the construction site, where the concrete basins were completed, contractors installed the first lengths of piping, platform-level structures are emerging, and equipment has started to arrive from India. In 2017 European contractors also completed the cladding of the Radio Frequency Heating Building, finalized technical galleries near the switchyard, and constructed buildings for AC current distribution

After recuperating the heat generated by the machine, cooling water will be transferred to the heat rejection zone (pictured) where it will be cooled using an evaporative process.

In July, the halfway point is reached in the largest civil works contract issued by the European Domestic Agency – TB03, for the construction of the Tokamak Complex and eight other buildings.

and reactive power compensation. The first 22 kV transformer of the steady-state electrical network was energized temporarily as part of preparations for the first use of power from the French grid.

MACHINE AND PLANT ASSEMBLY

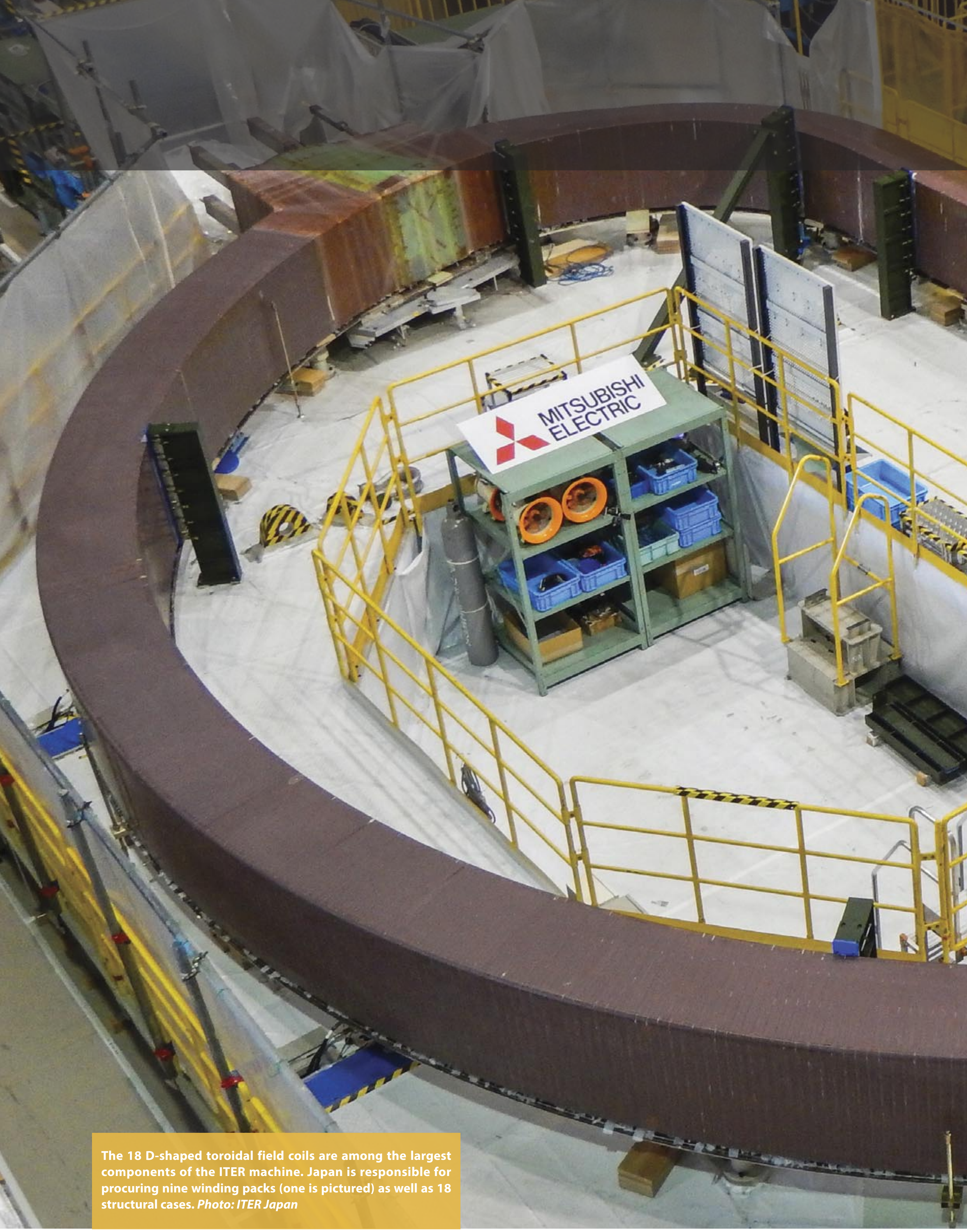
Plant installation works underway

Once the buildings are completed, the ITER Organization has overall responsibility for the successful integration and assembly of components delivered to the ITER site by the seven Domestic Agencies. The actual work of the assembly phase will be carried out primarily by ITER Organization contractors (and for some plant installation works, by Domestic Agency contractors). Work will be tendered out by the ITER Organization in nine main contracts. The first plant installation activities were launched this year on the ITER platform based on contracts awarded for early installation services in the site service, cryoplant, magnet power conversion, and reactive power compensation buildings.

In 2016 the ITER Organization selected a Construction Management-as-Agent (CMA) to support construction activities related to assembly and installation. Following an initial six-month preparation period the CMA contract has entered its first implementation phase covering early plant installation works and the start of Tokamak Assembly (February 2017 to August 2020). CMA team resources are currently distributed between four main work areas:

- Work preparation: the elaboration of the construction work packages to be issued to contractors (or bidders during calls for tender) and the assessment of contractor installation work packages;
- Work supervision: the quality control of work performed on site by ITER Organization contractors and the verification of compliance with engineering and quality requirements;
- Site and work coordination (performed in close relation with the European Domestic Agency Architect Engineer teams): the organization of the work at site level, materials management, coordination of radiological tests, and other transverse activities;
- Construction project management and control: acting as FIDIC engineer for ITER Organization contracts; performing tasks to support the ITER Organization in cost, schedule and risk management; documentation control; transverse missions such as quality assurance and nuclear safety; and the management of the CMA contract and team. The CMA is also involved in calls for tender launched by the ITER Organization for future works contractors and in improving the way the engineering input data is handed over to construction teams.

The fine-tuning of the ITER construction management oversight organization continues to ensure that all parties – the work contractors, the Construction Management-as-Agent, and ITER Organization technical departments – plan activities in a coordinated manner.



The 18 D-shaped toroidal field coils are among the largest components of the ITER machine. Japan is responsible for procuring nine winding packs (one is pictured) as well as 18 structural cases. *Photo: ITER Japan*

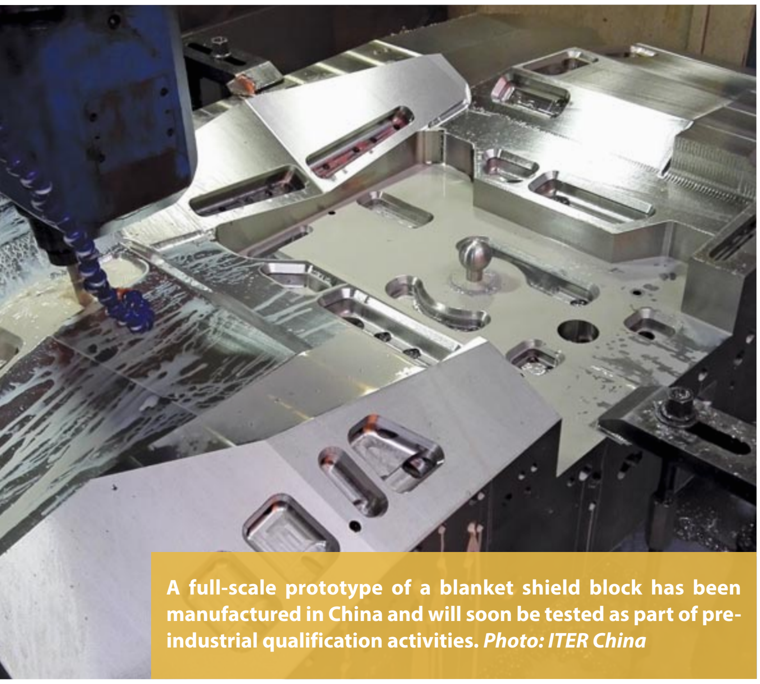
2017 HIGHLIGHTS
BY DEPARTMENT

Project Control Office (PCO)

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

As the focus of ITER Organization activity shifts increasingly from in-kind deliverable management to on-site assembly and installation, the Project Control Office is expanding the support it provides to construction.

In 2017, a dedicated unit was created for construction project control; schedulers and project control managers were allocated to each of the matrixed construction teams; support was provided to identify the type and format of engineering data needed to enhance the content of different construction management tools; and project control methods, processes and tools were shared with the Construction Management & Coordination Team (CMC) for propagation. Project-control mechanisms employed by the Construction Management-as-Agent have also been successfully integrated with those of the ITER Organization.



A full-scale prototype of a blanket shield block has been manufactured in China and will soon be tested as part of pre-industrial qualification activities. *Photo: ITER China*

Project performance was monitored against the ITER-Council-approved Baseline 2016 to First Plasma. The principal schedule control tool – the top-level Master Schedule – is now under performance baseline configuration control, signifying that any change is subject to formal change control processes. By tracking the physical progress of ongoing work packages, the Master Schedule has proven to be a robust basis for status reporting and "percent complete" statistics. These figures, as well as performance against a set of high-level construction/manufacturing and programmatic milestones, are reported every two months to the ITER Council. In the coming year, the Office plans to finalize the overall Master Schedule for commissioning activities and to secure savings for risk mitigation by further improving work rate efficiency.

Efforts to develop a risk response strategy for risks already identified – notably the completion of the Tokamak Building/services and the delivery of major components including the vacuum vessel sectors and the toroidal field coils – have resulted in the development of a Revised Construction Strategy that was proposed by ITER management to the Council in November. The approach was endorsed; now, the robustness of this revised strategy – which maintains the 2025 First Plasma date by optimizing machine assembly and the installation sequences of associated services – will be examined by the ITER Council in June 2018. The Project Control Office is closely involved in developing the detailed schedule, risk analysis and cost evaluations that underpin this recovery strategy.

An independent review by Management Advisory Committee experts in April confirmed that the management of risks and opportunities continues to mature through the strong collab-

Behind the lit offices of ITER Headquarters, where just over 800 employees are based, the scientific installation is rising.

oration and engagement of ITER Organization and Domestic Agency staff. The project now has a systematic and regular approach to the identification of risks, a structure for analyzing and monitoring risks, and agreement on the top risks facing the project. The Project Risk & Opportunity Management Committee (PROMC) working group is in charge of implementing continual improvement actions; in 2018, the group plans to enhance management competencies within the team in this area, improve risk and opportunity governance project-wide, and hone measurement and reporting tools.

A full suite of reporting mechanisms has now been deployed by the Project Control Office.

- Key performance indicators (KPIs) are used monthly to provide a comprehensive overview of project progress, for example measuring work progress compared to plan; milestone execution; the management of non-conformities; and trends for budget, staffing, and health and safety;
- Earned value management (EVM) has been fully established within the ITER Organization and is now operational against the Master Schedule;
- The original set of monitoring milestones proposed to the ITER Council is expanded routinely to permit the rolling-wave monitoring of strategic-level achievements. In addition, key and major milestones have been introduced to mark the achievement of system deliverables and key phases required to meet First Plasma operational needs;
- Centralized systems now permit information related to key milestones, key performance indicators, and earned value management to be escalated for decision making;
- The Project Management Plan – which encapsulates the quality management system for project control – was released in 2017.

The first project control training modules were launched in 2016 and expanded this year to accompany the organization-wide use of these tools; others are to be rolled out in 2018 and 2019. In addition, the Office has launched the concept development for an ITER Academy – an in-house training program that will provide competency certification for project management skills.

The updated project schedule and overall project cost – Baseline 2016 – is the compass by which the project is managed and controlled.

Central Integration Office

The Central Integration Office (CIO) guarantees the overall configuration of the project and supports the Director-General in his responsibility as design authority, project integrator and nuclear operator. Under its umbrella it groups the transverse 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; codes and standards; nuclear and engineering analysis; and documentation and records.

Configuration Management

An intensive effort is underway to re-establish the technical baseline for the staged approach under proper configuration management. The effort includes not only enhancing the present baseline structure, but also implementing proper requirements management and product lifecycle management (PLM), and identifying any technical issues that may impact configuration. During the latter half of 2018, an ITER Council in-depth independent review will be carried out on the configuration management and change control of all baseline elements.

New procedures for planning, status accounting, and audit and control have been introduced to tighten configuration management. The number of far-reaching design change requests has dropped off significantly, and the legacy issues that remain are being addressed and closed out through the Configuration Control Board process. Third and fourth versions of the Matrix platform – the ITER Organization's PLM system – were introduced in 2017; now, all functionalities relating to design changes and the management of different plant configurations under the staged approach are usable. In an important achievement for the project, the "product" and "geographical" breakdown structures of the new baseline have been uploaded and can be managed in configuration using PLM functionalities. A global strategy on uploading technical information to the PLM tool was developed in strong coordination with the Document Control Section and circulated to technical responsible officers.

In 2017 the project celebrates the tenth anniversary of the implementation of the ITER Agreement and the establishment of the ITER Organization.

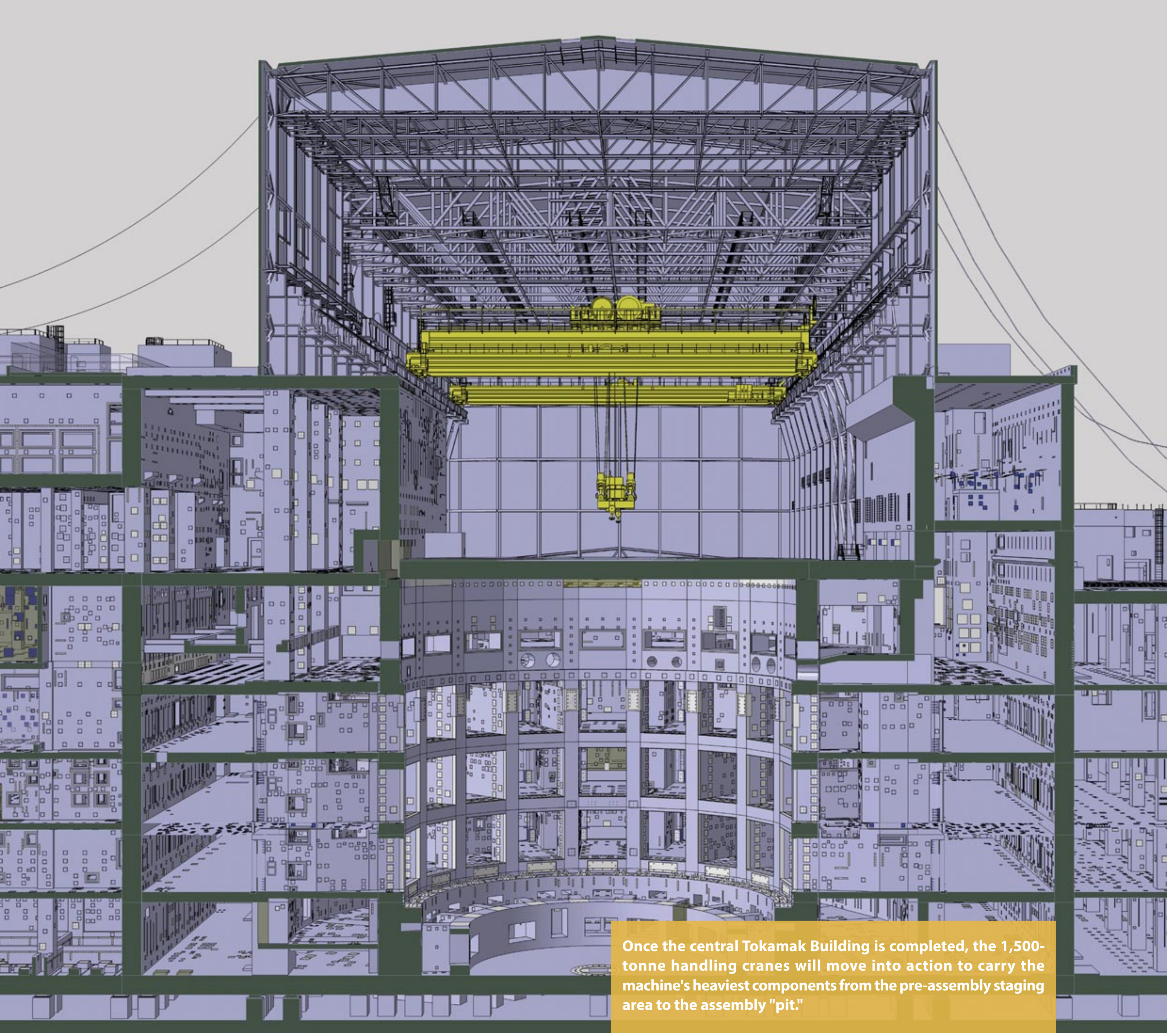
The Configuration Management Division also oversees the project's issue management process, ensuring that technical issues are quickly assessed, assigned for resolution, and tracked in a dedicated database. As part of a comprehensive management plan introduced during the year, weekly meetings were initiated to monitor transverse issues all the way through to resolution. Quality control was similarly strengthened: procedures for design reviews, manufacturing readiness reviews, and inspection and test procedures were harmonized with the Domestic Agencies; additional quality control engineers joined the team; and a global framework contract was signed for quality control inspections at all ITER production sites.

Finally, in 2017 Configuration Management continued its qualification program on protection-important activities, extending it from the Project Teams to apply to all concerned ITER Organization staff.

Design & Construction Integration

Through a systematic systems engineering approach, the Design & Construction Integration Division works to minimize the risk of system non-compliance with high-level functions and requirements. The team is now closely matrixed to the Construction Department in order to provide support for the preparation of work packages, assembly tooling, the resolution of interface issues, and the final integration of plant systems. As-built configurations are closely assessed and managed in conjunction with the construction teams and the providing parties to avoid deviation from baseline nominal tolerances.

Freezing the design through the clear definition of physical and functional interfaces is one of the most urgent tasks

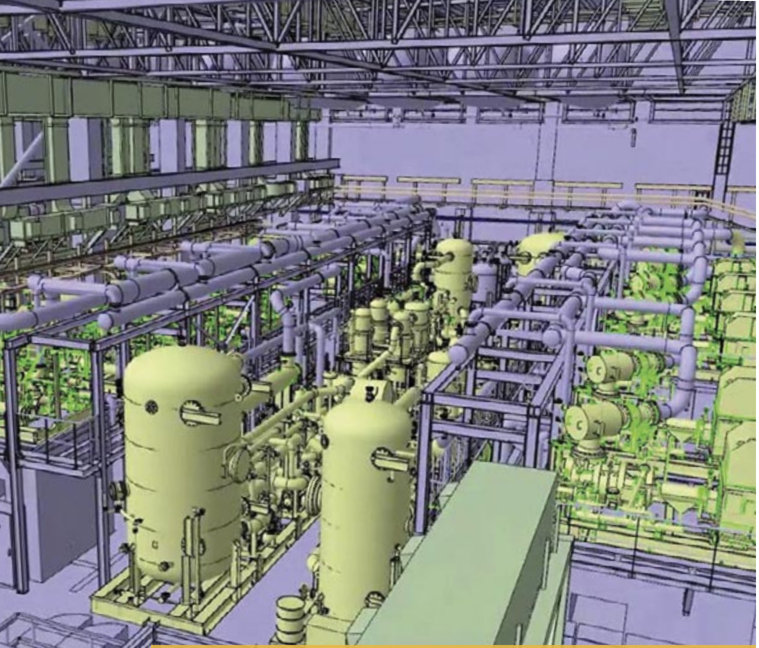


Once the central Tokamak Building is completed, the 1,500-tonne handling cranes will move into action to carry the machine's heaviest components from the pre-assembly staging area to the assembly "pit."

as the project advances to the installation phase. In 2017, the Division supported system owners in the resolution of outstanding issues, introduced an interface management database, and advanced the baselining of critical interface sheets for early need systems. By the end of the year most of the interface sheets for First Plasma systems under the responsibility of the United States were under configuration control and the work was being pursued with all other Domestic Agencies. In September, a Council-mandated in-depth review on interface freezing resulted in ten recommendations for the consolidation of interface control project-wide; to respond to these, the CIO Department is implementing an action plan.

Integrated functional analysis and functional/physical design integration reviews are used to control the compliance of systems with their expected functionalities, their integration into the machine or buildings, and technical and safety requirements. In 2017, the Division supported machine and Tokamak Pit integration by aiding in the resolution of issues related to permanent rails in port cells, Tokamak cooling water, thermal shield design, and penetration sealing; prepared drawings for the Tokamak assembly contracts; and increased the availability of the virtual reality platform used by systems and construction teams. As-designed critical gap drawings and functional tolerance drawings are in progress and will be ready next year for integration into the baseline. Finally, a transverse working group has been established to coordinate the management of the as-built configuration as works progress. The goal is to create reverse engineering as-built models based on metrology data, providing as-built information of the Tokamak machine and buildings in a centralized way and assessing the compliance of as-built systems with machine and plant system dimensional requirements.

Team members completed the integration design of Tokamak Complex concrete civil works in 2017, including the integration of all plant systems and the definition of building



A view of the equipment planned for the cryoplant. The first installation activities begin in June.

interfaces with openings and embedded plates up to the roof. The configuration management model, construction design and execution design for the civil works have been approved and integration reviews were organized to identify and resolve major interference issues with the building services that will be installed by European Domestic Agency contractors under the TB04 contract. A critical activity in 2018 will be the approval of the construction designs for building services at the lower levels. Design & Construction Integration continues to follow transverse issues affecting buildings such as radiation shielding, and to issue studies and design proposals. For auxiliary buildings, 2017 marked the start of a final cycle of system integration activities based on the as-built data for completed structures. Design reviews were held for the cryolines, and installation works began on site according to several "ready for equipment" milestones. All 3D models used for the design and integration of auxiliary buildings were updated to reflect the four-phase staged approach to assembly.

The systems engineering team performed integrated functional analysis in support of the technical baseline's staged approach, updated the high-level Project Requirements document to reconcile the propagation of requirements to the system level, and participated strongly in the effort to freeze design interfaces. A project is underway to harmonize requirements management and verification practices with the European Domestic Agency, based on its experience. Plans are also in development to support the design and/or operation of several ITER systems through integrated simulation analysis.

The ITER Domestic Agencies are working to respect project "need dates" for the major components of the upcoming assembly period – the cryostat, the vacuum vessel, the final magnet assemblies, and the thermal shield.

Information Technology

Information Technology manages computer services for 2,000 users – administering databases and networks, telecommunications, and the project's internal and external websites; handling requests (21,000 tickets) and incidents; and customizing information applications. The demand continuously grows as new users and new buildings require equipment; in 2017 close to 1,000 computers were installed. The group manages IT purchases for the ITER Organization as well as central applications and infrastructure (servers and storage), aiming for the highest availability (above 99 percent). Service enhancements are an important part of each reporting period – in 2017 nearly 300 projects were carried out to provide new solutions or enhance existing functionalities. Custom or off-the-shelf solutions are regularly provided for activities related to finance, human resources, communication, engineering, construction, and information systems for ITER management. A CAD replication site was also established at the Australian Nuclear Science and Technology Organisation (ANSTO) to allow for joint diagnostics development work under the ITER Organization-ANSTO Cooperation Agreement.

The Division is closely supporting the roll-out of ITER's product lifecycle management (PLM) tool through its testing and production phases. Adapting the SmartPlant® software for materials management and construction to better correlate the different applications to ITER's needs and providing training to users is also a regular activity. IT developed a database for the centralization of non-conformance reports related to early installation works and implemented an electronic permit system in support of on-site work. Cyber security remains a focus for the IT team – based on the conclusions of a security audit in 2017, an ambitious roadmap has been defined for the next four years. As part of this, security events are now monitored second-by-second and centralized for analysis.

Design Office

The Design Office Division administers the project's computer-aided design (CAD) infrastructure in close collaboration with Information Technology. In 2017 the Division executed the year's full CAD work plan, in particular producing thousands of schematics and drawings in support of construction call-for-tenders and the preliminary engineering and construction work packages. Industrial technical plateaus (containing schematics, drawings, mechanical and plant designs) continue to be developed to assist technical teams with respect to tight schedule milestones for critical components. The Division also initiated improvements in the areas of CAD quality, multi-CAD use, schematics, mass-production tools, and documentation to keep pace with evolving needs as the project enters the assembly and installation phase. Preliminary investigations have been launched for 4D analysis tools.

High CAD platform availability was maintained in 2017 for 650 ITER Organization and Domestic Agency users. The Division treated requests for support and tickets for data exchanges between users, while continuing to monitor outsourced work packages, CAD earned value measurements, and key performance indicators to ensure the efficiency and quality of the work. Team members provided support for the deployment and administration of the AVEVA plant design suite as well as the Matrix tool for product lifecycle management (PLM). In close collaboration with the technical and construction departments, a pilot has been launched for the implementation of proper component and part tagging – important elements for materials and warehouse management. A workshop was hosted in December to bring users together to improve collaboration in the area of construction support, component tagging and the harmonization of fabrication-to-delivery engineering data.

Analysis

The Analysis Section/Division carries out project-level structural, seismic, nuclear and electromagnetic analysis to contribute to the design of systems; flags integration and interface issues; and informs the qualification of equipment. Since 2007, 268 system load specification reports have been prepared and uploaded to ITER's document management platform, including 42 this year. Continuous support is provided for the structural analysis of the assembly tools as well as the definition of interface loads between buildings and equipment; a check on the consistency of the as-built configuration will be performed following any change and re-confirmed at the end of building construction.

The conclusions of an independent review of the Tokamak Complex civil structure have generated confidence in the global design and structural analysis done up to this point due to the consistency of results. A specific tool was developed for the verification of reinforced concrete; the Division also carried out structural analyses on the strength of embedded plates, anchorage in the port and bellows areas, cable tray supports and, more generally, in support of project design reviews. Another major area of activity – the thermal-hydraulic analysis of the vacuum vessel – is advancing through the evaluation of specific areas (neutral beam cells, port cell interspaces) using computational fluid dynamics. Work is also underway with the Science Division on the definition of loads related to machine movements during vertical displacement or disruption events.

Technical support was provided in 2017 for the propagation of seismic loads and criteria following the updating last year of design floor response spectra for the Tokamak Complex and subsequent impact assessment. Solutions were found for all issues, with only a limited number resulting in project change requests. An integrated seismic analysis model (building and machine) will be completed in 2018. New Management and Quality Program instructions have been uploaded to support quality control in the areas of both structural and seismic analysis.

A handbook on electrical, electronic, and electromechanical nuclear radiation compatibility was introduced in 2017 with the support of systems owners and the Domestic Agencies. Its conclusions on appropriate countermeasures against radiation, including the relocation of some electronics, had been largely anticipated, and the situation can be considered much improved. Most of the shielded areas of the Tokamak Building are now suitable for all electronics, and a number of Domestic Agencies are advancing radiation-hard solutions for specific applications.

This high-voltage rack has been supplied by India to the Neutral Beam Test Facility in Italy, where ITER's neutral beam injection technology will be tested in advance of operation. ***Photo: ITER India***

Through the Nuclear Integration Unit, the Analysis Section/Division is driving joint ITER Organization/Domestic Agency activities related to the improvement of radiation mapping in the Tokamak Complex – input that is important to the qualification of electronics. New radiation maps were released for the neutral beam cells, Tokamak Building maintenance operations, in-vessel remote handling, and the Assembly Hall during plasma operations, and a standardization strategy is being promoted for radiation-hard electronics. A new model of the ITER Tokamak (the C-model) was released and those for the toroidal and poloidal field coils were updated. Input data was compiled for the evaluation of worker radiation exposure during maintenance, and software was chosen for ITER contamination studies. A major focus for the Nuclear Integration Unit going forward will be to provide design solutions compatible with the guiding principle for radiation safety – "as low as reasonably achievable."

The electromagnetic team has responsibility for the preparation and management of the general models for electro-magnetic (EM) analysis – in 2017, procedures were developed and approved, disruption simulation input data updated, and the latest model versions distributed in-house and to the Domestic Agencies. Analysis activities were also carried out on the performance assessment of ferromagnetic shielded housing; the effect of rebar orientation in relation to stray fields; poloidal field coil transient voltages; and vertical displacement event loads (including asymmetric). Several agreements were reached for experiments on operational devices to inform the ITER model, and simulation activities are underway at ITER.

The Analysis Section/Division is contributing to the implementation of common codes and standards, and to the propagation of ITER materials requirements through support for materials procurement and fabrication, welding, corrosion analysis, non-destructive examination, and other testing.

Quality Assurance & Assessment Division (QAA)

The Quality Assurance & Assessment Division's objectives are to specify project quality requirements, perform independent assessments and audits on compliance with these requirements, and coordinate the integrated management system through the Management and Quality Program (MQP). 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.

To ensure that ITER activities are performed at a level of quality appropriate to achieving the safety and performance objectives of the project, ITER maintains and implements an overall Management and Quality Program (MQP). In 2017, the two highest-level MQP documents – the Project Management Plan and the Quality Assurance Program – were approved through the joint work of the Division, a specially created MQP Working Group, and the Domestic Agencies. The continuous evaluation and improvement of the MQP documents on all levels are a regular part of annual activities, including simplification to reduce duplication, conflict or inconsistency and to make the documents more user-friendly.

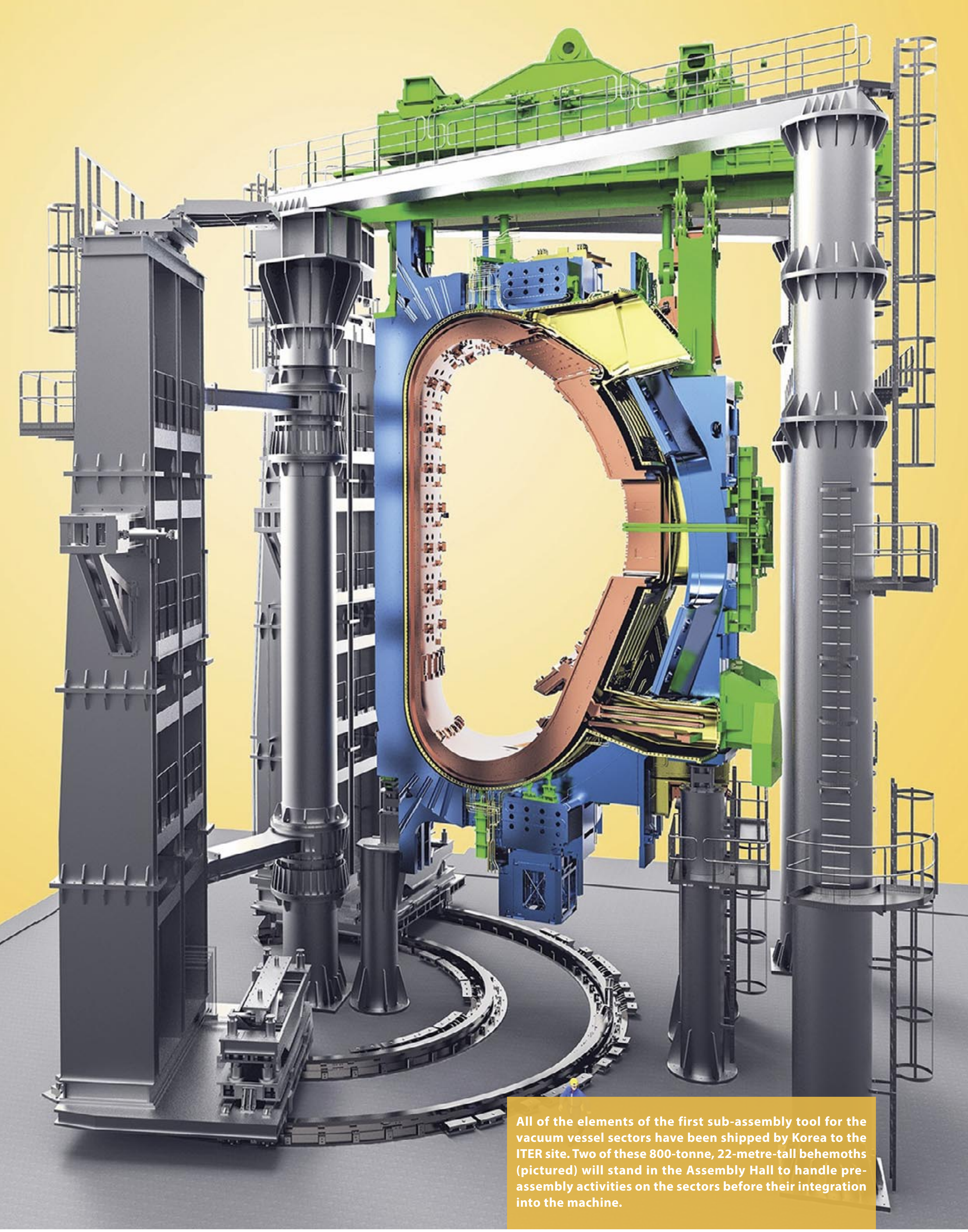
A two-month pilot was run during the year to test ITER's new database for non-conformities, with positive results. Quality Assurance & Assessment is pursuing the implementation of this management tool, which will be fully operational by end 2018; until then, temporary measures are being employed to track non-conformities and alert responsible parties in order to reduce the average time from detection to closure.

During the reporting period, the Quality Assurance & Assessment Division verified the effective implementation of the ITER Organization quality assurance program through 7 quality audits at the Domestic Agencies, 15 supplier/subcontractor quality audits covering 14 Procurement Arrangements, and 5 internal quality audits. Based on the resulting quality audit reports, improvements and adjustments were obtained in the areas of supplier evaluation; quality audit capabilities; the correct application of manufacturing inspection plans and contractual requirements; and improvements in processes, document management and non-conformity declarations. A new process-oriented approach for internal audits is being implemented in replacement of the organizational-unit-based approach of the past. Further actions to improve the quality management systems of suppliers and subcontractors will be implemented in strict accordance with applicable ITER Organization procedures.

> The ITER Organization will be publishing major calls for tender for the installation of the machine and Tokamak Complex systems.

Quality responsible officers supported process owners and systems teams in ensuring that quality procedures are correctly established – a necessary precursor to the correct propagation of safety and technical requirements at all levels of the project. The Division is also developing training activities for auditor qualification for early 2018. In order to ensure a common approach on quality audit activities, Quality Assurance & Assessment is planning to invite Domestic Agency representatives to participate in the audit of other Domestic Agencies alongside the ITER Organization. It is hoped that these "cross audits" will bolster strong connections and transparency as well as reinforce the effectiveness and independence of the audit process. A joint audit program was agreed during the year between the ITER Organization and all Domestic Agencies.

The Safety and Quality Assurance Working Group (SQAWG) is the channel for communication and discussion between the ITER Organization and Domestic Agencies with regard to safety and quality concerns. Safety and quality responsible officers meet regularly in this forum to share information on requirements and design conformity, supervision planning and inspections, procurement quality requirements, the mechanism for managing non-conformities, and other safety and quality issues.



All of the elements of the first sub-assembly tool for the vacuum vessel sectors have been shipped by Korea to the ITER site. Two of these 800-tonne, 22-metre-tall behemoths (pictured) will stand in the Assembly Hall to handle pre-assembly activities on the sectors before their integration into the machine.

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.

The staged approach strategy planned for ITER assembly was the object of continued exchange between the Environmental Protection & Nuclear Safety Division and France's Nuclear Safety Authority (ASN) in 2017, as the detailed implications of the approach were examined in relation to the ITER licensing process. Although the precise calendar of regulatory steps (such as safety demonstrations, regulatory inspections, and hold points) remains to be established, the ASN reiterated at a hearing in April that the approach is compatible with licensing. In this context, the technical safety prescriptions have been modified to separate the authorization for the assembly of tokamak equipment inside the cryostat from later-stage systems (test blanket modules, detritiation system, hot cell design …). Also underway is an update of the preliminary safety report taking into account all the changes in the facility's design, which must be sent to the Regulator before First Plasma.

The Environmental Protection & Nuclear Safety Division is also responsible for the surveillance of external interveners – including the Domestic Agencies, who are providing protection-important equipment to the project – as well as the control of protection-important activities. Surveillance activities have been reinforced, with particular focus on nuclear buildings and the vacuum vessel. The Division also analyzes the deviation requests and non-conformities of all protection-important components – in 2017, the closure rate for non-conformities increased considerably.

Surveillance activities have been reinforced, with particular focus on nuclear buildings and the vacuum vessel.

The Division is leading the implementation of a pressure equipment and nuclear pressure equipment (PE/NPE) network to ensure the proper application of European and French PE/NPE regulation project-wide, as well as the follow-up, control and inspection of pressure equipment. The network will manage requests for exemption, supervise equipment storage conditions, advise technical departments in their interactions with the Agreed Notified Body, and organize trainings for relevant staff. The network is also charged with putting into place a quality organization to demonstrate the compliance of equipment manufactured under ITER Organization responsibility (such as Tokamak cooling water or test blanket system piping) with European Pressure Directive Module H.

As part of regular activities, team members provided integration support to design owners, reviewed requirement documents, performed calculations in support of design choices, and assessed construction contracts to support tendering. Many technical meetings took place with the Regulator on instrumentation and control, electrical supply, and modifications to the layout of the vacuum vessel pressure suppression and Tokamak cooling water systems. ASN performed three inspections in 2017 – an unscheduled inspection in May on building construction, a three-day inspection at the European Domestic Agency in August to verify the surveillance organization put in place for external contractors, and an inspection on building construction in October. No significant issues were identified during these inspections.

Finally, the appropriation of ITER's robust safety culture by the entire chain of external interveners, including Domestic Agencies, remains a top priority. The respect of defined requirements, a collaborative and questioning attitude, and

Well over 3,000 people work at the site of the ITER Project in southern France, including ITER Organization staff, the European Domestic Agency buildings team, and ITER and Domestic Agency contractors. The appropriation of a robust safety culture by all actors remains a top priority for the Safety Department.

the efficient conversion of principles to actual behaviour is encouraged through surveillance activities, workshops and trainings – the objective being to limit bureaucracy while improving the efficacy of surveillance. The procedure for the proper propagation of safety requirements was updated in 2017, and a workshop was organized to promote a safety culture for the installation phase.

The Safety Department's 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 occupational 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 and another, to track health and safety indicators, will be put in place in 2018. The physical protection plan of the ITER site was also approved by French authorities.

The Division manages general emergency procedures on site, 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 design, procurement, acceptance, installation, commissioning, and operation of all core tokamak systems fall under the charge of the Tokamak Engineering Department. Scope includes the blanket, divertor, vacuum vessel, cryostat, thermal shields, magnets, in-vessel coils, port plugs and diagnostics, heating and current drive, system instrumentation and the test blanket module program. 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.

Divertor

From its position at the bottom of the machine the divertor faces the highest steady-state heat load of all ITER components. Each of the 54 divertor assemblies comprises a main cassette body and plasma-facing targets armoured in tungsten (the dome and inner and outer vertical targets). The divertor will be installed in the machine after First Plasma and replaced at least once during the lifetime of ITER.

Procurement activities are currently focused on material qualification tasks, the manufacturing of full-scale prototypes, and the design of the operational instrumentation. This year:

- Two full-scale cassette body prototypes successfully passed hot helium leak testing in Europe;
- New vacuum furnaces were commissioned in Russia for the post-weld heat treatment and baking of the divertor dome and blanket first wall panels;
- The tendering phase for the full-scale outer vertical targets is ready for launch in Japan now that financial questions related to the tungsten divertor strategy have been resolved;
- In Europe, four suppliers have been qualified for the fabrication of full-scale inner vertical target prototypes following an initial test campaign on small-scale mockups;
- The conceptual design review for operational instrumentation has been closed out, and optical sensors and feedthrough prototypes manufactured and tested successfully.

A transfer of scope was confirmed in 2017 for the divertor integration activities that had formerly been assigned to the European Domestic Agency. The integration of more than 20 items per cassette (including plasma-facing components and diagnostics) will now be managed directly by the ITER Organization to facilitate the management of interfaces. The first integration activities are planned on prototype cassette bodies in 2021.

Within the framework of a Cooperation Agreement signed in June with Kazakhstan, the Divertor Division is planning a series of irradiation tests on operational instrumentation; this plan will be formalized in an Implementing Agreement next year.

Closer to ITER, six plasma-facing units with ITER-relevant designs and technology have been installed for testing on the WEST tokamak at CEA Cadarache. The experimental results from this campaign will contribute to the ITER tungsten divertor development program.

Blanket

The 440 blanket modules on the interior of the vacuum vessel provide a plasma-facing surface that is compatible with the heat loads expected in ITER. Each module is composed of a plasma-facing first wall panel with beryllium armour and a thick steel shield block that is attached to the vacuum vessel.

Qualification programs to prepare for the manufacturing of the first wall are well underway in Europe – responsible for the procurement of 215 normal heat flux panels – and in Russia and China, which are sharing the procurement of 225 high heat flux panels. Highlights for the reporting period include the:

- Successful testing of four beryllium-tiled first wall "fingers" and a semi-prototype panel in Russia;
- Completion of the semi-prototype pre-qualification program (including high heat flux testing) in China;
- Development of three full-scale prototypes in Europe by suppliers who had been pre-qualified through prior R&D (testing of materials and bonding techniques, manufacturing of semi-scale prototypes);
- On-schedule procurement of the blanket connections (flexible supports, key pads and electrical straps) in Russia;

Korean manufacturers finalize the first segment of vacuum vessel sector #6 in December. As the first production unit of the procurement program, it represents a major milestone.

- Start of final design activities on the set of protection components that will temporarily stand in for the blanket during the First Plasma operation phase;
- Signature in September of the last Procurement Arrangement of the first wall program – with the European Domestic Agency for the normal heat flux panels.

For the shield blocks, China has completed its first full-scale prototype and the final qualification step – the hot helium leak test – will be carried out next year in a specialized vacuum chamber. In Korea, material procurement has been initiated for all shield blocks and sub-components, three of four planned contracts for fabrication and testing have been signed, and work is underway on a full-scale prototype. The design of the blanket manifold system, which feeds cooling water to the different blanket modules, is going through a final optimization exercise in Europe to prepare for the signature of the Procurement Arrangement.

In June, the Beryllium Management Committee – responsible for the safe storage, handling and use of beryllium – organized a three-day workshop at ITER to learn from the experience of the Domestic Agencies, international organizations, beryllium suppliers and manufacturers, and major users. A number of options were reviewed in 2017 for the implementation of a beryllium storage/work facility on site.

Test Blanket Modules

Six mockups of tritium breeding blankets, called test blanket modules (TBMs), will be tested on ITER in dedicated ports facing the plasma. TBM Leaders China, Europe (for two systems), India, Japan and Korea are developing technological solutions, while Russia and the US are supporting the TBM program through specific R&D.

A major programmatic milestone was achieved during the year as the conceptual design review for the sixth and final test blanket system – the lithium lead ceramic breeder proposed by India – was concluded. All test blanket systems have now entered the preliminary design phase, with reviews planned from 2019 to 2022. In addition to the breeding modules themselves, development is underway on ancillary systems for cooling, tritium extraction, coolant purification, and instrumentation and control. A set of maintenance tools and equipment is also planned as part of the infrastructure required to host the TBM program on ITER.

The final design of the TBM connection pipes – the first components expected at ITER – is advancing through outside contract under ITER Organization supervision. Progress was made in 2017 on the design of dummy TBM sets (to be used during the replacement of one or more modules); system analysis (power supply needs/tritium permeation from the helium coolant pipes); and the validation of metallic sealing gaskets through collaboration with ITER vacuum team experts.

Data has been collected from the Members relative to the safety demonstration of the test blanket program as requested by the French Nuclear Safety Authority (ASN); this information can now be transmitted on time. The working group on radwaste management continues to meet annually to address questions relating to project dismantlement and the management of radioactive waste, and to prepare for the signature of trilateral agreements (TBM Leaders/ITER Organization/Host state) on these issues. Finally, a TBM Project Team has been launched for implementation in 2018; this instance – created to accelerate decision making and improve the efficiency of joint activities – replaces the TBM Program Committee.

Vacuum Vessel

The fabrication of the ITER vacuum vessel is advancing under the responsibility of the Domestic Agencies of Korea (four main sectors, equatorial ports, lower ports and gravity supports), Europe (five main sectors), Russia (upper ports), and India (in-wall shielding), while the ITER Organization is procuring in-service inspection tools, lower penetrations and port shielding, sealing flanges and instrumentation directly. Within the Vacuum Vessel Project Team, regular remote and in-person meetings allow all actors to share experience in manufacturing, collaborate on the resolution of non-conformance issues, review documents, and monitor performance against schedule milestones. In-shop teams were introduced in 2017 to improve follow-up on issues encountered in the fabrication of first-of-series units.

Industrial activities are accelerating and the first 440-tonne sector (#6) is expected to be completed in 2019 in Korea. Among the milestones achieved this year:

- Korea celebrated the completion of the first segment of the vacuum vessel manufacturing program – inboard segment PS1 for sector #6. The achieved tolerances (+/-4.0 millimetres) were well within ITER Organization requirements;
- Europe finalized the first sub-segment assembly for sector #5;
- Russia shipped the first port stub extension to Korea for upper port #12 after all pressure, baking and leak tightness tests were performed successfully. Eight other upper port stub extensions are now in production;
- The ITER Organization issued a contract for instrumentation and launched four of the five calls for tender to procure in-service inspection tools;
- Nine lower port stub extensions are on track for finalization in Korea in the 2018/2019 timeframe;
- At the end of 2017 the first sectors required at ITER – sectors #6 and #5, in that order – were respectively 77.5 and 47 percent complete.

In Europe, the performance of the vacuum vessel manufacturing consortium was strengthened through the reinforcement of project coordination, four additional subcontractors, and concerted efforts by suppliers; however, to match schedule milestones, the production rate must continue to improve. The rate of in-wall shielding manufacturing in India is also tracked closely, as these shielding blocks must be received by the vacuum vessel manufacturers for integration into the sectors on schedule. The ITER Organization has introduced a number of measures to support the Indian Domestic Agency in the mitigation of this schedule risk – including an incentive agreement proposed to the main supplier to prioritize the shipments needed for the first sectors, re-cleaning activities on the blocks already delivered (mainly for sectors #6 and #5) in order to meet ITER specifications, and the procurement of material for spare-sector in-wall shielding as a precautionary measure. In December, India issued letters of intent to alternative suppliers.

In planning for the reception, pre-assembly and assembly of the vacuum vessel sectors, the ITER Organization has introduced a new approach to sector welding as part of the Revised Construction Strategy, modelled after a technique that was employed successfully during the assembly of the KSTAR tokamak in Korea. Instead of welding the nine sectors in triplets as originally planned, the modified field strategy prioritizes the sequential welding of the outer walls, while allowing additional time for inner-wall welds. Efforts are underway to incorporate the previous R&D design assessments into the new technical specifications.

Cryostat

The assembly of the ITER cryostat is progressing in an on-site workshop under the responsibility of the Indian Domestic Agency. Indian procurement scope includes the fabrication, assembly, welding and testing of four major sections (the base, lower cylinder, upper cylinder and top lid) as well as in-pit installation and welding.

Contractors concluded assembly activities on tier one of the cryostat base in October and made good progress on the second tier, which comprises a pedestal and a rim. The twelve segments of the lower cylinder were delivered in 2017 and installed on the facility's second assembly frame, where welding activities are underway; activities on this 10-metre-tall section should conclude during the third quarter of 2018. To make space for the assembly of the next section – the upper cylinder – the completed lower cylinder will be moved out of the workshop and stored on the platform in an airtight "cocoon" with a regulated atmosphere. The ITER Organization concluded a contract for this temporary housing in November. In India, the fabrication of the upper cylinder segments is nearly completed and teams are ready to begin on the top lid after the validation of a mockup in late 2017.

Milestones were also recorded in the procurement of cryostat subsystems such as the torus cryopump housings, for which the design was frozen, and the cryostat rectangular bellows, which will be contracted out to industry early next year.

Thermal Shield

The thermal shield, actively cooled at 80 K, will be installed between the vacuum vessel and the cryostat to reduce the heat loads on the magnets during operation. Specific challenges in the manufacturing of this system include tight fabrication tolerances, high leak tightness requirements, and the coating in silver – to high quality standards – of nearly 600 thermal shield parts.

Korea will deliver the thermal shield to ITER in six batches between 2018 and 2020. Fabrication is proceeding on schedule: the thermal shield for the vacuum vessel is 50 percent complete and final machining is underway on the first delivery sector; sub-assembly tests on the lower cryostat thermal shield cylinder are progressing; manufacturing activities have begun on the support thermal shield; and the qualification of the silver coating process will conclude next year.

Port Plugs & Diagnostics Integration

The diagnostic systems planned on ITER will cover a wide range of the electromagnetic spectrum in order to provide important feedback for the control of the plasma, a strong understanding of plasma physics during operation, and key

This elbow-shaped feeder segment produced in China is the first completed magnet component to reach ITER. Next year, it will be the first machine component to be installed in the basement of the Tokamak Building.

information for machine protection. While a huge number of diagnostics are situated along the wall of the vessel, many others will be situated in port plugs for a direct view of the plasma; these customized plugs also provide housing for other systems such as fuelling and disruption mitigation. The complexity of port plug integration, the large number of interfaces with other components, and the involvement of all seven Domestic Agencies in the supply of diagnostics makes coordination in this area especially critical. The ITER Organization and the Domestic Agencies are forming a team to coordinate this work in 2018 and many Domestic Agency colleagues are arriving on site to progress the work under the ITER Project Associate scheme.

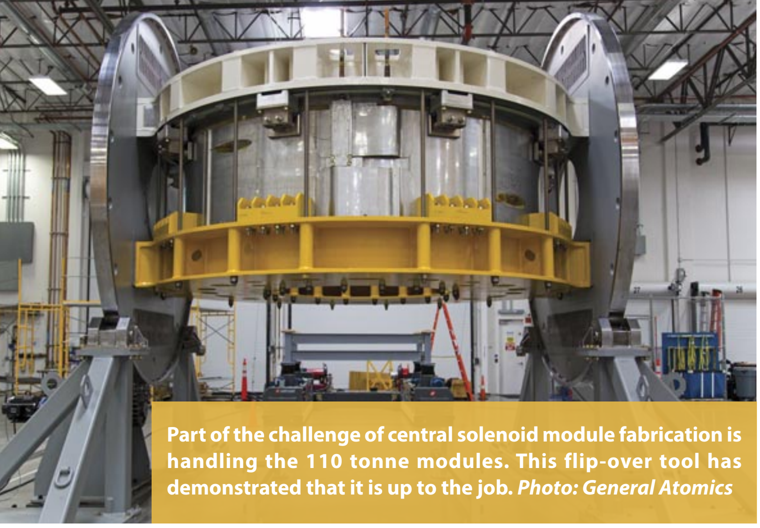
Port plug structures are in fabrication now and will be assembled and tested by the supplier over the next three years. Manufacturing is also progressing on several of the First Plasma diagnostic systems, including the outer vessel coils, flux loops, steady state sensors, and the neutron flux monitor for equatorial port 7. The first system to pass site acceptance tests at ITER – CER coils from Europe – can now be shipped to Japan for integration on three of the toroidal field coils. Preliminary design reviews were held in 2017 for the First Plasma port plugs, equatorial ports 11 and 12, and upper port 18. Seven Complementary Diagnostic Procurement Arrangements were signed with Europe during the year, including five for port plug integration.

A proxy of ITER's metallic first mirror was removed from the JET torus in April after two years in the vessel and the first results on particle deposition were quite encouraging for ITER. The final design review for the first batch of fused silica-based window assemblies is expected in 2018. Concepts for water and electrical feedthroughs are being advanced both at the ITER Organization and in the Domestic Agencies to comply with safety requirements and to fulfil need dates for port integration. Mockups and trials are also being executed for the diagnostic first walls to address manufacturability. A concept is under development for the diagnostic shield modules – the component of the port plug assembly that must maximize shielding capabilities while staying within imposed weight limits. Under the first Implementing Agreement of the ITER Organization Cooperation Agreement with the Australian Nuclear Science and Technology Organisation (ANSTO), joint work is underway on the design of a Doppler imaging diagnostic for ITER. Finally, planned experimentation on an electron cyclotron emission (ECE) diagnostic installed in 2017 on an ITER India test lab will provide valuable input for the design ECE diagnostics in general.

In order to prepare for installation activities, supportive engineering analysis has been executed and analyzed to address thermal stresses for diagnostics that are welded to the vacuum vessel; ex-vessel diagnostic supports are under development to fulfil systems' needs and to comply with the construction schedule; and First Plasma interfaces have been finalized to comply with project deadlines. Mitigation plans are underway for First Plasma diagnostic systems expected from the US Domestic Agency in the case that funding issues perturb the planned execution of this specific development program.

Heating & Current Drive

The workhorse of ITER's external heating systems is neutral beam injection. Two neutral beam injectors will deliver a total of 33 MW of heating power to the ITER plasma and a space reservation has been made for a third if needed; in addition, a smaller diagnostic neutral beam will be installed on ITER to probe the helium ash content in the plasma core region. A decision has been made to transfer the responsibility for the final design of some of the neutral beam cell components (vessels, front-end components, passive magnetic shielding, coils) from the European Domestic Agency to the ITER neutral beam team, in order to facilitate the general integration of heating and diagnostic neutral beam components at ITER.



Part of the challenge of central solenoid module fabrication is handling the 110 tonne modules. This flip-over tool has demonstrated that it is up to the job. ***Photo: General Atomics***

Because the unprecedented size of ITER imposes enhanced requirements, a neutral beam injection development program has been implemented to validate concepts before the system is required on site. R&D will be carried out at the PRIMA Neutral Beam Test Facility in Padua, Italy, where test beds of the ion source (SPIDER) and the full-scale injector (MITICA) will provide proof-of-concept testing for components designed for ITER.

The beam source for SPIDER was delivered to the PRIMA facility in October and tested successfully, effectively completing a long list of deliveries from Europe (vacuum vessel, high voltage deck, gas and vacuum system, beam source) and India (beam dump, 100 kV power supply) to this full-size negative ion source test bed. Commissioning will begin on schedule in March 2018. For MITICA, the installation of the last high voltage power supply component from Japan – the high voltage bushing – was the occasion for an on-site celebration in Padua in November. In Europe, three potential suppliers are preparing manufacturing designs for the MITICA beam source, and the procurement of this critical element will be launched in 2018. Negotiations are underway to develop the agreement(s) that will govern the management structure and funding of the PRIMA facility throughout its operational phase up to 2030.

At the Max Planck Institute for Plasma Physics in Garching, Germany, technological solutions are tested in advance of PRIMA on the half-size negative ion source ELISE. In 2017 ELISE produced very significant results, demonstrating negative ion performances in hydrogen at the ITER specifications for short pulses and in deuterium at 85 percent of the requirement. For long pulses, significant improvement was made, with 66 percent of the desired ion current density achieved. Progress on the non-uniformity of the co-extracted electrons was substantial, with the introduction of an increased magnetic filter field and potential rods. These results followed important advances in the resolution of high-power arcing issues that are also relevant for ITER.

A second auxiliary heating system – electron cyclotron resonance heating (ECRH) – is responsible for initiating each plasma discharge, contributing 20 MW of plasma heating, and providing local instability control. Series production for the microwave-generating device at the core of the system (the gyrotron) began in 2017 after a multi-decade development program:

- Russia completed factory acceptance tests on the first gyrotron production unit, demonstrating reliable operation at 1 MW for 1000 seconds. A second gyrotron will complete factory testing in 2018;
- Ongoing tests in Japan will conclude next year on two units; series production is underway for six others;
- Factory acceptance tests are scheduled early next year on the first main high voltage power supply in Europe and two auxiliary body power supplies;
- Europe has constructed a high-power (˜1MW) long-pulse microwave test facility for testing the electron cyclotron upper launcher, waveguides and control system in Switzerland.

The ECRH system's microwaves will be transmitted to the plasma through windows sealed by synthetic diamond disks. The industrial production of these disks will kick off in Europe in 2018 after the successful performance of two prototypes in ITER-relevant pressure cycles and a successful final design review. A reduction in waveguide diameter has been implemented according to the results of a mode purity analysis study in the US last year, and proof-of-concept waveguide component prototypes are being developed that will be tested at high power and long pulse at either the Japanese (QST) or European (Switzerland) test facilities.

Metrology studies were carried out to determine the layout of the ECRH components in the as-built buildings, including revised estimates on as-built building displacements for different building environments that impact the transmission line layout and deformations. Through outside contract, Europe's port plug design for ECRH components is also advancing.

The ion cyclotron resonance heating (ICRH) system will contribute to the auxiliary heating of ITER by providing 20 MW of plasma heating power and current drive capacity. Although the system is not needed for First Plasma, high power transmission components are required for early installation in the Radio Frequency Building. The current focus is on finalizing the design of the ICRH antenna, the design of the transmission line components, and prototypes of the radio-frequency sources. A workshop was held in June at ITER Headquarters to discuss all ICRH scenarios and identify further experimentation and modelling R&D needs. In the past year:

- Europe led a contract to address technical issues that had been raised during the preliminary design review and to propose manufacturing simplifications;
- The US Domestic Agency held final design reviews for First Plasma transmission lines and for instrumentation and control components required for the radio frequency source acceptance tests;
- India successfully tested one prototype radio frequency source and testing on a second is underway. The series production contract should be launched in 2019;
- India also tested the prototype high voltage power supply, which is compatible with either radio frequency source prototype;
- The ICRH team is developing the plant ICRH instrumentation and control system in preparation for the final design review in 2019.

Magnets

Six Domestic Agencies are contributing to the fabrication of the ITER magnets through 21 Procurement Arrangements, while the ITER Organization is directly procuring two additional packages (magnet instrumentation and in-vessel coils) as well as specialized assembly tooling. Fabrication activities have been underway since 2007 when the first Procurement Arrangements were signed for toroidal field magnet conductors; today, the focus has shifted to coil fabrication. The bulk of deliveries to the ITER site (magnets, feeders, magnet supports, assembly tooling and structures) are planned in the 2018-2020 timeframe.

Successful fitting trials were carried out in Japan in December on the first toroidal field coil case – the massive steel structure that will enclose each superconducting winding pack. The two sides of the 16-metre-tall case were matched to within gap tolerances of 0.25 to 0.75 mm – a major milestone that validates years of manufacturing studies, mockups and welding trials. This first set of case structures will now be shipped to a European facility for the insertion of the first European winding pack in 2018, while series production continues on the case segments required for 18 other coil cases. The return on experience from the first insertion operation – scheduled to take place in Japan – will be shared with European contractors to reduce the uncertainty and risk related to this highly technical activity.

The production of 19 toroidal field winding packs is a work-intensive process that includes winding, heat treatment, radial plate insertion, and impregnation phases. After first-of-series winding packs were achieved in Europe (October 2016) and Japan (January 2017) series production is now underway. Seventy-seven percent of toroidal field double pancake windings have been completed and 21 percent have passed the impregnation step. The first winding pack left the European manufacturing facility in November for transfer to the coil insertion facility.

Testing during the year on an insert coil built from ITER toroidal field conductor confirmed that no negative impact on performance is to be expected from the type of thermal and electromagnetic cycling conditions foreseen by the ITER Research Plan.

In the on-site Poloidal Field Coils Winding Facility, European contractors have produced the first two of eight double pancake windings for poloidal field coil #5 and are proceeding with the qualification of impregnation tooling. The fabrication of this first poloidal field coil is expected to conclude in May 2019, followed by approximately six months of cold testing. A gantry crane was installed late in the year for later-stage assembly activities. Two smaller poloidal field coils are underway in Russia (#1) and China (#6, on behalf of the European Domestic Agency). In both locations, over half of the windings have been realized and vacuum pressure impregnation is complete on the first three double pancakes.

In the United States, the first central solenoid module passed the one-month heat treatment phase that renders the niobium-tin alloy superconducting and continued on to the next step: resin impregnation. Winding is now underway on the fourth of seven modules (six for the central solenoid plus one spare). The last lengths of central solenoid conductor were completed in Japan for delivery to the US contractor. Fabrication activities advanced during the year on central solenoid support structures (tie plates and key blocks) and on elements of the platform that will be installed at ITER for the duration of central solenoid assembly activities. The main assembly platform was delivered in August.

Chinese contractors launched the series production of bottom correction coils in 2017 after manufacturing readiness reviews were successfully completed for the bottom coil case, side coil windings and insulating flanges. By the end of the year, winding was underway on the second bottom correction coil, the first production winding pack had progressed to the vacuum impregnation stage, and series production had started on the case elements. Reviews are planned to assess the final qualification steps – the insertion of the dummy winding pack into a prototype case and laser closure welding.

Other magnet program accomplishments for 2017 include:

- The first feeder component – a cryostat feedthrough for poloidal field coil #4 – was delivered by China to the CEA magnet infrastructure test facility (MIFI) created for ITER. This feeder segment is a captive component that needs to be brought into position before the completion of the cryostat base support ring;
- R&D on superconducting joints advanced as a main busbar joint sample produced in China was reproduced by the MIFI team and tested electrically with good results. Three hundred of these joints connecting the segments of the busbars – and connecting busbars to the coil terminals – will have to be created in the field during assembly;
- The first prototype of a feeder high-voltage feedthrough was successfully tested by the supplier;
- Japan produced the first intercoil structures that link the toroidal field coil cases above and below mid-plane;
- The in-vessel coil procurement program under ITER Organization oversight progressed through the signature of a second conductor supply contract. An ELM coil mockup at MIFI demonstrated that the sliding concept for in-vessel coil supports works well;
- A final design review was held in Europe for the pre-compression rings following successful prototyping activities. As a risk mitigation measure for these important structural components that bind the toroidal field coil cases at top and bottom, the ITER Organization is planning a full-scale mechanical test facility to verify performance in advance of installation. A preliminary design review for this facility was held in July;
- The first production gravity support for the toroidal field coils passed the final factory test in China. The fabrication of poloidal field and toroidal field support clamps is also underway;
- All instrumentation components required for the toroidal field coils produced in Europe were delivered on time by the ITER Organization. Instrumentation for all magnet Procurement Arrangements should be finalized in mid-2019;
- The Director-General established a Superconducting Magnet Coordination Group at senior level to manage any issues related to risks and issues in the delivery, assembly and installation of the magnets.

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.

Field Engineering Installation

The Field Engineering Installation Division carries out in-field engineering support and surveillance for "balance of plant" installation activities (i.e., outside of the Tokamak Complex). The first plant installation activities are underway on the ITER platform based on contracts awarded in 2017 for installation services in the cryoplant, as well as the site service, magnet power conversion, and reactive power compensation buildings. First-phase work to install the underground piping to the Site Services Building, which was carried out within cost and schedule envelopes, has provided first-case experience in the management of engineering resources on site.

Extensive field engineering activity was performed during the year to adapt Domestic Agency documents to site needs and to prepare for the launch of tender packages. International competition was opened for the installation of type X cryolines and for coil power supply components (busbars, fast discharge units and the switching network) – two of the six contracts covering auxiliary plant installation. On site, the team carried out surveillance and technical supervision for the cooling system underground network contract, positioned the first set of DC transformers outside of the Magnet Power Conversion buildings, and oversaw the installation of equipment in the cryoplant. A workshop was organized in May to review the installation sequences in the Magnet Power Conversion buildings, where ITER construction contractors, Domestic Agency construction contractors and sub-contractors, and the Construction Management-as-Agent will all have teams.

The schedule is challenging, but achievable. According to the stringent metrics measuring project performance, the 50 percent completion mark to First Plasma was passed in December and the rhythm is accelerating.

Electrical Engineering

The majority of components for the steady state and pulsed power electrical networks have been delivered to the ITER site; as a result, the focus of the Electrical Power Distribution Section turned in 2017 to site installation. Detailed engineering work packages have been transferred to the European Domestic Agency for the electrical distribution systems needed for First Plasma and installation activities are in progress. The electrical team managed the temporary power supply to worksite contractors, established commissioning plans for interfaces between electrical power distribution and clients on the construction site, and awarded contracts for energy, electricity transport, maintenance and operation as part of the lead-up to testing and commissioning activities next year. Electrical distribution will be the first ITER plant system to enter operation.

The first connection to the French grid was tested in March in respect of an ITER Council milestone; this achievement will be followed by the energization of the full substation in 2018. Three large transformers delivered by China for the project's pulsed power electrical network were installed in their final position in the high voltage substation, and the very last in-kind delivery was received from the United States for the steady state electrical network, concluding a five-year procurement effort. Progress was achieved on distribution infrastructure (including technical galleries) and on the buildings for main AC distribution, power conversion for the magnet coils, and reactive power compensation. The Division continues to provide service engineering within the project to support plant system responsible officers.

ITER is directly connected to France's 400 kV electrical transmission network. In 2017, the first energization of one 400 kV bay on site permits the ITER team to validate all procedures ahead of full substation energization next year.

The coil power supply and distribution system provides the pulsed power for energizing the superconducting magnets and in-vessel coils, converting power received from the 400 kV transmission grid into controlled DC power. Component manufacturing is underway in China, Korea and Russia. In 2017:

- China finalized factory acceptance testing on nine poloidal field coil power converter units and carried out the integrated factory acceptance test for the first unit of the reactive power system with one AC/DC power converter. Five converter transformers were delivered to ITER and installed outside of the Magnet Power Conversion buildings; nine further poloidal field coil power converter units are on track for shipment in 2018;
- Korea completed the factory acceptance tests of the first AC/DC power converter unit for the vertical stability coils, successfully factory tested the first of twelve transformers for the central solenoid magnet, and dispatched the first converter transformers for the correction and vertical stability coils;
- Russia completed the final design reviews of the switching network unit and switching components; finalized the pre-qualification process for the in-vessel coil busbars; prepared a contract for in-vessel coil R&D and prototyping; and delivered a batch of busbars, fast discharge units, and switching network resistors to ITER;
- The ITER Organization completed the conceptual design of the in-vessel coil busbars, which it will procure directly.

Some 40 kilometres of electrical cables will deliver the required power to every area of the ITER scientific installation, routed via underground galleries, racks, trays and towers. The Electrical Engineering Division provides the global design of cable trays across all buildings, strict control of updates to cable diagrams, and centralized material procurement. The first cable tray installation activities were initiated in 2017 in the completed technical areas and buildings on site, and cable pulling and termination activities were realized in the Assembly Hall for the cranes and within the 400 kV substation for the energization of the first bay. Cable routing was updated in the Tokamak Complex in collaboration with Domestic Agency partners – particularly with respect to the most recent radiological maps – and the design of the secondary trays was issued for many of the auxiliary buildings. Testing of some components for operation under magnetic field induction was completed; lightning protection studies were initiated; and a support contract for lightning zone risk analysis study and definition was issued.

The cryostat is a leak-tight vacuum container that will act as a thermos to insulate the ultra-cold superconducting magnets from the outside environment. Tolerance control is achieved using sophisticated laser alignment and metrology equipment ... as well as a standard spirit level.

Fuel Cycle Engineering

The ITER Tritium Plant, the largest of its type in the world, will have the capability to process exhaust from the ITER torus and prepare fuelling gases for reinjection within one hour. Although not required in full until Deuterium-Tritium Operation at ITER, non-tritium gases must be supplied during First Plasma and a large quantity of captive equipment, including piping, must be installed.

The design of all systems is progressing:

- Preliminary design reviews were held for tokamak exhaust processing (US) and radiological and environmental monitoring (Europe);
- A successful final design review was achieved for captive detritiation pipes in the Tokamak Complex (B2 level) and the analysis of B1-level piping is underway;
- Initial final design activities for the Tokamak Complex detritiation system were completed;
- The fabrication of the second group of storage tanks for the water detritiation system is on schedule in Europe for delivery in May 2018;
- A preliminary design status meeting was held with Korea on tritium storage and delivery, and the required number of deuterium-tritium storage beds has now been determined;
- A report describing systems in the Tritium Plant Building – including system safety analysis – has been completed for submission to the French Nuclear Regulator;
- A switch from molecular sieve tritiated water collection to scrubber column technology was approved for the normal detritiation system. An atmosphere detritiation system qualification test rig is being designed for installation at Japan's Tritium Process Laboratory;
- The ITER Organization met with the UK Atomic Energy Authority (UKAEA) in 2017 to discuss the UKAEA's plans to build a pilot tritium plant adjacent to JET. There is openness to test and demonstrate ITER-relevant technology in this new facility, H3AT.

The fuelling and wall conditioning systems on ITER will provide fuel and impurity particles to the plasma through gas injection and pellet injection; control impurities and tritium inventory in the machine with glow discharge cleaning; and reduce the consequences of plasma disruptions through disruption mitigation. The gas injection and glow discharge cleaning systems, both procured by China, must be operational for First Plasma. Conceptual designs are advancing and the first subsystem – the manifolds for gas distribution – can now enter fabrication after the successful completion in 2017 of the manufacturing readiness review. Arrangements are underway for glow discharge anode tests early next year in advance of the preliminary design review.

Shattered pellet injection is under development in the US for both fuelling and as the baseline concept for disruption mitigation. In 2017, in-vessel flight tube and cask concepts passed the preliminary design review phase and – following successful pellet firing experiments – the injector is being upgraded to improve its mechanical punch and pellet forming process. R&D to quantify shattering capabilities for ITER configurations is ongoing.

As part of a strong international effort to develop reliable disruption mitigation for ITER, world experts participated in a three-day workshop at ITER Headquarters in March. Alternative injection concepts were discussed as well as a short-term R&D plan to address uncertainties with the baseline concept. Dedicated experiments at the DIII-D (US) and JET (Europe) tokamaks will allow shattered pellet injection to be tested in advance of ITER; in 2017, a new shattered pellet injection platform was installed at the top of the JET torus and the first equipment from the US was installed. Operators successfully completed pellet forming and firing experiments following a successful shakedown at 5 K; the full program of experiments will get underway next year. The outcome of the disruption mitigation workshop was summarized in an R&D work plan and, beginning in 2018, an international task force will coordinate all aspects of the program (technology, experiments, theory and modelling).

The vacuum pumping systems are designed to establish and maintain a vacuum in and around the key ITER components and to support, across the project, the vacuum standards necessary to achieving qualitative and reliable vacuum. In a vacuum laboratory installed in the basement of ITER Headquarters, the team can carry out material or process qualification tests in support of the design or qualification of vacuum components.

In August, the pre-production cryopump was delivered by European contractors after more than four years of fabrication. During factory acceptance tests, the pump's all-metal high vacuum valve (the world's largest) sealed six times better than specification. The final design review for the fabrication of eight additional ITER cryopumps will be held in 2018.

The standardization and validation of vacuum components such as valves, flanges, seals, gauges and controllers continues; of particular note in 2017 was the start of seismic test campaigns to validate ultra-high vacuum valves for nuclear safety applications. A large seal test rig developed in India is now ready for delivery. Reproducing a full-size equatorial port plug, this rig will enable the testing of port plug sealing options – beginning with elastomer options for First Plasma, followed by metallic gasket options for the deuterium-tritium phase.

Other 2017 procurement highlights for the vacuum program include:

- The final delivery of vacuum leak detection tooling from the US;
- The placement of the main order for vacuum pipework under the centralized piping arrangement;
- Successful reviews for vacuum auxiliary and roughing pump systems (conceptual design) and first-phase vacuum auxiliary systems (final design);
- The start of warm regeneration line fabrication following a successful manufacturing readiness review;
- The signature in April of a Procurement Arrangement with Europe for front-end cryo-distribution.

A wide variety of electrotechnical components are being tested at the Efremov Institute in Russia for the switching network, fast discharge unit and busbar procurement package. Many of them have been designed specifically for ITER. *Photo: ITER Russia*

The larger cold box, at left, is the first piece of equipment to be installed in the ITER cryoplant.

Cooling Systems Engineering

The Tokamak Cooling Water System (TCWS) is designed to reject all the heat generated in the plasma and the in-vessel components through transfer to an intermediate component cooling water system and, ultimately, to the environment via the heat rejection system. Under the procurement responsibility of the United States, the final design and relevant piping procurement has been assigned by agreement to a US-funded team based at ITER. In a major milestone for the system in November, a final design review was held for first-phase piping and components, opening the way for manufacturing to begin. The procurement process for valves has started, and the first batch of nuclear-grade stainless steel piping and fittings was delivered to ITER. Quality assurance audits were completed on all TCWS suppliers.

The procurement, testing, and delivery of secondary and tertiary cooling circuits under Indian scope also advanced during the reporting period. Factory acceptance tests were successfully concluded on several batches of equipment (pumps, chillers, heat exchangers, electronic plant control); the first equipment arrived for the cooling tower station; and European contractors have started to install buried cooling water piping. The quality and on-time receipt of the early cooling water deliverables are an object of particular attention due to the schedule-critical nature of buried installation works. As part of ITER Organization scope, the cooling water team is preparing all of the engineering work packages related to piping distribution inside of the buildings.

Cryogenic power will be required from the start of ITER operation to cool the ITER magnets, thermal shields, cryogenic vacuum pumps and pellet fuelling systems. In 2017 Europe completed its delivery scope, the first cryolines arrived from India, and part of the building was turned over to the ITER Organization for the installation of the first plant equipment (three cold boxes and 18 helium compressors for the liquid helium plant). Installation activities are expected to last two years. A pilot case on cryogenic system commissioning is under study in PED as part of a team effort by cryogenic, electrical power, cooling water and CODAC specialists.

Finally, the design of the vacuum vessel pressure suppression system continues to evolve to meet safety requirements and resolve maintenance issues. This system – which is used to limit the internal pressure of the vacuum vessel – is under the procurement responsibility of the ITER Organization. Four vapour suppression tanks were manufactured in 2017; they will reach ITER for installation in the Tokamak Complex drain tank room next year after the completion of all testing. Contracts have been granted for the structural assessment of the relief lines as well as the verification of large-scale steam condensation, and the tender process has begun for the assembly of the rupture disks. The design of a hydrogen mitigation system is under development now for deployment to the drain tank room.

Remote Handling

The design of the majority of ITER's remote handling systems must be completed within the next five years in order to be operational during the second-phase assembly period. Key milestones achieved in 2017 include the conceptual design reviews for the Hot Cell remote handling and vacuum vessel pressure suppression handling systems; the delivery of the first design data package for remote handling transfer casks; and the tender launch for the remote handling supervisory control system. The pace of engineering activities linked to both hands-on and remote maintenance systems is also accelerating to confirm the long-term operability of the ITER machine. These activities take into account both phases of ITER operation – non-nuclear and nuclear – and the environment particular to each phase.

The work scope for procuring parties Europe, Japan and the ITER Organization includes design, fabrication, installation and preparation for operation through trials and training. The ITER Organization has embarked on a joint collaboration with UKAEA to develop and carry-out full-scale mockup trials for component replacement and refurbishment activities. Over the next few years these trials will mimic port plug repair, as well as smaller-scale remote handling activities planned in the neutral beam and port cells.

Radioactive Materials

The ITER Hot Cell Complex will provide a secure environment for the processing, repair or refurbishment, testing, or disposal of components that have become activated by neutron exposure. Work is underway to stabilize the layout of the Hot Cell and to prepare the tender documentation for the preliminary design activities planned from 2019 on. Conceptual designs were successfully passed for type B radwaste processing and for refurbishment remote handling systems, and value analysis was initiated to review the Hot Cell layout against the staged approach to operation with the aim of optimizing the plan for building construction.

The beryllium facilities working group concluded its work in 2017 with a proposal for a stand-alone building for the pre-assembly of beryllium blanket components. Design activities for this new building – the Tokamak Assembly Preparation Building – were launched for planned construction in 2020. Work also began in the framework of a joint ITER Organization/Agence Iter France decommissioning working group to identify the functions needed in the Hot Cell Complex during the deactivation phase. The working group was established in 2017 following the conclusion of four years of analysis on the global deactivation and decommissioning strategy for ITER (the DACo Report).

Construction Department (CST)

The Construction Department plans and manages installation and assembly works on site in close cooperation with the ITER engineering departments and the Domestic Agencies; coordinates and supports work teams and contractors executing the Tokamak assembly and plant installation works; ensures that construction is carried out in accordance with the ITER Nuclear Safety Standards, the Environment & Health Policy and the ITER Management & Quality Program; oversees the global logistics process including transportation, logistics and material management; and manages the Construction Management-as-Agent contract.

Construction Management

The ITER Organization continues to adapt its construction management organization to the evolving needs of the project. To prepare for the launch of installation and assembly activities for the first major Tokamak components, a number of core machine assembly experts were transferred in 2017 to the Construction Department from the engineering units. The expertise of other staff – who continue to follow up on procurement activities from within their technical departments – remains closely matrixed to the construction organization through integrated teams that have been formed for each of the three assembly zones on the worksite (Tokamak machine, Tokamak Complex systems, and plant). The Construction Management Division (CMG) has a coordinating role in the matrixed organization – ensuring that site construction works are performed within schedule and resource envelopes and in respect of ITER requirements, providing transverse support to the construction teams, and creating procedures and processes to effectively manage co-activity.

In 2017 the Division initiated site coordination activities for installation work in the magnet power conversion and cryoplant buildings, prepared contracts to optimize resources over multiple contractors and zones (mobile cranes, scaffolding, general services …), led the effort to resolve space allocation and interface coordination issues, and managed materials arriving from the Domestic Agencies. Through its oversight of Construction Management-as-Agent (CMA) deliverables the Division also worked to strengthen communication and reporting practices in relation to the broader construction management organization. The CMA contract is now in its second year, with 70 staff effectively deployed to the ITER site to fulfil the role of providing key support to the ITER Organization during the assembly and installation phase.

Construction Management is participating in a project-wide effort to standardize the engineering data that is captured and recorded for each of the ITER systems and components, from raw materials all the way through manufacturing, testing and transport. The effort, which will continue in 2018, involves defining the content and the format of the data and managing its migration to the SmartPlant® suite of construction management tools.

Once the buildings are completed, the ITER Organization has overall responsibility for the successful integration and assembly of components delivered to the ITER site by the seven Domestic Agencies.

Tokamak Assembly

To consolidate preparatory activities for the start of Tokamak machine assembly, the engineering/procurement teams for the cryostat, toroidal field coils, and thermal shield joined the Tokamak Assembly Division (TAD) late in the year, where new Sections have been created for vacuum vessel sector pre-assembly, in-cryostat assembly, and assembly support (tooling, metrology, inspection).

With full oversight responsibility for worksite area 1 (Tokamak machine), the TAD Division reviews designs to ensure constructability, prepares the processes for the assembly of each component in coordination with the technical teams, and establishes the technical specifications for assembly and installation contracts. Engineering work to back up the three main Tokamak assembly contracts was a major focus in 2017:

During load tests in December, ITER's main lifting cranes are tested at +10 percent of their nominal lift capacity. The 1,650-tonne load is the equivalent of 1,500 average-sized cars, 300 African elephants or five fully loaded Boeing 747s.

- The call for tender for preparatory site works prior to the installation of the cryostat base (contract TAW-A0) was launched in February;
- Work has advanced to ready the two main installation work contracts, TAC-1 and TAC-2, for tender early next year;
- As part of the technical basis for the installation contracts, engineering work packages were developed for phase-one work;
- An internal review began on the conceptual design of the toroidal field coil transportation frame, in advance of the delivery of the first coil from Japan;
- Twenty metrological survey nests were installed in the bioshield to prepare for the first installation activities.

The ITER Organization contract for the in-situ welding of the vacuum vessel sector and ports is progressing as, step by step, the contractor develops and qualifies bespoke tooling and procedures. The arrival during the year of full-size mockups at the contractor facility led to the successful completion of planned welding qualification activities, and an additional qualification activity was launched to trial combined manual and mechanized welding techniques in the case of tolerance or alignment difficulties. The preliminary design reviews of six tools have been closed out and the Division continues to provide the support needed for the contractor to complete all required tools on time.

The installation of the first tool from Korea – the sector sub-assembly tool SSAT-1 – is progressing well in the Assembly Hall under TAD supervision. In parallel a second, identical unit has been manufactured in Korea and is ready for factory testing; this tool will ship as soon as on-site commissioning and tests have been successfully completed on the first. Following a series of contract awards during the year, all 43 assembly tools under Korean scope are now under contract with industry. Progress was also made on the procurement of the purpose-built tools under ITER Organization scope, with orders for the first 21 tools and tooling systems placed in 2017. Ground-breaking begins next year on a contractor test facility not far from ITER that will be used to qualify specialized handling tools for the assembly of in-vessel components and to train future operators.

Tokamak Complex

The Tokamak Complex Section/Division (TCS) focuses on the installation of Tokamak Complex systems through the integrated construction team in charge of worksite area 2 – which includes the Tokamak Complex (outside the vacuum boundary of the machine) and Radio Frequency Building. Division responsibilities include preparation and evaluation for assembly and installation tender contracts, oversight of contractor works, review of contractor documents, and the establishment of optimized processes for assembly. As part of changes to

Work is underway on the last level of the ITER bioshield. The circular structure, as thick as 3.2 metres in some areas, is designed to protect workers and the environment from radiation generated by the fusion reaction.

construction management in 2017, the Plant Engineering Department – responsible for the procurement of the ITER plant systems – was fully matrixed to the integrated construction teams.

The documents necessary for the first major call for tender in worksite area 2 – the TCC0 contract for early mechanical installation works such as captive pipework – have been compiled and the tender is ready for launch early next year. Work to prepare the document packages for the main installation contracts TCC1 and TCC2 is also on schedule for late 2018 release. A dedicated interface team now ensures that all ITER Organization functional requirements are aligned to the contract tendering strategy and activities.

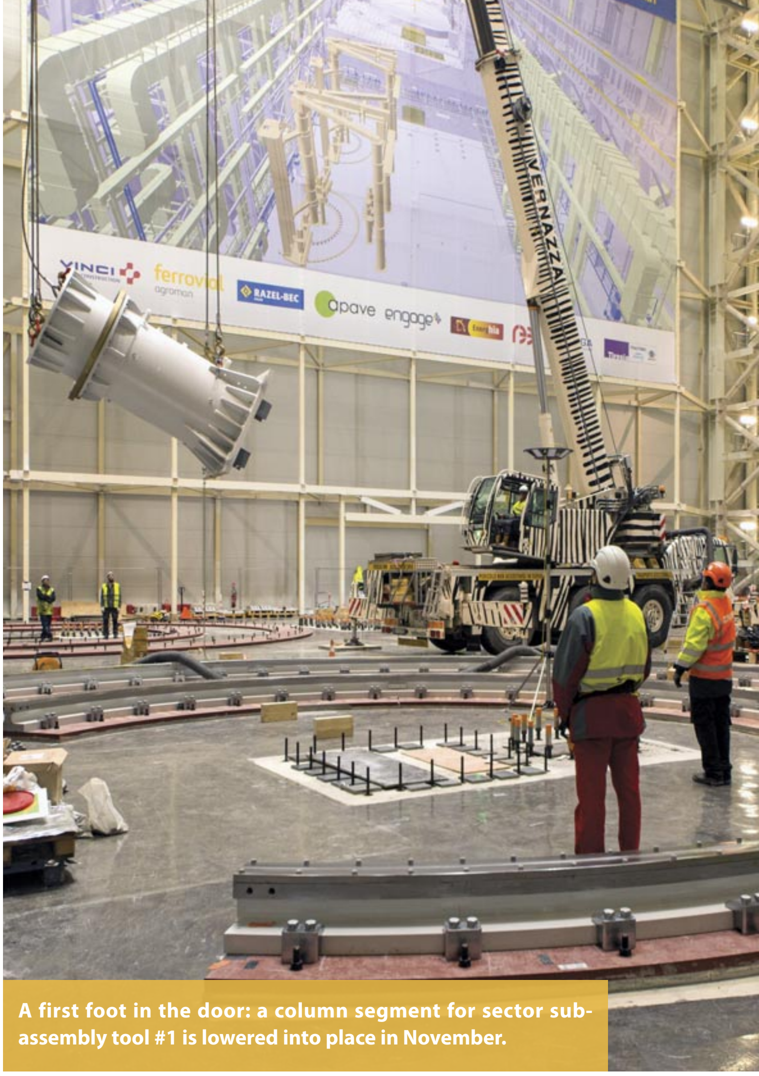
A major effort was carried out in 2017 to optimize planned construction activities and site material deliveries to ensure better consistency between systems installation work and work being carried out in the same zone by European Domestic Agency building contractors. All CST Divisions participated in this effort, which also involved the technical responsible officers for the systems. The result – the Common Assembly Sequence – mitigates a number of risks and issues that were generated by the delay in building construction by planning the sequence of work from a top-down perspective instead of from the point of view of individual contracts.

A new initiative, the Holistic Integration Team, will gather ITER Organization assembly and installation specialists with relevant Domestic Agencies to jointly deliver clash-free final construction and execution designs per area. As part of this approach, the ITER Organization is negotiating to take over the Tokamak Complex installation scope that falls under the European Domestic Agency's TB04 contract, as well as installation scope of the other components such as busbars and cryolines in the Tokamak Complex, in order to optimize assembly sequences and co-activity in this area. Both of these related initiatives – the formation of a Holistic Integration Team and the transfer of installation scope for components in the Tokamak Complex – are expected to be confirmed in 2018.

Facilities, Logistics & Materials

Through participation in the merged European Domestic Agency/ITER Organization team for buildings – the Buildings, Site Infrastructure and Power Supplies (BIPS) Project Team – the Facilities, Logistics & Materials (FLM) Division carries out technical monitoring and supervision of all construction on site to confirm that work is performed according to project requirements. This supervision complements nuclear operator surveillance activities carried out by the Safety Department.

The Division also maintains and operates all site infrastructure – including storage facilities, roads, drainage and lighting, and completed buildings turned over to the ITER Organization. In 2017 new welfare facilities were prepared on the construction platform for contractors; work began on a new office block near Headquarters for ITER and Domestic Agency assembly teams; one additional parking lot was completed and a second is underway; and the initial call for tender for the future maintenance contract for site facilities was issued. Tendering



A first foot in the door: a column segment for sector sub-assembly tool #1 is lowered into place in November.

for an additional storage area equipped with an overhead gantry crane was largely completed in 2017, as well as a small contract to provide minor civil engineering modifications to the structures handed over by the European Domestic Agency to the ITER Organization.

In addition to hundreds of conventional loads, 18 highly exceptional loads weighing up to 150 tonnes were received during the year. FLM manages the warehousing of these components and – in the context of tight space constraints – anticipates future storage needs. The lease of 12,000 m^2 of additional storage space near the port of Fos-sur-Mer was decided in 2017, and an agreement was reached with the neighbouring CEA facility to expand the volume of ITER components stored there. New agreements were also prepared with the global logistics provider in order to guarantee that components are properly preserved and delivered to the construction teams as requested.

The first plant installation activities were launched this year based on contracts awarded for early installation services in the site service, cryoplant, magnet power conversion, and reactive power compensation buildings.

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.

Fusion Science

The Science Division in the SCOD Department is in charge of developing the ITER Research Plan and coordinating the required supporting research with the Member physics community and laboratories, especially through the various groups of the ITPA (International Tokamak Physics Activity). The foreseen plasma scenarios in the ITER Research Plan are analyzed to confirm that the different systems of the ITER facility will meet the operational demands required to reach the physics objectives, with a particular focus on plasma-wall interactions, plasma stability, and the confinement of the thermal plasma and the fast ions present in the plasma.

In 2017 the review of the major elements of the ITER Research Plan in relation to the proposed staged approach was completed with support from fusion science experts from the Members and the Domestic Agencies. The revised plan – which defines the research objectives for each operational phase, physics and technology R&D, and the detailed experimental program from First Plasma to long-pulse Deuterium-Tritium Operation – was presented to the ITER Council Science and Technology Committee (STAC) where it received a very positive evaluation. The final version will be made publicly available as an ITER Technical Report in 2018.

R&D in support of the ITER Research Plan is coordinated with the Member science communities through the International Tokamak Physics Activity (ITPA) and the ITER Organization Scientist Fellow network.

A first-of-kind, full-3D plasma chamber model has been completed to capture the gas pressure rise in the vacuum vessel at the start of ITER plasma pulses. This model, which is being used to guide the last elements of the gas fuelling lines design, can also provide valuable input to operational planning for First Plasma, the achievement of which is very sensitive to the time evolution of the neutral pressure in the vacuum chamber. In parallel, an exascale computing collaboration was started with the Jülich Supercomputing Centre in order to study the early phase of plasma breakdown and to extrapolate the knowledge base from existing tokamaks to ITER.

In collaboration with the Member R&D community, increasing focus has been placed on advancing the understanding of the various physics mechanisms affecting the long-term behaviour of the tungsten divertor targets under plasma exposure. Thanks to experimental support from the Members' operating tokamaks, the models required to study tungsten melting caused by transient loads have been benchmarked in detail, which has led to increased understanding of the phenomenology in ITER. The WALLDYN material migration code has been deployed at ITER to determine the feasibility of using early experiments to measure the expected levels of fuel retention in advance of nuclear operations.

The preliminary design of the ITER plasma control system was approved in May, including the control of moderately heated hydrogen and helium plasmas up to a plasma current of 15 MA. The final design of the First Plasma control system is underway, supported by a consortium of plasma control experts from Europe and the United States; this consortium will develop the initial control algorithms for plasma initiation, electron cyclotron heating, and density control as well as the architecture for the complete control system including advanced control. A workshop held in March at the ITER Organization, with wide participation of experts from the Members, established

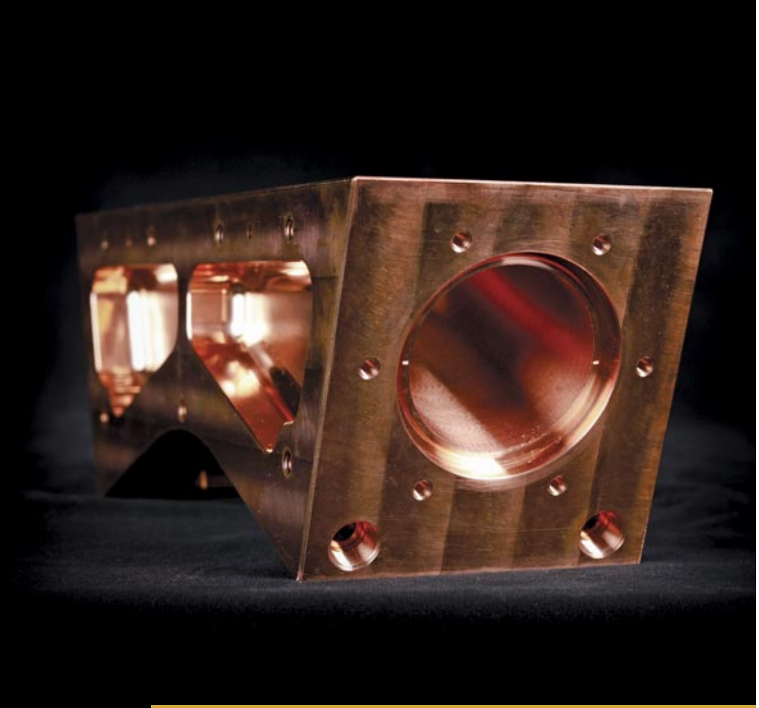
This unusually shaped opening is reserved for one of ITER's two neutral beam injectors - a heating device that will shoot beams of high-speed, high-energy particles into the plasma.

consensus on shattered pellet injection as the best scheme for disruption mitigation, a decision that has been supported by experimental campaigns on the DIII-D tokamak (US). Additional studies on the European tokamak JET will take place in 2018, including the operation of a US-developed shattered pellet injector, in order to provide experimental results at a scale closer to ITER. Alternative concepts to the shattered pellet injector are also being explored for the avoidance and suppression of high energy (runaway) electrons during disruptions. The Member fusion community is strongly engaged in developing solutions for this issue and, beginning next year, an international disruption mitigation task force set up by the ITER Organization will coordinate R&D on the baseline and alternative approaches to the disruption mitigation system on ITER.

Experts from the Members continue to participate actively in the improvement of ITER's integrated modelling capabilities and the infrastructure of the ITER Integrated Modelling and Analysis Suite, IMAS. Modelling activities have also progressed through the strong support of ITER Scientist Fellows:

- Newly acquired modelling capabilities have been applied to perform end-to-end simulations of ITER scenarios (including edge boundary conditions to ensure that divertor power fluxes remain within engineering design limits) and to optimize the application of 3D fields for the control of edge localized modes (ELMs) during the pre-fusion phase of operation;
- Completed studies of ELM triggering by pellet injection show that the pellet mass needs to be increased to ensure the reliable triggering of ELMs when the ELM frequency increases;
- The modelling of an ELM-less high confinement plasma regime (QH-mode) has demonstrated that sufficiently large gradients in edge plasma rotation are essential to achieving this alternative regime through their effect on edge plasma stability. The consequences of this finding for ITER operation are under evaluation;
- Collaboration is underway with EUROfusion to map European tokamak experimental data to the IMAS data model;
- The systematic mapping of existing ITER plasma simulations to IMAS has started.

Division scientists published 55 papers during the year as leading author or co-author in refereed journals. They also represented ITER science at fusion conferences worldwide and mentored fusion trainees from the ITER internship program, the European FUSION-DC PhD program, and the Monaco-ITER Postdoctoral Fellowship program. The ITER International School took place again this year to promote the training of postgraduate students and young researchers on ITER-relevant issues; the focus for this ninth session in Aix-en-Provence, France, was disruption physics.



A particular waveguide prototype is under development in the United States for the transmission lines of the electron cyclotron heating system. ***Photo: US ITER***

Operation Management

The Operation Management Section/Division is in charge of central coordination and management during all operational stages of the installation, including commissioning phases and shutdowns. As part of the newly launched ITER Operations Network, the Division invited 19 experts from other facilities to Headquarters in September to share their experience of system commissioning, operation and control room design. Numerous actions were identified to support the ITER Organization in making the necessary detailed preparations for the operation phase of the machine. Regular meetings are planned and – under the ITER Project Associate scheme – Operations Network experts also have the chance to work on site.

Commissioning is the final validation that each ITER system has been designed, manufactured and installed correctly. Planning for this important phase is underway – this year the Operation Management Section produced the first detailed system commissioning plans; worked with the Project Office to establish the overall master schedule; and joined the Plant Engineering Department and control system specialists in a pilot commissioning case on the cryogenic system. The plan for diagnostics commissioning in relation to the staged approach to assembly also advanced during the year.

The systems requirements for the ITER plant simulator are under development through outside contract; this integrated tool will mimic the behaviour of the 16 systems that make up the ITER plant in order to help validate foreseen operational scenarios and to train future operators. The Section is also collecting return-on-experience data from operational tokamaks, with a focus on the control room and human-machine interfaces. As part of the work to establish the layout of the Control Building, the design of the main control room is underway on the basis of ergonomics-based task analysis. A database was launched in 2017 to visualize the status of all RAMI (for reliability, availability, maintainability and inspectability) assessments at ITER.

Control Systems

In addition to a central control system (CODAC) that will monitor, control and coordinate all ITER plant systems, the scientific installation will be equipped with a central interlock system for machine protection, central safety systems (nuclear and occupational), and an access control and security system.

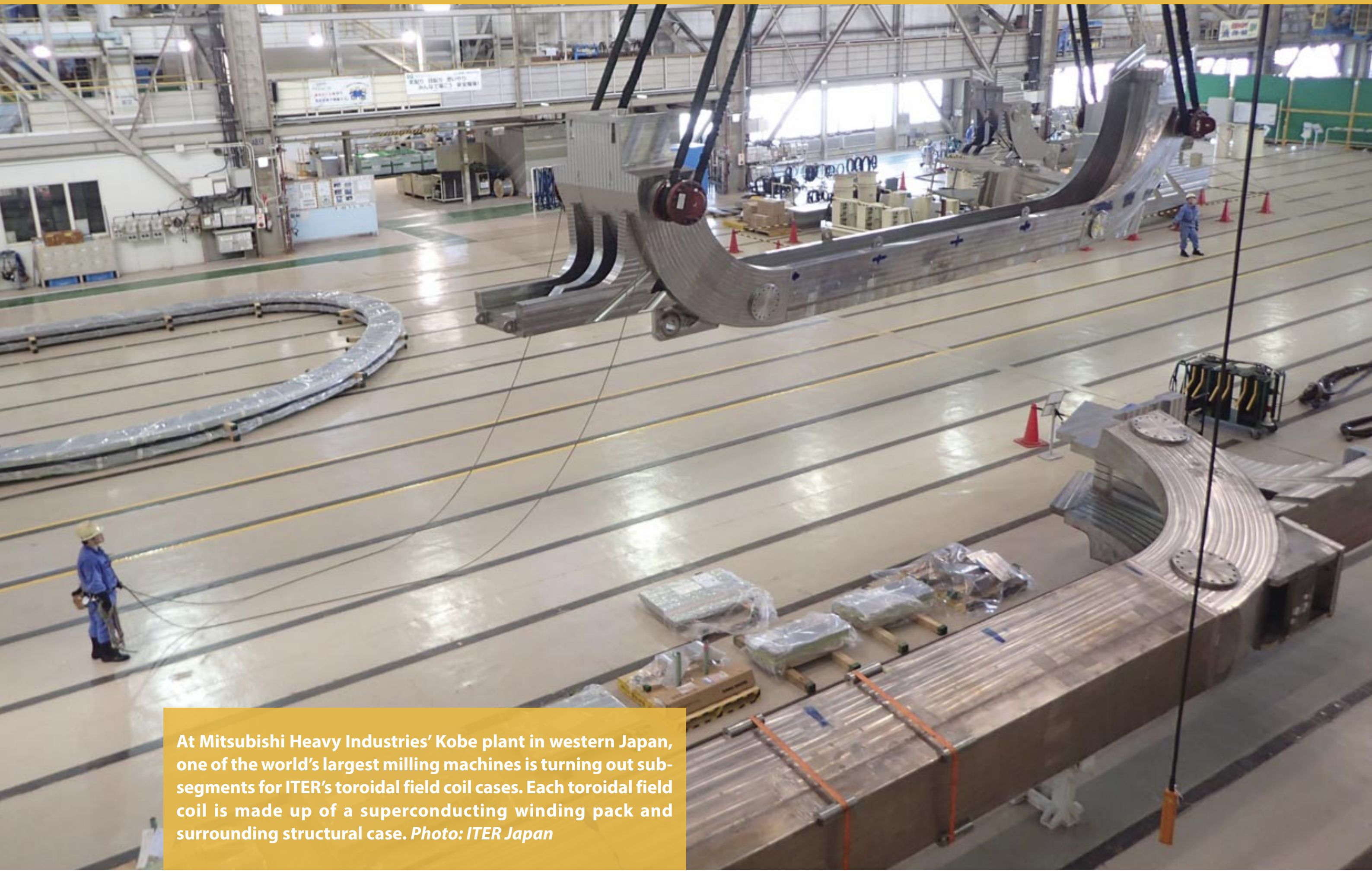
In 2017 the Division released and distributed a new version of its conventional software CODAC Core System, which provides the companies or organizations supplying plant systems to ITER with standards to ensure central control integration. To further promote the proper integration of over 170 local plant systems, the Division supplies free, preconfigured standard hardware in kit form, as well as hands-on and on-line training. Two hundred requests for user support were processed in 2017. Another standardized package – CODAC Operation Applications – is under development for the factory and site acceptance testing of plant systems; version two has been released and further evolution is planned to support integrated commissioning and operation.

Based on currently defined machine protection functions, the first version of the central interlock system successfully passed factory acceptance tests at the supplier in Korea. The team is now pursuing meetings with operations and plant responsible officers to refine the understanding of machine protection functions per system. The qualification of components for the nuclear safety control system also progressed: seismic tests continue and the hardwired architecture for safety-important components (class 1) is expected to be qualified next year. For efficiency purposes, it was agreed in 2017 to transfer the main scope of the local nuclear safety control systems from the Domestic Agencies to the ITER Organization.

On site, the first of eleven interconnected control rooms – which will stand in until the ITER Control Building is built – was constructed and tested successfully in the lab. The Division contributed its expertise to construction specifications in order to ensure the correct installation of the platform-wide control system architecture and to provide specifications for the first engineering work packages for early buildings. A major campaign was carried out to update the documents relating to all of the physical interfaces between the central and localized control systems. Finally, a software testbed has been created to simulate the First Plasma configuration and to run scalability and integration tests; in 2017 automated management was introduced to this control system model to allow its rapid and safe re-configuration for different purposes.

The ITER Organization has signed over 50 Memoranda of Understanding for technical, scientific or academic cooperation since 2008.

Large diameter cryogenic lines and multi-process pipes leave the manufacturing site in India for shipment to ITER. Nearly 25 tonnes of liquid helium – at minus 269 °C – will circulate in the Tokamak Complex through a five-kilometre network of pipes, pumps and valves. *Photo: ITER India*



At Mitsubishi Heavy Industries' Kobe plant in western Japan, one of the world's largest milling machines is turning out sub-segments for ITER's toroidal field coil cases. Each toroidal field coil is made up of a superconducting winding pack and surrounding structural case. *Photo: ITER Japan*

Finance & Procurement Department (FPD)

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

In 2017, the Finance & Budget Division worked closely with the technical departments, Project Control, and Procurement & Contracts to finalize the 2018 budgets as well as estimates for 2019 and 2020. It closely monitored commitments from purchase request through contract signature, reporting monthly to the Central Team Management Board on any issues or problems, and tracked payments, credits, and cash. The final execution of allocated commitments and allocated payments during the reporting period was 90 percent and 83 percent respectively.

In addition to overseeing the planning and execution of the budgets, the Division continued its implementation of the Reserve Fund as a tool for addressing cost impacts due to changes in scope or design within the ITER Organization or Domestic Agencies, as well as the undistributed budget as a mechanism for addressing cost increases and other internal cost impacts. Throughout the year, it reviewed project change requests, implemented decisions in the budgets, executed payments to the Domestic Agencies, and prepared reports for the Members on high-value allocations and the overall status of the Reserve Fund.

The regular verification of commitments, invoices and other financial transactions such as debit notes, small-value purchase orders and invitation letters also contributed to sound financial management at the ITER Organization.

As part of the annual reporting exercise, the Accounting Officer produced the 2016 Financial Report based on more than 59,000 entries. The ITER Council Financial Audit Board (FAB) issued an unqualified audit opinion on this report in March, in which it recognized the substantial efforts made by the ITER Organization to address former recommendations. In the audit opinion, the FAB members stated that the Financial Statements present fairly, in all material respects, the financial position of the ITER Organization as of 31 December 2017, its financial performance, and its cash flows for the year in accordance with the International Public Sector Accounting Standards (IPSAS) and the Project Resource Management Regulations (PRMR).

Also, during 2017 approximately EUR 0.78 million were earned as financial income through sound and secured cash investments.

The Procurement & Contracts Division implements competitive, fair and transparent processes in the placement of contracts and task agreements; manages changes in contract terms and conditions as well as any issues that may arise during execution; and shares its expertise project-wide to enhance good business practices, efficiency and cost savings. About four hundred new contracts were signed during the year for a total value of EUR 231 million. The largest contracts were awarded for:

- Lifting and handling equipment for assembly and installation;
- Balance of plant (BOP) Group 1 installation works for test equipment and piping; BOP Group 2 installation works for the cooling water plant;
- Design and integration of the ITER control systems;
- Manufacturing and testing of ITER diagnostics equipment.

A significant amount of preparatory work was also carried out to prepare to tender the following large construction contracts: the early works contract in the Tokamak Pit (A0), and the main contracts for machine assembly (TAC-1, TAC-2) and systems assembly in the Tokamak Complex (TCC-1, TCC-2). Contracts resulting from the Revised Construction Strategy were prepared for presentation to the Management Advisory Committee and the ITER Council, and negotiations were conducted for the partial transfer of installation scope from the Tokamak Complex Building Services Contract (TB04) to the ITER Organization.

In addition, key task agreements were concluded for the testing of the toroidal field insert coil, and for the installation of a shattered pellet injector on JET for disruption mitigation studies.

The ITER Business Forum in March attracts business and industry leaders from all over the world with a program organized around industrial opportunities at ITER.

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 supports the project by leading the development of the overall strategy and policies for human resource management, managing the staffing plan based on organizational needs and forecasts, carrying out a wide range of staff services (contract management, training, performance review, salary, and social insurance), and contributing to strengthening project and managerial culture.

The Human Resources Department accompanies the evolving human resource needs of the project by continually modernizing, updating, and harmonizing its policies, processes and tools. Progress in the implementation of a detailed action plan for human resources management – developed based on the Director-General's Action Plan of 2015 and the recommendations of an independent review group in 2016 – is regularly presented to the ITER Council.

During the latest reporting period, a new competency model and framework were introduced to accompany the increasing complexity of the organization and to assist the Department in determining how human resources can best be optimized going forward. New core behavioural competencies have been identified for all ITER Organization staff as well as specific behavioural and technical competencies for a number of pilot units. During the initial phase, the updated model will be applied to job descriptions, recruitment procedures, performance reviews, and renewal and internal mobility decisions; longer term, a comprehensive database will be made available to management and staff to promote a clear vision of the existing and required competencies for the organization.

These test stands under development in Russia will verify the performance of ITER's port plugs – critical components that seal the openings of the plasma chamber. *Photo: ITER Russia*

The Human Resources Department continues to support the implementation of new and revised organizational structures, including a matrixed organization chart for construction that has been developed to ensure that the knowledge and skills of staff working in engineering departments fully transfers to assembly and installation activities. In 2017 measures were taken to clarify matrix roles and responsibilities, strengthen line management, and organize delegations of authority. Matrix assignments, staff transfer, or internal competition related to the new organization affected about 150 staff during the year.

Hiring at the ITER Organization is proceeding in accordance with the Council-approved staffing plan. In 2017 the Department managed:

- 130 appointments, 44 departures, and 234 contract renewal decisions. Nineteen of the appointments were ITER Organization staff members recruited through internal or external competition;
- 121 vacancies, for which 3,661 applications were received through the Domestic Agencies and 774 interviews conducted;
- 62 interim staff (more than 100 contracts), 37 expert contracts, and 35 student interns.

As of December 2017, the ITER Organization employed 825 staff members, including 5 postdoctoral researchers funded under the Monaco-ITER Partnership Arrangement as well as staff funded by the US Domestic Agency for work on the tokamak cooling water and vacuum systems.

Staff directly employed by the ITER Organization now number 825 – an 11.5 percent increase over 2016.
Photo: ITER Organization/Gérard Lesénéchal

The Department seeks not only to increase the attractiveness of employment offers, but also to improve the reliability of the recruitment process to ensure that the correct profile is selected for each position. Specific actions include the training of selection boards, the improvement of selection and assessment tools (through a "multi-hurdle" approach and competency-based questionnaire), the review of job descriptions by the Staff Committee, and the simplification of the job titles when possible and appropriate. Improving Member representation within the staff pool also remains a top objective. The Department works closely with the Members to promote the ITER Project Associates recruitment scheme, which allows experts from the Members' scientific, technological and industrial communities to work on site at ITER. The first wave of 13 ITER Project Associates began their assignments in 2017.

To assist in the rapid acclimation of new recruits, the Department strengthened its staff induction program in 2017 – new staff members now participate in a three-day induction course comprising a visit to the construction site, presentations, and trainings. A buddy program was also launched to pair newcomers with an experienced member of staff who can serve as a point of contact during the early months of integration. Training sessions were organized internally and externally in security (including a specific workshop to qualify staff on construction/safety regulations), project and contract management, and scientific and technical topics to the benefit of 2,128 attendees. The Department began a review of administrative support services, assisted staff with international school issues (particularly the application process), and interacted with the Staff Committee on issues impacting the day-to-day work environment.

In 2017, internal administrative circulars related to contract renewal, performance management, and on-call duty matters were revised, and others created to prevent conflicts of interest and implement flexible working. Policies on official duty expenses and data protection were reviewed, and adjustments were made to a number of employment-related information tools to improve the experience of users. The ITER Academy, to be launched in 2018 by the Project Control Office, will provide face-to-face training and web-enabled remote learning tools on project management and systems engineering topics.

Finally, a relaunched Ethics Committee has been involved in renewing the ITER Organization Code of Conduct and in defining a set of core values for the ITER Project. The Human Resources Department coordinated the activities of the Advisory Board on Pension and Social Insurance, the Ethics Committee and, where necessary, the Committee for Health & Safety. The Department also represented the ITER Organization in its relations with the French labour inspectorate and social security administration.

The distribution of human resources across the organization continues to evolve, as the project transitions from design to construction.

Cabinet of the Director-General (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 affairs and communication; contact with external stakeholders; document preparation and editing of input documents for 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 works on strategic issues for the Organization as decision-making support.

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.

A scientific and engineering Collaboration Agreement signed in June with the National Nuclear Center of Kazakhstan opens the way to the exchange of technical experts, as well as access to Kazakhstan's KTM tokamak for materials testing.

In 2017 the team assisted in the continued daily implementation of the Director-General's Action Plan – supporting the project-wide effort to finalize Baseline 2016, 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.

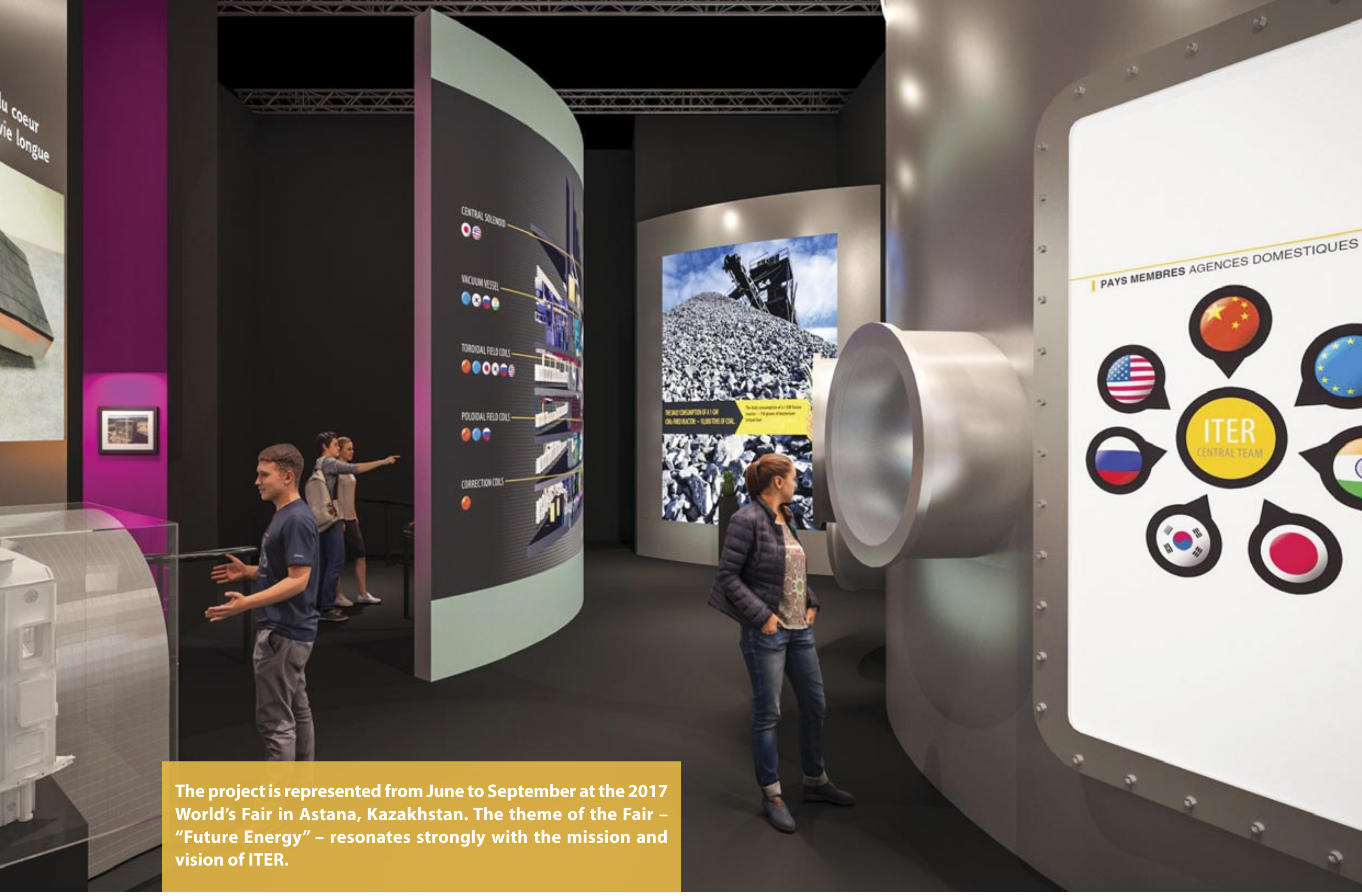
Communication (COM)

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 other aspects of implementation of the Director-General's Action Plan. Finally, COM maintains strong ties to Member State agencies, decision makers and external collaborators in the fusion community through the development of sustainable and collective actions.

The celebration in December of a major project milestone – the achievement of 50 percent of total work scope to First Plasma – was the occasion for ITER Communication to plan and launch a global media campaign that resulted in more than 750 press articles in 40 countries and a dozen TV interviews for the Director-General. This type of worldwide communication effort, rolled out for the first time in 2017, will become increasingly opportune as the project passes technological and programmatic mileposts on the way to machine operation that can interest and inspire large audiences.

ITER was also present at the United Nations Climate Conference (COP-23) in Bonn, Germany; the 27th IEEE Symposium on Fusion Engineering (SOFE 2017) in Shanghai, China; the World Conference of Science Journalists (WCSJ) in San Francisco, California (US); and the 2017 World's Fair in Astana, Kazakhstan, with a multimedia stand in the French Pavilion for the duration of the three-month event. Elements of the Astana display will be "re-purposed" as part of a planned upgrade of ITER's on-site Visitors' Centre, while a new version of the project's travelling stand – with a walk-in cinema – is being designed to keep pace with an ever-increasing number of high-visibility external engagements at conferences related to energy, environmental sustainability, and scientific and technological innovation.

The worldwide release of an in-depth documentary on fusion and ITER in February has also contributed to elevating public understanding of the project. *Let There Be Light*, the 100-year journey to fusion – filmed by Montreal-based EyeSteelFilm over three years, including repeated visits to ITER – won initial



The project is represented from June to September at the 2017 World's Fair in Astana, Kazakhstan. The theme of the Fair – "Future Energy" – resonates strongly with the mission and vision of ITER.

attention on the independent film circuit before being made available later in the year on well-known video platforms, where it can potentially reach an audience of millions.

High-level stakeholder advocacy was a priority in 2017, as part of global efforts to ensure that government decision makers have the information needed to make informed decisions on the Baseline 2016 in relation to specific legislative or budgetary cycles. The team also supported the Director-General and Deputy Director-Generals in their representation responsibilities both on-site and abroad; this year, a ten-member Speakers Bureau was introduced to help with some of the increasing volume of requests.

As part of regular activities Communication maintains and upgrades the project's internet presence in order to reach ever-more-diverse categories of the public. The public website (15,000 unique visitors per week), the weekly news bulletin Newsline (11,000 subscribers), the French-language ITER Mag, and ITER Organization accounts on Facebook, Twitter, Instagram, LinkedIn, and YouTube are all important tools in this regard. In 2017, the project's presence on Twitter was re-invigorated, a live-cam link was introduced to the website for real-time viewing of Tokamak Complex construction progress, and high-quality digital material (in the form of photographs, presentations, videos, brochures, and quarterly updates to the online virtual tour) was created and diffused in-house and externally.

The team planned visit and interview programs for international media groups, organized a two-day event for journalists, and partnered with Agence Iter France and the European Domestic Agency to receive 13,000 people on site (including as part of two Open Doors events). The ITER Business Forum (IBF/2017) industrial event and the ITER Robots contest for secondary school students were also carried out with Communication support. An on-line fusion education program to supply classroom materials to teachers at primary, secondary and university levels – INFUSE – is also in the concept phase.

Finally, a series of targeted initiatives are underway to support the quality of the work environment at ITER. Among these is the development of a weekly lecture series on the basics of ITER science and technology (to be launched in January), the complete re-design of the project's intranet platform Buzz, and improvements to the visual work environment (dynamic digital signage, ITER posters). The organization of well-attended staff events during the year – including a celebration for the ITER Organization's tenth anniversary, ITER Games, all-staff meetings, and the second annual holiday party – also contributed to creating a strong project culture.

The worldwide release of an in-depth documentary on fusion and ITER in February has contributed to elevating public understanding of the project.

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).

A regular activity for Legal Affairs is to provide counsel on the implementation and interpretation of ITER Agreements. In 2017 the team was strongly involved in the transfers of scope from the Domestic Agencies to the ITER Organization and in coordinating the elaboration of an Internal Administrative Circular related to transfer of scope. Legal notes were issued on a variety of issues including the legal status of the Domestic Agencies, the participation of the ITER Organization in a company for profit, and the possibility of introducing an "associate partnership" project status to the ITER Organization. Regular support was also provided to the Director-General in the implementation of risk mitigation measures.

International cooperation activities have significantly increased through the ITER Project Associate (IPA) hiring scheme, with 66 IPA agreements signed in 2017. Several non-Member countries continue to demonstrate interest in the ITER Project and Legal Affairs has analyzed in detail the various possible forms of cooperation – work that contributed to the signature in June of a Cooperation Agreement with the National Nuclear Center of the Republic of Kazakhstan. Legal Affairs drafted and negotiated 16 agreements, 6 license agreements, and numerous non-disclosure agreements during the year.

In the framework of planning activities for the decommissioning phase of the project, Legal Affairs coordinated the action of a working group on reference documentation and methodology that resulted in an agreement with the French authorities on how to account for changes in the decommissioning plan of the ITER facilities. As part of other regular activities, Legal cooperates with the Host organization CEA within the Site Support Agreement Liaison Committee, and provides advice on strategic ITER Organization construction contracts, worksite coordination documents, and administrative authorizations on the worksite.

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

> In 2017 the ITER Organization signs the second non-Member technical Cooperation Agreement of its history with the National Nuclear Center of the Republic of Kazakhstan.

Extensive support continues to be provided on visa and work permit issues for contractors and Domestic Agency staff members in order to prevent delay in contract execution. In 2017 Legal Affairs interfaced with the labour inspectorate and the French administration to create a "single desk" (guichet unique) for contractors' immigration formalities. The team also managed insurance claims and insurance-related matters, and supported the start of renegotiations for the CEAR (Construction Erection All Risks) insurance policy.

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.

Finally, Legal Affairs 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, and negotiating an amendment to the Social Security Agreement. Legal Affairs managed litigation cases in close collaboration with the Human Resources Department, and provided counsel for the activities of the Ethics Committee, the updated 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 managed a tax assistance campaign to support staff with their income tax declarations.

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 comprehensive annual risk assessment exercise carried out in 2017 by Internal Audit covered 100 major processes used by ITER Organization departments and divisions – including the Cabinet, Human Resources, Finance & Procurement, Construction, the Design Office, IT, Document Control and Project Control. The exercise also identified and weeded out some of the processes from the risk assessment perspective that had outlived their utility and that, with changes in the environment, had been superseded or were discarded by the process owners.

The results of the annual risk assessment exercise were submitted to the external auditors of 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.

IAS reviewed the accounting of the ITER Organization Financial Report in 2017 and performed audits in important areas including: the accountability framework and its implementation across the ITER Organization, the administration of non-disclosure agreements, engineering documents deliverables, inventory storage and the baseline count process, and negotiation procedures.

IAS performed advisory services as requested periodically by management and carried out assignments related to human resource matters, budget for salaries, procurement issues, and allowance regulations. It also provided regular support to the accounting and financial control units, advised on the adequacy and effectiveness of financial control functions, and held workshops to impart knowledge and skills on matters relating to the computation and accounting of liabilities and provisions. Similarly, in collaboration with ORAP, IAS verified the effective implementation of MQP process simplification related to the list of Procurement Arrangement applicable documents.

IAS also assisted the Accounting Officer in the preparation of the response, on behalf of the ITER Organization, to the request for feedback from the International Public Sector Accounting Standards (IPSAS) Board® on Exposure Draft 23 on the accounting of non-exchange transactions.

Lastly, IAS followed up on the implementation status of its recommendations, of which a large number (65) were addressed and implemented during the reporting period by line management leading to savings and/or to augmentation of revenue. Of these, the most significant in terms of cost savings was the institution of the mechanism to levy the liquidated damages/recoveries on account on non-achievements of key performance indicators by contractors.

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.

The ITER Council, consisting of representatives of the seven ITER Members, is the governing organ of the ITER Project. It is assisted in its work by its two advisory bodies – the Management Advisory Committee (MAC) and the Science & Technology Advisory Committee (STAC). A Financial Audit Board has been established to perform the audit of the annual accounts of the ITER Organization.

The ITER Council met for two statutory sessions in 2017 – the Twentieth Meeting in June and the Twenty-First Meeting in November. The Management Advisory Committee convened in May and October and also held a special video meeting in June. The ICS provided support to all of these meetings, as well as secretarial support to the Financial Audit Board, the 2017 Management Assessment, and two MAC In-Depth Independent Reviews commissioned by the ITER Council.

A popular experience on the ITER stand : an immersive reality tour of the construction site.

External Relations & Action Plan Implementation Office (ORAP)

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

In 2017, 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 the Netherlands and prepared the necessary briefing documents.

The Office was assigned by the Director-General to take serious action to encourage the widest possible dissemination among the ITER Members of intellectual property resulting from ITER design and construction activities. Concretely, this dissemination takes the form of declaring generated intellectual property to the ITER intellectual property database. ORAP worked intensively in 2017 with the Domestic Agencies, ITER departments and suppliers to increase overall awareness and, as a result, the number of generated intellectual property declarations had been multiplied by six by the end of the year.

The Office continues to work closely with Internal Audit and ITER Organization process owners to simplify and optimize Procurement Arrangement applicable documents, and to jointly monitor implementation. The Office 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.

In close cooperation with Legal Affairs and its contracted immigration expert, ORAP contributed to updating work permit application procedures for Member contractors, communicated intensively inside and outside the organization on visa/work permit procedures, and aided, when necessary, in the successful conclusion of the visa/permit process for Domestic Agency contractors. The Office coordinated with the Welcome Office of Agence Iter France to ensure prompt and efficient visa services to all ITER staff members.

100,000 tonnes of concrete, 30,000 tonnes of steel reinforcement – the seven-storey Tokamak Complex is rising year after year. Another two years will be necessary to finish the Tokamak Building and ensure overhead crane availability for the first major lifts of the machine assembly phase.

STAFFING & BUDGETARY TABLES

Staffing tables

Staff By Member As Of 31 December 2017

STAFF BY MEMBER	31/12/2015	31/12/2016	31/12/2017
People's Republic of China	55	67	77
Euratom	446	512	571
Republic of India	22	30	36
Japan	25	25	25
Republic of Korea	32	32	32
Russian Federation	30	36	36
United States of America	32	38	48
Total	**642***	**740****	**825*****

** Includes 5 Monaco Postdoctoral Fellows and staff funded for the Tokamak cooling water system (24) and vacuum system (1).*

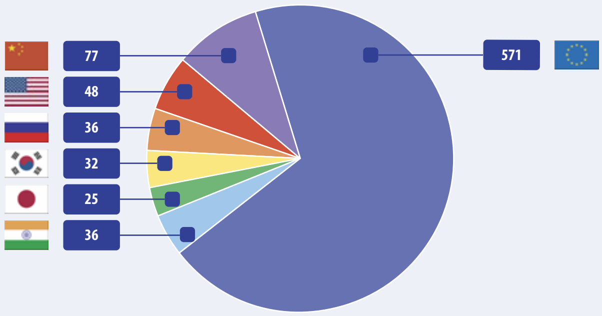
*** Includes 4 Monaco Postdoctoral Fellows and staff funded for work on the Tokamak cooling water system (23), vacuum system (2) and safety control system for nuclear (1).*

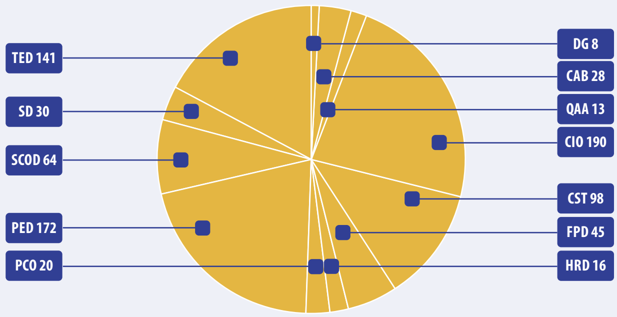
**** Includes 5 Monaco Postdoctoral Fellows and staff funded for work on the Tokamak cooling water system (27), vacuum system (2) and safety control system for nuclear (1).*

Staff By Organizational Unit as of 31 December 2017

	Professional & Higher	Support	TOTAL
DG	7	1	8
CAB	14	14	28
QAA	5	8	13
CIO	90	100	190
CST	76	22	98
FPD	21	24	45
HRD	8	8	16
PCO	15	5	20
PED	120	52	172
SCOD	54	10	64
SD	21	9	30
TED	113	28	141
TOTAL	**544**	**281**	**825**

** For the full names of organizational units, see page 72.*





Budgetary tables

Amounts in thousands of Euro

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

BUDGET HEADINGS		Total Commitment Appropriations 2017 1	De-commitments and Transfers of previous years' Total Commitments 2	Total Actual Commitments 2017 3	Unused Commitment Appropriations carried forward to 2018 4 = 1 + 2 - 3
Title I	*Direct Investment (Fund)*	*285,683*	*25,376*	*257,523*	*53,536*
Title II	*R&D Expenditure*	*1,347*	*226*	*355*	*1,219*
Title III	*Direct Expenditure*	*205,227*	*6,029*	*182,886*	*28,370*
TOTAL COMMITMENTS		492,257	31,631	440,764	83,125

** Excluding Reserve Fund*

Budgetary tables (continued)

Amounts in thousands of Euro

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

BUDGET HEADINGS		Total Payment Appropriations 2017 1	Total Actual Payments 2017 2	Unused Payment Appropriations carried forward to 2018 3 = 1 – 2
Title I	*Direct Investment (Fund)*	*179,543*	*121,051*	*58,492*
Title II	*R&D Expenditure*	*4,249*	*2,877*	*1,372*
Title III	*Direct Expenditure*	*209,637*	*163,914*	*45,724*
TOTAL PAYMENTS		**393,429**	**287,841**	**105,588**

** Excluding Reserve Fund*

Contributions from Members

	Cash and Short-Term In Kind			
MEMBERS	**Cash** **1**	**Task Agreements and Secondments** **2**	**Procurement Arrangements** **3**	**TOTAL** **4 = 1 + 2 + 3**
Euratom	190,362	4,464	72,148	266,974
People's Republic of China	22,730	-	15,548	38,278
Republic of India	-	-	17,324	17,324
Japan	36,731	-	56,360	93,091
Republic of Korea	25,093	-	5,586	30,679
Russian Federation	43,038	-	17,174	60,212
United States of America	-	1,715	30,236	31,951
TOTAL CONTRIBUTIONS	**317,955**	**6,179**	**214,376**	**538,510**

Cumulative In-Kind Payments through 31 December 2017

	Procurement Arrangements	
MEMBERS	**IUA ***	**in million EUR**
Euratom	**252,331**	**419.52**
People's Republic of China	**89,505**	**150.95**
Republic of India	**45,733**	**76.54**
Japan	**220,710**	**367.82**
Republic of Korea	**64,691**	**108.03**
Russian Federation	**78,848**	**132.71**
United States of America	**57,023**	**95.49**
TOTAL	**808,841**	**1,351.05**

** ITER Unit of Account*

These tables show tabulations in thousands of Euros which could cause minor differences due to rounding.

The assembly of the ITER cryostat is progressing under the responsibility of the Indian Domestic Agency, whose procurement scope includes the fabrication, assembly, and welding and testing of the four major sections of the cryostat as well as final in-pit installation and welding.

DOMESTIC AGENCY HIGHLIGHTS

Procurement highlights key

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

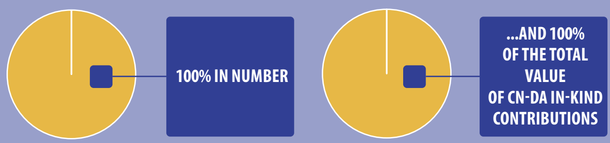
The figures on the following pages are adjusted annually for changes in credit value due to Procurement Arrangement Refinements (PAR) and Additional Direct Investments (ADI) related to Project Change Requests. Please note that 2017 figures supersede all previously published figures.

ITER CHINA (CN-DA)

www.iterchina.cn

PROCUREMENT ARRANGEMENTS*

Fourteen PAs signed since 2007 representing…



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

Chinese procurement highlights in 2017 — % of ITER system procured by China

MAGNET SYSTEMS

Toroidal Field Conductor — 7.5%
- All 11 conductor unit lengths completed and delivered in 2016

Poloidal Field Conductor — 65%
- All conductor fabrication completed for PF4
- 9 conductor unit lengths delivered to EU-DA at ITER site

Magnet Supports — 100%
- First toroidal field gravity support (GS) production unit successfully passed helium leak testing; two other units fabricated
- Completed first batch of poloidal field coil supports (PFCS) and calibration coil supports (CCS)
- Series production officially launched (GS/PFCS/CCS)

Feeders — 80%
- Most qualification tasks completed; only qualification of S bend and high temperature superconducting current leads remains
- Manufacturing readiness assessments held
- Cryostat feedthrough for PF4 delivered to IO **(IC milestone)**

Correction Coils — 100%
- Cold test contract for bottom correction coil 1 (BCC1) and side correction coil 1 (SCC1) awarded
- Most qualification tasks completed; only qualification of case enclosure laser welding remains
- Completed two bottom correction coil windings (BCC5, BCC6) on time
- First vacuum pressure impregnation insulation carried out on BCC1

Correction Coil and Feeder Conductors — 100%
- All correction coil and feeder conductors delivered in 2016

POWER SYSTEMS

Pulsed Power Electrical Network (PPEN) — 100%
- All components of PPEN sub-package delivered to ITER site

AC/DC Converters — 55%
- 5 rectifier transformers delivered
- 9 sets of AC/DC converters passed FAT; 4 units ready for shipping

Reactive Power Compensation — 100%
- First unit passed integrated test and is ready for shipment

BLANKET

Blanket First Wall — 12.6%
- Completion of semi-prototype pre-qualification program
- First wall process qualification contract signed

Blanket Shield Block — 50.2%
- Fabrication of full-scale prototype completed

FUEL CYCLE

Gas Injection System — 100%
- Contract for mass flow controller R&D and manufacturing signed
- Preliminary design of gas valve boxes ongoing
- Manifold MRR completed

Glow Discharge Cleaning — 100%
- Preliminary design of temporary/permanent electrodes ongoing

DIAGNOSTICS

Diagnostics — 3.2%
- Final design of fission chamber and electronics in equatorial port 7 (EQ#7) ongoing; FDR closure for support frame ongoing
- PDR closure report approved for radial x-ray camera; final design launched
- PDR for EQ#12 port integration held
- Preliminary design of divertor Langmuir probe ongoing

Abbreviations • **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

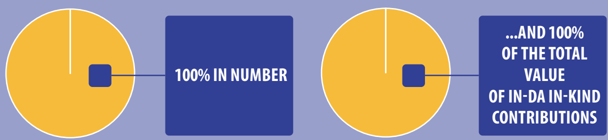
* Does not include Complementary Diagnostic Arrangements

ITER INDIA (IN-DA)

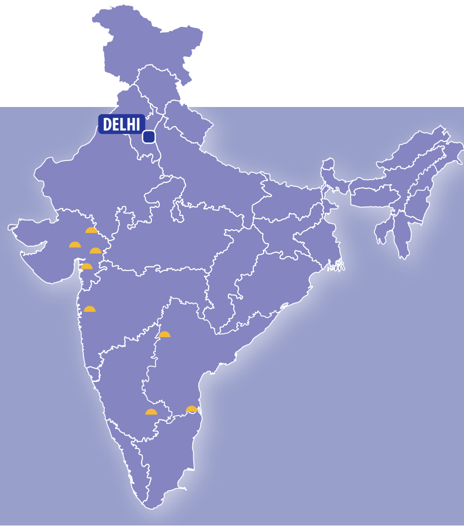
www.iter-india.org

PROCUREMENT ARRANGEMENTS*

Fourteen PAs signed since 2007 representing…



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



Indian procurement highlights in 2017 | **% of ITER system procured by India**

CRYOSTAT

Cryostat — 100%

- Manufacturing and FAT completed on lower cylinder tier-1 and tier-2; all segments delivered to ITER
- Sub-assembly (fabrication/welding) and testing activities progressing on base and lower cylinder in on-site Cryostat Workshop; tier-1 base section completed
- Upper cylinder fabrication underway in India; top lid mockup approved

CRYOGENIC SYSTEMS

Cryolines & Cryodistribution — 100%

- PDR, FDR and MRR carried out for several batches of cryoline and cryodistribution components
- Several batches of Y-group cryolines, X-group cryolines, and warmlines manufactured and delivered

HEATING & CURRENT DRIVE SYSTEMS

Diagnostic Neutral Beam (DNB) Power Supply and Beam Line — 100%

- Manufacturing of beam source and beam line components in progress
- Development of large-diameter ceramic ring carried out

NBTF Components (beam dump and 100 KV power supply) — 2%

- Delivery, installation and testing of SPIDER components completed
- Integration underway in lab of high voltage transmission with high voltage deck
- 100 kV power supply installed and tested in lab
- 100 kV power supply (acceleration grid) installed and tested at SPIDER

Ion Cyclotron Radio Frequency (RF) Power Sources — 100%

- R&D and experimental activities completed on diacrode-based system
- R&D activities and high power operation are in progress on tetrode-based system

Ion Cyclotron Heating & Current Drive RF Power Supply (8 out of 10) — 44%

- Prototype high voltage power supply tested

Electron Cyclotron High Voltage Power Supply — 30%

Electron Cyclotron RF Power Sources (2 gyrotrons out of 24) — 8%

- Finalization of contract in progress for ITER-relevant test gyrotron and waveguide set for the ITER India gyrotron test facility
- Domestic R&D/experimental activities in progress

COOLING WATER SYSTEMS

Heat Rejection System, Component Cooling Water System, Chilled Water System — 100%

- MRRs completed for valves, pumps and other electrical/mechanical/instrumentation items
- Piping deliveries continue
- Batches of chillers, heat exchangers, valves, and structural supports delivered to IO

VACUUM VESSEL

In-Wall Shielding Block Assemblies — 100%

- Fabrication and FAT conducted for several batches of components
- Shipments sent to vacuum vessel manufacturers
- Fabrication in progress on rest of scope

DIAGNOSTICS

Diagnostics — 3.1%

- Experiments carried out on fast-scanning Fourier transform spectrometer
- R&D and experiments on a number of diagnostic systems
- System integration review activities carried out

Abbreviations • **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

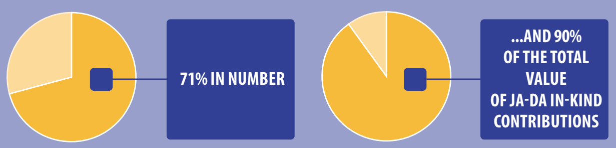
* Does not include Complementary Diagnostic Arrangements

ITER JAPAN (JA-DA)

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

PROCUREMENT ARRANGEMENTS*

Twelve 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 2017	% 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%
■ Completion of first toroidal field winding pack **(IC milestone)**; insulation successfully completed	
■ Series production underway	
Toroidal Field Magnet Structures	100%
■ First coil case fabrication successfully completed	
■ Material procurement and coil structure production underway; first intercoil structures produced	
■ First large-scale fitting trials completed successfully (gap tolerances < 1 mm)	
Central Solenoid Conductor	100%
■ Fabrication of all conductor unit lengths completed	
■ 45 unit lengths shipped to US-DA, cumulative (91%)	
HEATING & CURRENT DRIVE SYSTEMS	
ITER & Neutral Beam Test Facility (NBTF) High Voltage Bushing	100%
and accelerator	33%
■ Procurement activities completed in 2017 for high voltage bushing	
Neutral Beam Power Supply System for ITER and NBTF	59%
■ Completion of manufacturing and shipping of all power supply components	
■ 90% of installation work completed at NBTF site	
Electron Cyclotron Radio Frequency Power Sources (8 gyrotrons out of 24)	33%
■ FAT underway on two gyrotrons	
■ FAT on 1MW output completed successfully	
■ Manufacturing of gyrotron auxiliary part 1 components completed	
■ Manufacturing of gyrotron auxiliary part 2 components underway	
■ FDR of anode and body power supply completed	
■ MRR of mirror optical units and cooling manifolds completed	
Electron Cyclotron Equatorial Launcher	71%
■ Multilayer bellows prototype test underway for movable mirror steering mechanism	
■ Proof-of-principle test completed on new angle detector for movable mirror	
■ Final design of equatorial launcher in progress	
REMOTE HANDLING	
Blanket Remote Handling System	100%
■ Closing procedure for package #1 FDR (main components) underway	
■ Final design for package #2 (rail deployment system) and #3 (control system, tools) underway	
DIVERTOR	
Outer Target	100%
■ Updated strategy on full tungsten divertor approved through project change request; tender phase ready for launch	
■ Entry into force of Procurement Arrangement amendment	
■ Contract awarded for prototype materials	
TRITIUM PLANT	
Atmosphere Detritiation System	50%
■ Progression on qualification activities: performance test of shaken scrubber column completed	
■ Joint JA-DA/IO procurement activities proceeding	
DIAGNOSTICS	
Diagnostics	14.2%
■ Neutron irradiation tests for micro fission chamber in progress	
■ Optical train test completed for poloidal polarimeter	
■ YAG laser development for edge Thomson scattering	
■ Contracts awarded for infrared IR thermography (prototyping and final design) and micro fission chamber (prototyping of feedthrough; design of ex-vessel components)	
■ PDRs held for divertor impurity monitor and IR thermography	

Abbreviations • **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

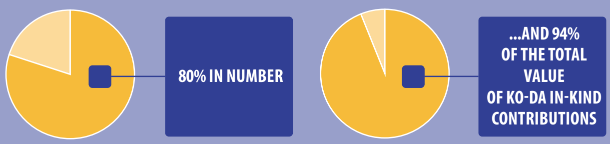
* Includes Complementary Diagnostic Arrangements

ITER KOREA (KO-DA)

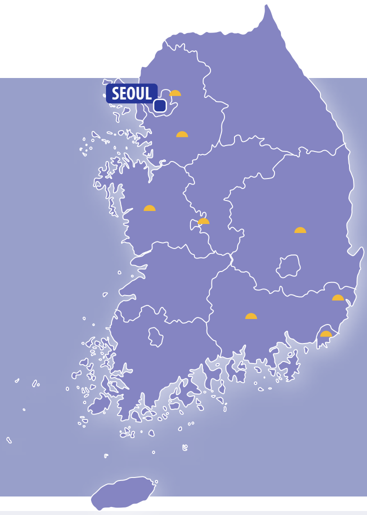
www.iterkorea.org

PROCUREMENT ARRANGEMENTS*

Eight PAs signed since 2007 representing…



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



Korean procurement highlights In 2017 — **% of ITER system procured by Korea**

VACUUM VESSEL

Main Vessel (2 of 9 segments) — 21.26%
- Material manufacturing/fabrication activities underway for Sectors #7 and #8
- Fabrication activities underway for Sector #6 (78% complete) and Sector #1 (51% complete)
- First vacuum vessel segment (inboard segment PS1 for Sector #6) realized **(IC milestone)**

Equatorial Ports — 72.92%
- Neutral beam port stub extension and in-wall shielding manufacturing in progress
- Manufacturing design ongoing for neutral beam port extension, connecting duct and regular port

Lower Ports — 100%
- Lower port stub extension and port extension manufacturing underway
- Completed pipe manufacturing for local penetration

BLANKET

Blanket Shield Block — 49.82%
- Process qualification started with shield block (SB) SB06 type A module (full-scale prototype)
- Contracts signed for raw material, manufacturing, and sub-component FAT

POWER SYSTEMS

AC/DC Converters — 37.17%
- AC/DC converter FAT completed for correction and vertical stability coils; equipment shipped
- Completed FAT of first AC/DC converter transformer for central solenoid
- Master controller FAT completed for toroidal field power supply

In-Vessel Coil Power Supply (busbars) — 100%
- Agreement reached to transfer scope to IO

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%
- Welding of vacuum vessel thermal shield sector#6 completed
- Final machining of lower cylinder thermal shield completed
- Manufacturing drawing of manifold (first batch) approved
- Qualification of silver coating process drawing to a close

ASSEMBLY TOOLING

Machine Assembly Tooling — 100%
- IO receiving inspection completed for sector sub-assembly tool (SSAT) #1 **(IC milestone)**
- Fabrication of SSAT#2 completed
- Two assembly tool contracts awarded (for 18 tools and 21 tools respectively)

TRITIUM PLANT

Tritium Storage & Delivery — 94.24%
- Storage and delivery system process flow diagram in revision phase; number of beds determined
- Tritium inventory calorimetry, helium 3 recovery process validation ongoing

DIAGNOSTICS

Diagnostics — 2%
- PDR held for upper port #18 integration
- PDR held for neutron activation system (NAS) port components
- Prototype test of vacuum ultra-violet spectrometer and NAS on KSTAR tokamak proceeding
- Development and testing of key diagnostic components

Abbreviations • **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

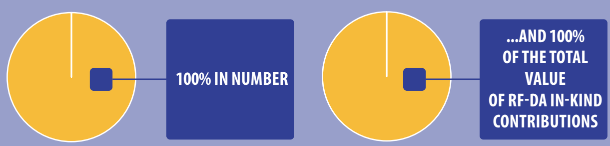
* Does not include Complementary Diagnostic Arrangements

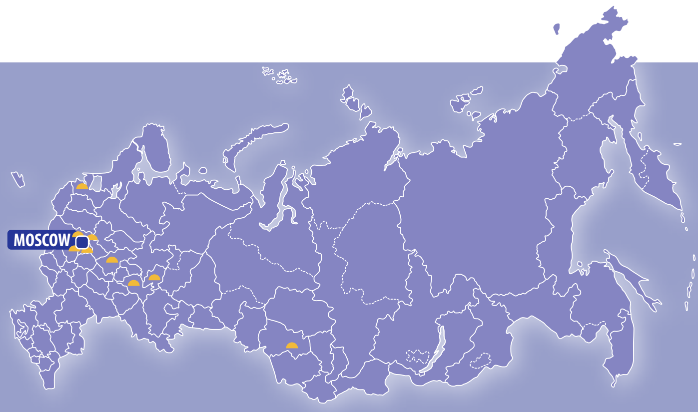
ITER RUSSIA (RF-DA)

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 2017 — **% of ITER system procured by Russia**

POWER SYSTEMS

Switching Network, Fast Discharge Units, DC Busbar and Instrumentation — **100%**
- FDR held for switching network unit and switching components
- Second and third deliveries made to ITER (busbars, flexible links, rigid inserts, cooling water connectors, busbar boxes and supports) following successful testing
- Manufacturing ongoing for busbar system components (busbars, copper links, supports …)
- FAT procedures and type test reports approved by IO

MAGNET SYSTEMS

Toroidal Field Conductor — **19.3%**
- All conductor unit lengths completed and delivered to EU-DA in 2015

Poloidal Field Conductor — **20%**
- Fabrication and testing completed in 2017
- Tests at SULTAN facility fully completed

Poloidal Field Magnet No.1 — **100%**
- 4 double pancakes wound; 3 impregnated
- Full-size joint sample successfully tested; SULTAN test report approved
- Tail sample manufactured and tested

BLANKET

Blanket First Wall — **40%**
- First wall fingers with beryllium armour manufactured for qualification, optimal technology developed
- High heat flux (4.7 MW/m^2) testing of semi prototype first wall fingers (including extra testing at 5.9 MW/m^2) conducted

Blanket Module Connectors — **100%**
- Documentation packages for production materials approved by IO
- End-of-manufacturing reports (316L, CuCrZr) approved by IO
- CuCrZr/316L bonded joint and LFC/AS coating pre-qualification programs partially completed

DIVERTOR

Dome — **100%**
- Design, manufacturing drawings and MIP approved by IO for outer particle reflector plate and umbrella and stainless steel support structure plasma-facing units (PFUs)
- Special operations jigs manufactured
- New vacuum furnaces commissioned for post-weld heat treatment and baking
- Inner particle reflector plate (IPRP) PFUs manufactured for full-scale prototype

Plasma-Facing Component Tests — **100%**
- High heat flux test protocol and MIP approved by IO for full-scale IPRP PFUs
- Test assembly designed for high heat flux testing (HHF) of IPRP full-scale prototype PFUs
- Test assembly for HHF testing of IPRP full-scale prototype PFUs manufactured

VACUUM VESSEL

Upper Ports — **100%**
- Manufacturing dossier and FAT procedures completed for first upper port stub extension (PSE12)
- Delivery of PSE12 to Korea; eight others in production
- Manufacturing dossier and FAT procedures prepared for PSE2
- Materials for port stub extension manufacturing and assembly procured

Port Plug Test Facility (PPTF) — **100%**
- Progress on non-nuclear PPTF design; procurement of vacuum system components
- Progress on nuclear PPTF design; calculation of pressure suppression system
- Finalizing sealing mockup testing

DIAGNOSTICS

Diagnostics — **17%**
- PDRs held for divertor Thomson scattering, H-alpha spectroscopy, equatorial port 11 integration, and upper vertical neutron camera
- Progress on R&D mockups
- Mirror cleaning technique developed for charge exchange recombination spectroscopy
- Diamond detectors developed for neutral particle analyzer and vertical neutron camera

HEATING & CURRENT DRIVE SYSTEMS

Electron Cyclotron Radio Frequency Power Sources (8 gyrotrons out of 24) — **33%**
- FAT completed on first gyrotron set, successfully demonstrating reliable operation at 1 MW for 1000 seconds
- Second gyrotron set manufactured, preliminary tests completed
- Purchases carried out for third gyrotron set manufacturing

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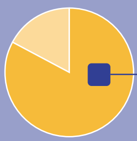
US ITER (US-DA)

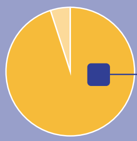
www.usiter.org

PROCUREMENT ARRANGEMENTS*

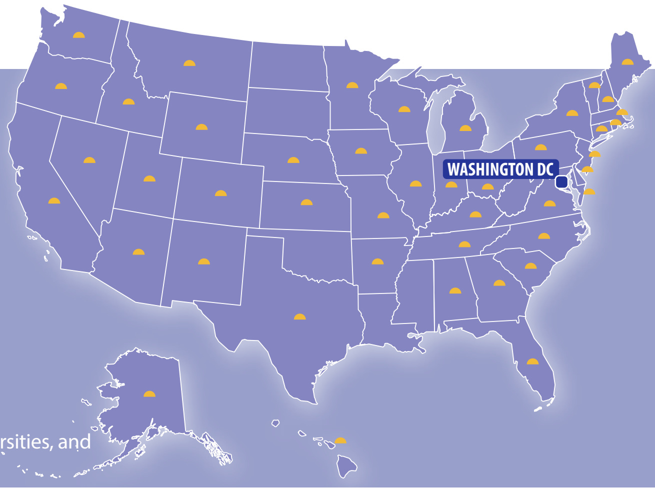
Fifteen PAs signed since 2007 representing…



83% IN NUMBER



…AND 95% OF THE TOTAL VALUE OF US-DA IN-KIND CONTRIBUTIONS



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

US procurement highlights In 2017	**% of ITER system procured by the US**
COOLING WATER SYSTEM	
Tokamak Cooling Water System	100%
■ Delivered bulk piping material to ITER site	
■ Completed FDR for First Plasma hardware	
■ Procurement of valves has started	
MAGNET SYSTEMS	
Central Solenoid (CS) Modules, Structure and Assembly Tooling	100%
■ 4 of 7 modules in fabrication; heat treatment phase successfully completed on first module	
■ Delivered assembly platform to ITER	
■ Fabrication underway on lifting fixture	
■ Continued fabrication of structure lower key blocks, outer tie plates, tensioning components, upper components, and early-need components	
Toroidal Field Conductor	8%
■ All deliveries completed and accepted in 2017	
DIAGNOSTICS	
Port-Based Diagnostic Systems	14%
■ Prototype components in fabrication for upper port wide-angle view visible infrared camera	
■ Prototypes in fabrication for low field side reflectometer; test stand assembly established	
■ Mirror-cleaning R&D continues for motional stark effect diagnostic system	
HEATING & CURRENT DRIVE SYSTEMS	
Ion Cyclotron Transmission Lines	88%
■ Completed FDR for First Plasma hardware	
■ Completed FDR for I&C First Plasma hardware	
Electron Cyclotron Transmission Lines	88%
■ Detailed drawings in preparation for 50 mm inner diameter transmission line components	
FUEL CYCLE	
Vacuum Auxiliary and Roughing Pump Stations	100%
■ Completed final delivery of vacuum acceptance test equipment to ITER	
■ Delivered first batch of piping vacuum flanges and pipe supports	
■ Completed CDR for vacuum auxiliary and roughing pumps systems	
■ Completed FDR for vacuum auxiliary main piping (levels 3 and 4)	
■ Roughing Pump Sets Procurement Arrangement drafted by IO and in review by US-DA	
Pellet Injection System	100%
■ Completed PDR of First Plasma hardware	
Disruption Mitigation System	100%*
■ Shattered pellet injector prototype components tested and delivery underway to JET	
TRITIUM PLANT	
Tokamak Exhaust Processing System	88%
■ Completed PDR	
POWER SYSTEMS	
Steady State Electrical Network	75%
■ All deliveries completed	

**Up to a capped value*

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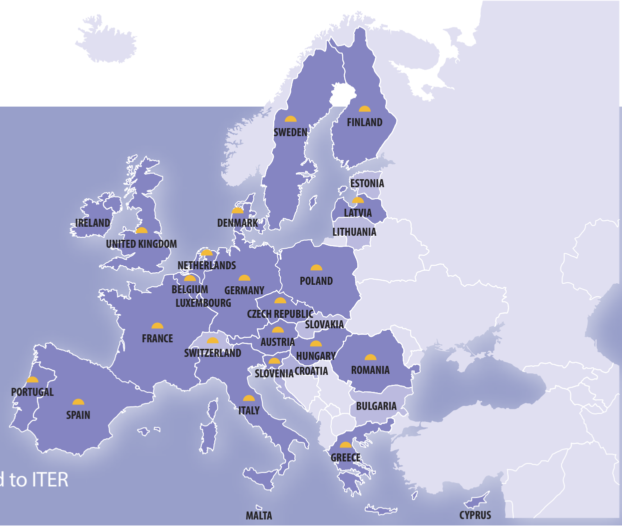
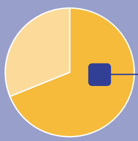
FUSION FOR ENERGY (EU-DA)

www.fusionforenergy.europa.eu

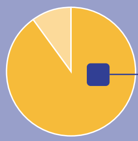


PROCUREMENT ARRANGEMENTS*

Thirty-four PAs signed since 2007 representing…



69% IN NUMBER



…AND 90% OF THE TOTAL VALUE OF EU-DA IN-KIND CONTRIBUTIONS

The EU has awarded 654 research, design or fabrication contracts (59 in 2017) related to ITER procurement to universities, laboratories and industry since 2007.

EU procurement highlights In 2017 — **% of ITER system procured by EU**

BUILDINGS

Building Construction, Tokamak Pit Excavation and Drainage, Ground Support Structure, Seismic Isolation Pads — 100%
- Anti-seismic bearings completed in 2012
- Assembly Hall Building delivered "ready for equipment" **(IC milestone)**
- Cleaning, Site Services, Cryoplant buildings delivered "ready for equipment"
- Cooling water basin structure ready to host cooling towers
- Work has started on Tokamak Building level 3 (L3) and concrete crown

Architect Engineer Services — 100%
- Tokamak Complex civil works construction design delivered all levels
- Tokamak Complex building services final design approved

ITER Headquarters — 53.5%
- Headquarters building completed in 2012

MAGNET SYSTEMS

Toroidal Field Conductor — 20%
- All conductor unit lengths completed in 2016

Toroidal Field Magnet Windings (10 out of 19) — 53%
- Last radial plate delivered (70/70)
- First toroidal field winding pack delivered to insertion facility
- Series production well underway: second winding pack completed, 70/70 double pancakes wound, 67/70 heat treated and transferred to radial plates, 50/70 impregnated
- Winding pack and coil case inspection tooling, cryo-facility, one assembly rig and gap-filling facility commissioned

Pre-Compression Rings — 100%
- Two manufacturing processes are running in parallel: automated filament placement technology (80% of qualification completed); pultrusion technology (2 out of 3 mockups successfully tested, winding machine installed)

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

Poloidal Field Magnets No. 2-6 — 100%

PF2-5 (manufactured at ITER site):
- Dummy double pancake: component qualification, winding, termination completed on site
- First two double pancakes wound for PF5; vacuum pressure impregnation (VPI) started
- Installation of 400-tonne gantry crane

PF6 (manufactured for EU-DA in China):
- 6 out of 9 double pancake windings completed; VPI completed on 4
- Trial stacking of winding pack with first double pancakes

HEATING & CURRENT DRIVE SYSTEMS

Power Supply Heating Neutral Beam — 35%
- SAT completed for high voltage deck bushing assembly and high voltage deck
- FAT completed for acceleration grid power supply conversion system
- Ownership of SPIDER high voltage deck and transmission line formally transferred to IO
- Ion source and extraction power supplies (ISEPS) for SPIDER accepted; ownership transferred to IO

Neutral Beam Test Facility (NBTF) Components — 64.7%
- SAT completed for SPIDER cooling plant and shared parts with MITICA
- MITICA SF6 plant accepted by IO
- SPIDER beam source installed in vacuum vessel
- MITICA high voltage bushing support structure installed
- Framework contract signed for procurement of MITICA beam line components
- Completion of SPIDER gas and vacuum system

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%
- Development of Ti-SS rotary friction welding completed
- Cold spraying of copper on titanium Gr5 completed
- Consultation for hydrogen embrittlement of Ti-SS joints performed
- Task Order for design simplification signed

Electron Cyclotron Control System — 100%
- High power testing facility set up; gyrotron installed
- Task Order signed for plant control prototypes

Electron Cyclotron High Voltage Power Supply — 62%
- FAT for first unit performed, with performance exceeding specification

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* Does not include Complementary Diagnostic Arrangements

EU procurement highlights In 2017

% of ITER system procured by EU

Electron Cyclotron Upper Launchers — 76%
- Pressure tests of diamond disk brazing mockups performed
- Contracts signed for procurement of blanket shield module prototype (for exploration of connections) and corrugated waveguide mockups
- Framework contract signed for nuclear safety, analysis and engineering verification
- Diamond disk FDR meeting held

Electron Cyclotron Radio Frequency (RF) Power Sources (6 gyrotrons out of 24) — 25%
- SAT for cryo-free magnet completed
- PDR performed for gyrotron cooling system

VACUUM VESSEL

Main Vessel (5 of 9 segments) — 55%
- All materials for sectors 5, 4 and 3 are at manufacturing site
- Fabrication initiated for all sectors; first sub-segment assembly completed for sector 5 **(IC milestone)**
- Reinforcement of consortium through three additional main sub-contractors
- First welding activities

DIVERTOR

Inner Vertical Targets — 100%
- First full-scale prototype produced
- Stage 2 launched for pre-qualifying additional suppliers

Cassette Body and Assembly — 100%
- Two full-scale prototypes completed; hot helium tests passed successfully
- Transfer of scope agreement signed with IO for diverter integration activities (plasma-facing components and diagnostics)

In-Vessel Divertor Remote Handling Equipment — 100%

Divertor Rail — 100%

BLANKET

Blanket First Wall — 47.4%
- Procurement Arrangement for Blanket First Wall (normal heat flux panels) signed in September
- Development of three full-scale prototypes underway by different suppliers

Blanket Cooling Manifolds — 100%
- Two contracts awarded for the manufacture and testing of "bolted support" design concept prototypes

REMOTE HANDLING

In-vessel Divertor Remote Handling System — 100%
- Cassette toroidal mover preliminary design pack issued; R&D on hydraulic valve technologies completed

Cask and Plug Remote Handling System — 100%
- Preliminary design system specifications achieved

Neutral Beam Remote Handling System — 100%
- Operational concepts and main crane features identified

Common Technologies — 100%
- R&D phase 2 for rad-hard electronics started
- Stage 2 of development for GENROBOT framework software for equipment controllers

In-Vessel Viewing System — 100%
- Preparatory works completed; preliminary design has started

POWER SYSTEMS

Steady State Electrical Network (SSEN) and Pulsed Power Electrical Network (PPEN): Detailed System Engineering Design — 100%
- SSEN 400 kV and 22 kV switchyard design approved
- PPEN 400 kV switchyard design approved

Installation and Commissioning — 100%
- Energization of 400 kV switchyard **(IC milestone)**

Emergency Power Supply — 100%

SSEN Components — 25%

FUEL CYCLE

Front End Cryo-Distribution: Warm Regeneration Lines — 100%
- Procurement Arrangement for Front End Cryopump Distribution signed in April
- Manufacturing started

Front End Cryo-Distribution: Front End Cryopump Distribution — 100%

Cryopumps, Torus (6) and Cryostat (2) — 100%
- Pre-production vacuum cryopump delivered to ITER site for testing

Cryopumps, Neutral Beam — 100%

Leak Detection — 100%

TRITIUM PLANT

Water Detritiation System — 100%
- Approval of final design; start of manufacturing on four tanks

Hydrogen Isotope Separation System — 100%

CRYOPLANT

Cryoplant: LN2 Plant and Auxiliary Systems — 50%
- Installation started on site
- Contracts signed for procurement of Johnston couplings and quench line header

DIAGNOSTICS

Diagnostics — 25%
- Continuous External Rogowski coil delivered to ITER; SAT successful
- Seven Complementary Diagnostic Procurement Arrangements signed
- Contract signed for magnetics outer vessel coil sensor manufacturing
- Grant signed for final design of visible/IR wide-angle viewing system
- Contract signed for preliminary design of divertor remote handling connector
- Contract signed for final design of vacuum vessel feed-outs, and preliminary and final design of ports
- Preliminary design completed for magnetics instrumentation and control electronics
- Conceptual designs completed for high energy neutron spectrometer and radial gamma ray spectrometer
- Several contracts signed for prototyping of key components

RADIOACTIVE MATERIALS

Waste Treatment and Storage — 100%

Radiological Protection — 100%
- PDR completed for radiological and environmental monitoring

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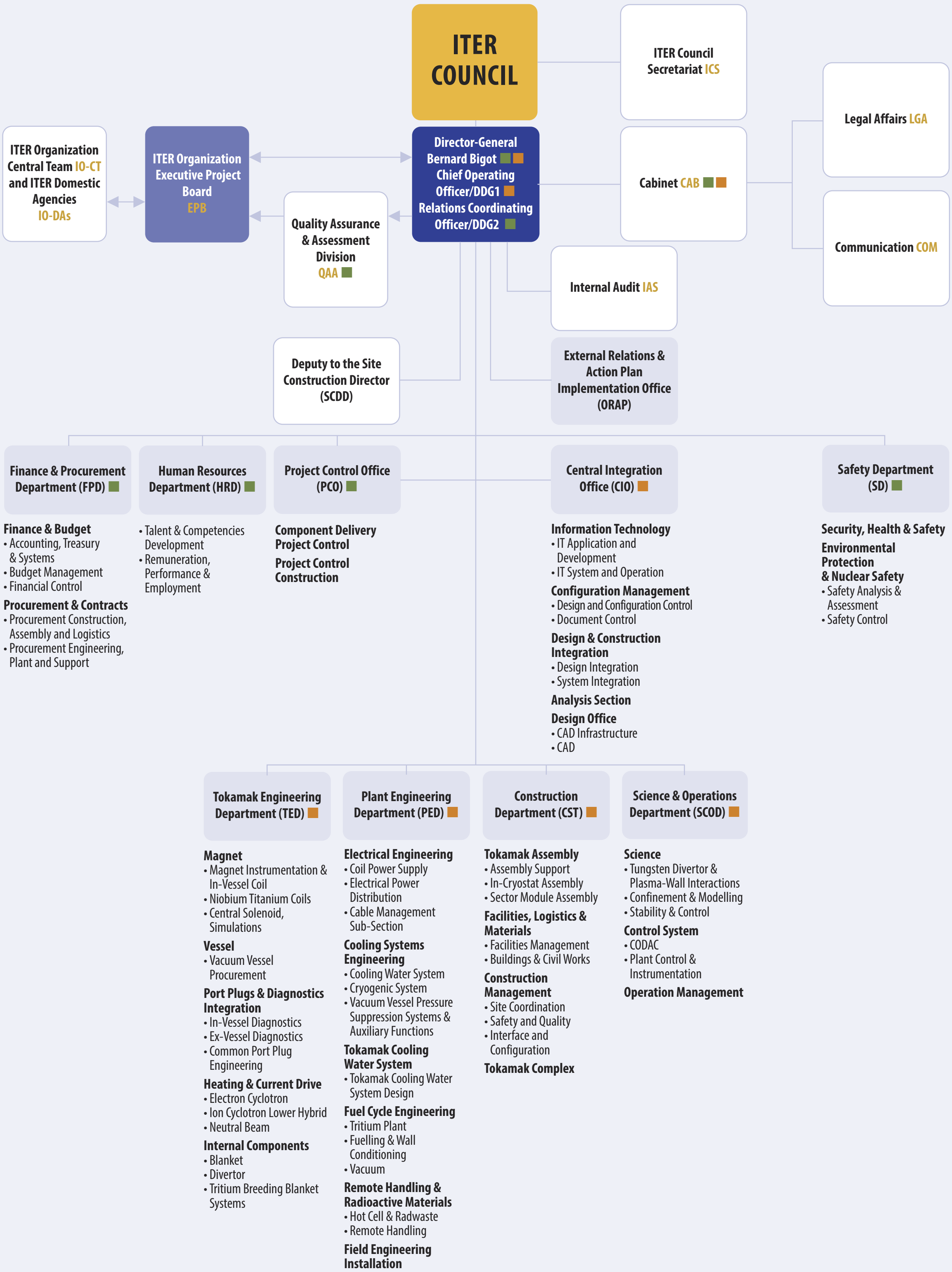
A last picture for the year – the ITER "planet" in December.
Photo: ITER Organization/EJF Riche

INTERNATIONAL COOPERATION

The following entities have signed Cooperation Agreements with the ITER Organization as of 31/12/2017.

International Organizations	
CERN (European Organization for Nuclear Research	**Switzerland**
ERIC (European Spallation Source European Research Infrastucture Consortium)	**Sweden**
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 Energie - 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**
Southwestern Institute of Physics (SWIP)	**China**
Instituto Superior Técnico (IST)	**Portugal**
SOcietà Gestione Impianti Nucleari (SOGIN-S.p.A)	**Italy**
The Ioffe Institute	**Russian Federation**
Barcelona Supercomputing Center	**Spain**
Universities	
Seoul National University	**Korea**
The Eindhoven University of Technology, TU/e	**Netherlands**
The National Research Nuclear University (Moscow Engineering Physics Institute MEPhI)	**Russian Federation**
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**
University of California, Los Angeles (UCLA)	**United States**
University of Bologna (Department of Electronic and Information Engineering, DEI)	**Italy**
University of Rome Tor Vergata, URTV	**Italy**
University of Kyushu	**Japan**
University of Sevilla	**Spain**
University of Columbia	**United States**
University of Peter the Great St. Petersburg Polytechnic	**Russian Federation**
National Schools	
Ecole Centrale 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**
National Nuclear Center of the Republic of Kazakhstan	**Kazakhstan**

ITER ORGANIZATION



This solid base will serve as a platform as six central solenoid modules are stacked and joined to form ITER's 1,000-tonne central electromagnet. ***Photo: US ITER***

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