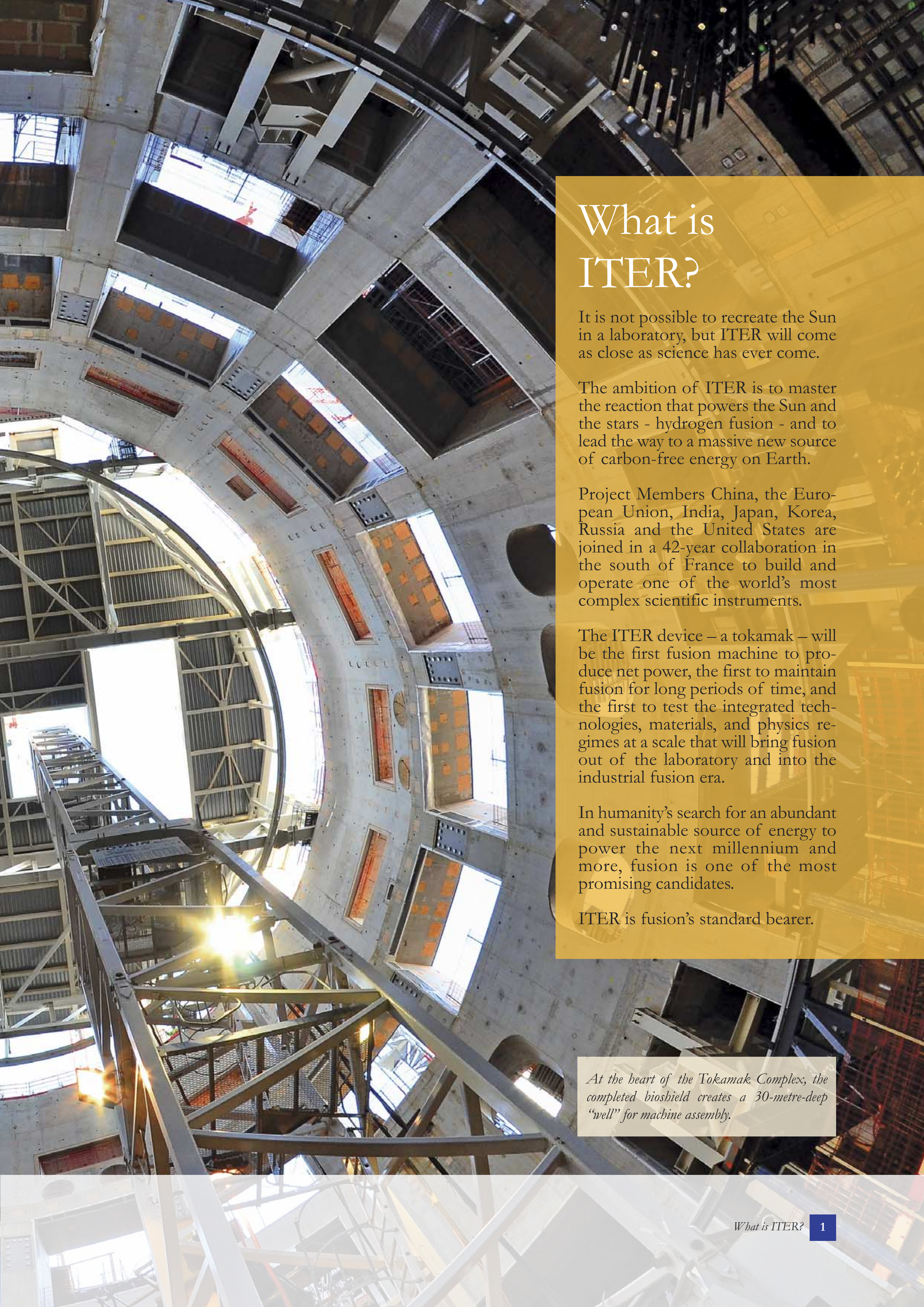
ITER ORGANIZATION

Annual Report 2018

china eu india japan korea russia usa

7	35	42	858	2025
Members	**nations**	**years**	**staff**	**First Plasma**



What is ITER?

It is not possible to recreate the Sun in a laboratory, but ITER will come as close as science has ever come.

The ambition of ITER is to master the reaction that powers the Sun and the stars - hydrogen fusion - and to lead the way to a massive new source of carbon-free energy on Earth.

Project Members China, the European Union, India, Japan, Korea, Russia and the United States are joined in a 42-year collaboration in the south of France to build and operate one of the world's most complex scientific instruments.

The ITER device – a tokamak – will be the first fusion machine to produce net power, the first to maintain fusion for long periods of time, and the first to test the integrated technologies, materials, and physics regimes at a scale that will bring fusion out of the laboratory and into the industrial fusion era.

In humanity's search for an abundant and sustainable source of energy to power the next millennium and more, fusion is one of the most promising candidates.

ITER is fusion's standard bearer.

At the heart of the Tokamak Complex, the completed bioshield creates a 30-metre-deep "well" for machine assembly.

ITER
An "international project that aims to demonstrate the scientific and technological feasibility of fusion energy for peaceful purposes, an essential feature of which would be achieving sustained fusion power generation." *(From Article 2 of the ITER Agreement)*

Project Members
The People's Republic of China, the European Atomic Energy Community (Euratom), the Republic of India, Japan, the Republic of Korea, the Russian Federation and the United States of America are the seven signatories to the ITER Agreement, which establishes the ITER Organization and defines the joint implementation of the ITER Project.

ITER Organization
Established to construct, operate, exploit and de-activate the ITER facilities in accordance with project objectives; encourage the exploitation of the ITER facilities by the laboratories, other institutions and personnel participating in fusion energy research and development programs of the Members; and promote public understanding and acceptance of fusion energy. *(Article 3)*

ITER Council
The governing body of the ITER Organization. The Council is responsible for the promotion and overall direction of the ITER Organization and has the authority to appoint the Director-General, to approve the Overall Project Cost (OPC) and Overall Project Schedule (OPS), to approve the annual budget, and to decide on the participation of additional states or organizations in the project. *(Article 6)*

Domestic Agencies
Each Member has created a Domestic Agency to fulfil its procurement responsibilities to ITER. These agencies employ their own staff, have their own budget, and contract directly with industry.

STAC
The Science and Technology Advisory Committee advises the ITER Council on science and technology issues that arise during the course of ITER construction and operation.

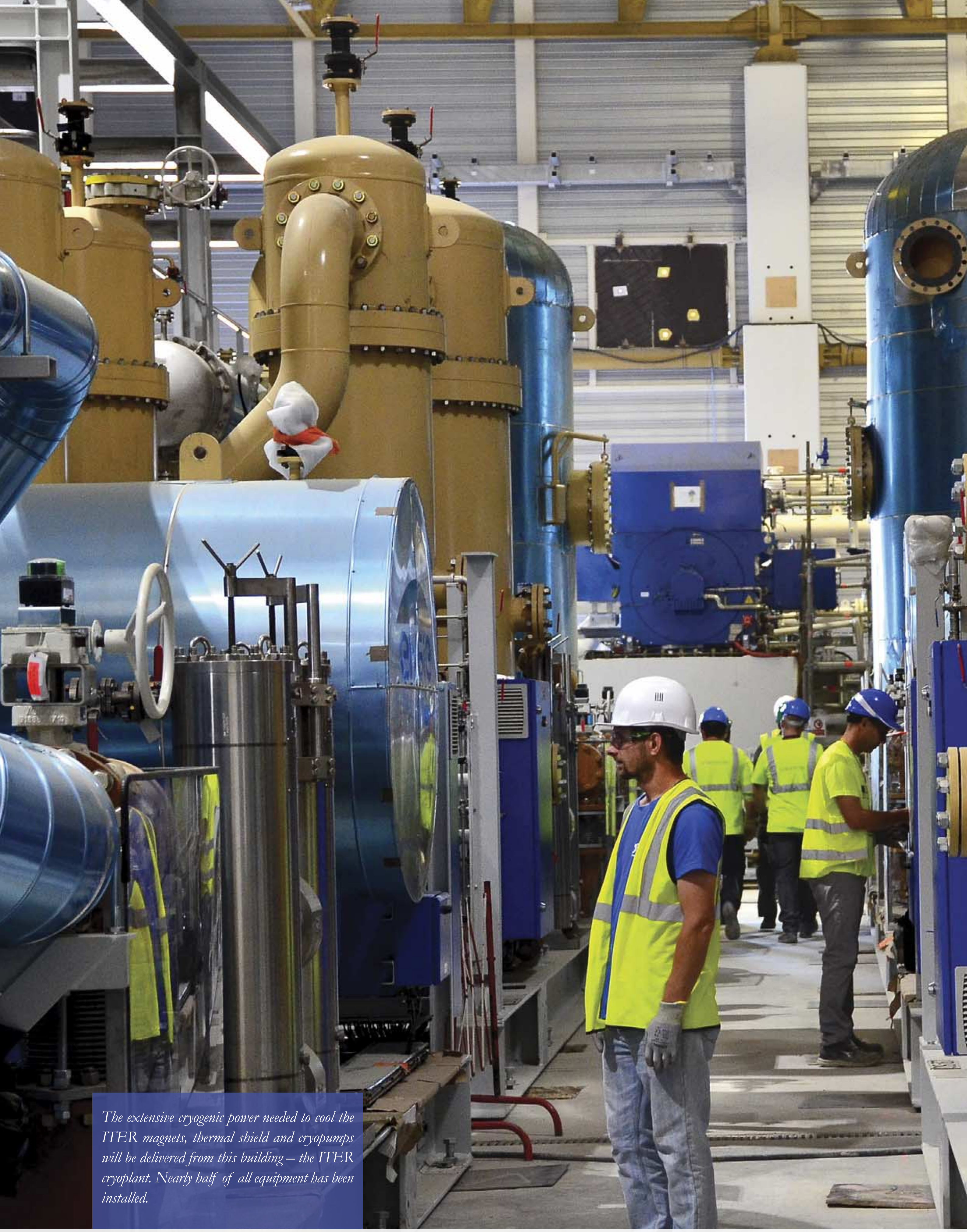
MAC
The Management Advisory Committee advises the ITER Council on management and administrative issues arising during the implementation of the ITER Project.

FAB
The Financial Audit Board (FAB) undertakes the audit of the annual accounts of the ITER Organization. *(Article 17)*

Management Assessor
A Management Assessor is appointed every two years by the ITER Council to assess the management of ITER Organization activities. *(Article 18)*

Contents

Thirty-one feeders will be positioned around the machine to feed electrical power and cryogens in to the magnets. At the lowest basement level of the bioshield, a first feeder segment has been installed in a bioshield opening.



The extensive cryogenic power needed to cool the ITER magnets, thermal shield and cryopumps will be delivered from this building – the ITER cryoplant. Nearly half of all equipment has been installed.

Foreword from the Chair of the ITER Council

In 2018, the project continued to maintain pace and performance at a level that is consistent with the Baseline established in 2016. In 2018, the project achieved 59.7% of overall physical progress to First Plasma.

Cooperation between the ITER Organization and the Domestic Agencies as a "One-ITER" team has been pivotal to this achievement. In a project as complex as ITER – with a high number of interfacing components, interlinked assembly sequences, and shared ownership of the schedule – transparency, effective communication and mutual support are the keys to success. We are able to witness this spirit among all Members.

The Revised Construction Schedule is one example of what "one team" can achieve. Within the overall Baseline, the Revised Construction Strategy optimizes the schedule and approach to centralizing machine assembly activities in the Tokamak Complex as a way to save time and cost. Another example is the temporary funding mechanism – the Inter-Organization Non-Conformity Resolution Mechanism – that has been agreed for any required adjustment or re-working of components that have already been delivered to the site. This mechanism anticipates problems that the project might encounter and proposes a framework for resolution. In 2019, the Terms of Reference and detailed processes of this mechanism will be proposed to the ITER Council for approval.

In the areas of risk analysis and management, interface control, and configuration management, In-Depth Independent Reviews carried out at the request of the ITER Council have confirmed that the project is on the right track.

The start of machine assembly in 2020 heralds a new chapter for the project, and Council is accompanying this transition by planning an In-Depth Independent Review in 2019 on the ITER Organization's strategy for assembly and installation. The project's critical and near-critical path continues to pass through the buildings, the vacuum vessel sectors, and the toroidal field coils, with building availability and transversal engineering works for the Tokamak Complex on the very-near critical path. The ITER Organization must continuously look for optimization of the schedule and cost containment in the execution of work contracts to maintain project performance. The Domestic Agencies, for their part, are strongly requested to stay committed to their in-kind and in-cash delivery schedules.

At each ITER Council meeting, Members reaffirm their strong belief in the value of the ITER's mission and vision, and resolve to work together to find timely solutions to facilitate ITER's success. This is the key to the success of this project. With the "One-ITER" team as the basis for all work, we will be able to achieve our goal in time. The Council will continue to closely monitor project performance, and to provide the support needed to maintain the required pace of achievement.

Arun Srivastava
St. Paul-lez-Durance
June 2019

This temporary lid will protect the machine assembly arena below until a permanent roof has been erected over the Tokamak Building.

Foreword from the Director-General

As I look back over the last four years, I am proud of what the dedicated and untiring management and staff at the ITER Organization and the Domestic Agencies have been able to achieve with the support of the ITER Members.

Together we have delivered a credible schedule; created the project control tools to monitor our schedule commitments and identify both risks and opportunities; developed funding mechanisms that speed up decision making processes; and transformed our way of working together. Despite challenges related to the size and unparalleled complexity of ITER as a first-of-a-kind machine, the collective atmosphere in the project is one of determination, anticipation and mutual trust across our One-ITER team as we move forward without discouragement, even when we are faced with difficulties in accomplishing our challenging mission and fulfilling the expectations of the ITER Members.

For every challenge, we have developed a solution. When it was recognized that the extensive assembly and installation activities in critical zones were better managed out of one central office, we reached agreement on the transfer of selected scope from the Domestic Agencies to the ITER Organization. When the agreed schedule for the completion of the Tokamak Building could no longer be respected and a similar issue with the delivery of the first vacuum vessel sector risked jeopardizing our overall project schedule, we reacted by optimizing assembly sequences, introducing parallel activity and tightening coordination to arrive at the same goal – First Plasma in December 2025 – through the Revised Construction Strategy. When challenges have arisen due to budgeting cycles in the ITER Members, we have shown we can temporarily reprioritize work to focus on critical path activities with the expectation that the ITER Members will successfully soon recover.

This gives me the confidence to say that – whatever hurdles lay ahead – the ITER Project is now well equipped to face them head on.

In 2018 the first mechanical and electrical installation activities began in the Tokamak Complex, the first machine component was lowered into the machine pit, and steps were taken to commission the first plant system – the steady state electrical distribution – for operation next year.

A large number of first-of-a-kind components (magnets, first vacuum vessel sector and ports, thermal shield, cryostat sections, heating gyrotrons, cryolines, assembly tooling) are nearing completion in Member factories and will be arriving over the next 36 months. The logistics team on site is preparing for the receipt, registration and storage of the loads, while system owners are readying the engineering work packages that will instruct installation contractors on how each "piece" or system fits into the machine.

Very little float exists on many of the critical construction and component milestones and we all know that delay to any one of them – which would not be unheard of in a first-of-a-kind project like ITER – could cause cascading delay in others. The commitment I have made to the ITER Council is to inform the Members immediately, in full transparency, if the delay cannot be recovered and our schedule goal becomes unattainable.

It is only with the complete confidence of our stakeholders that we can carry out our commitments. As one of the ITER Member delegates to Council stated recently to colleagues: "We are partners on a long journey to a new future." It do believe that the reward for the whole of humankind of a successful ITER Project is worth our best joint efforts.

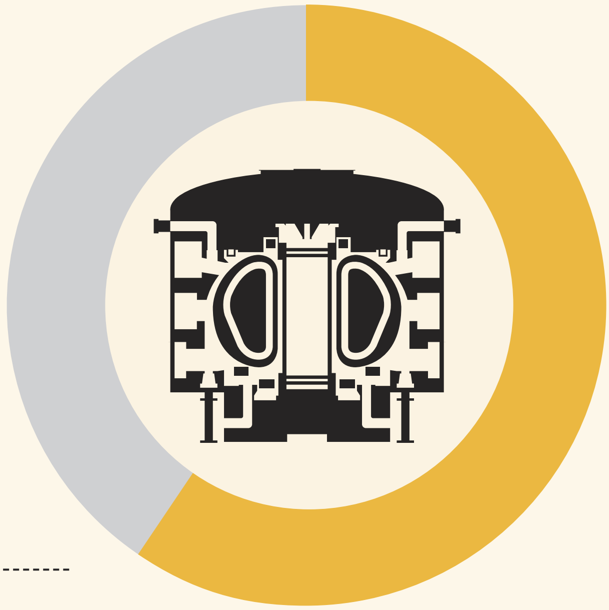
I thank you for your confidence.

Bernard Bigot
St. Paul-lez-Durance
May 2019

Year in review

Physical work achieved to First Plasma

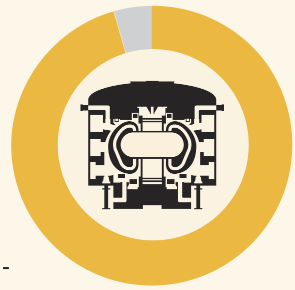
(design, component manufacturing, building construction, shipment and delivery, assembly and installation)



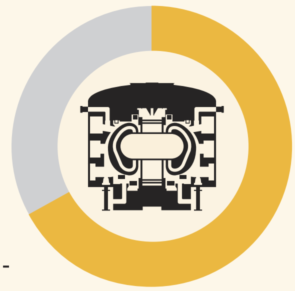
59.7%

Progress toward the realization of First Plasma systems and components

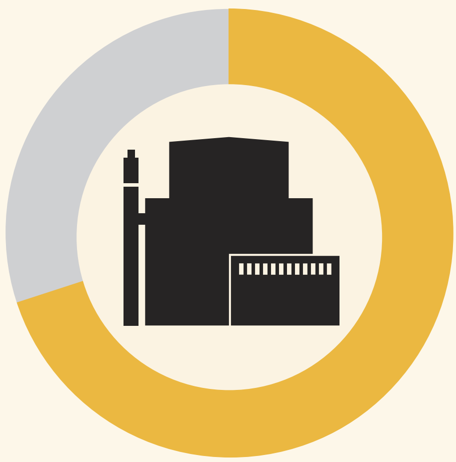
95.8%
of design
completed



67.2%
of manufacturing
completed



Building construction completed on site



70%
First Plasma scope

All figures and graphics as of 31 December 2018

2018

Procurement Arrangement signatures

83%

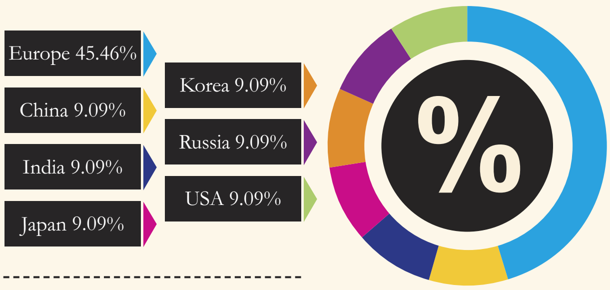
in number

93%

in value

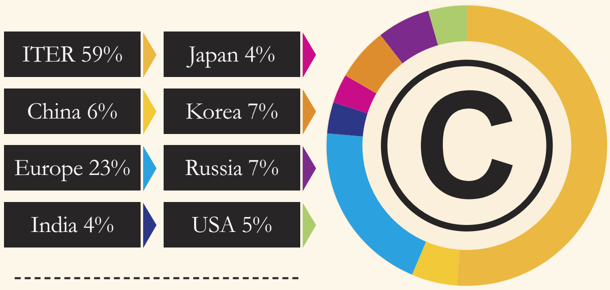
Project sharing by Member

(Construction phase)



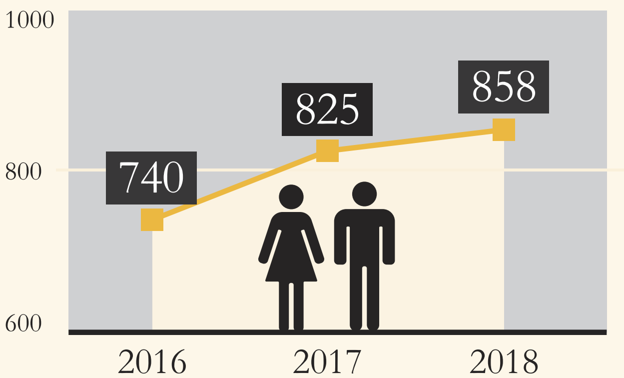
Intellectual property declarations

Declaration of "Generated Intellectual Property," cumulative



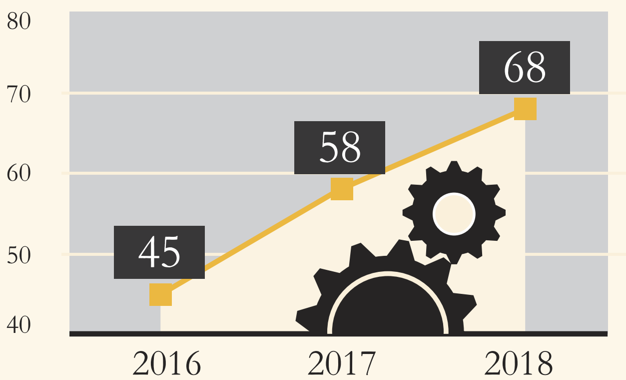
Staff

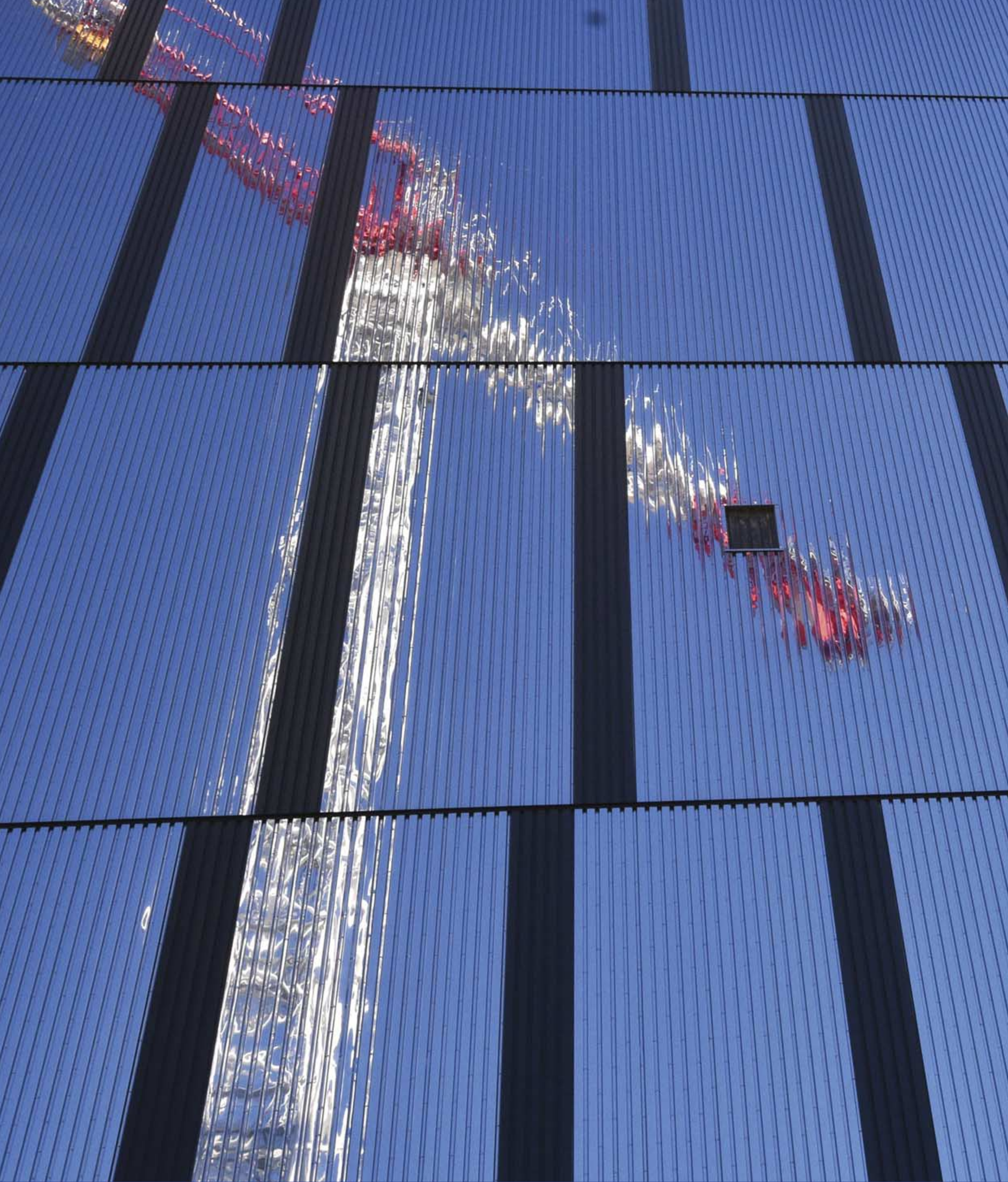
(see page 42)



Cooperation Agreements

(see page 55)

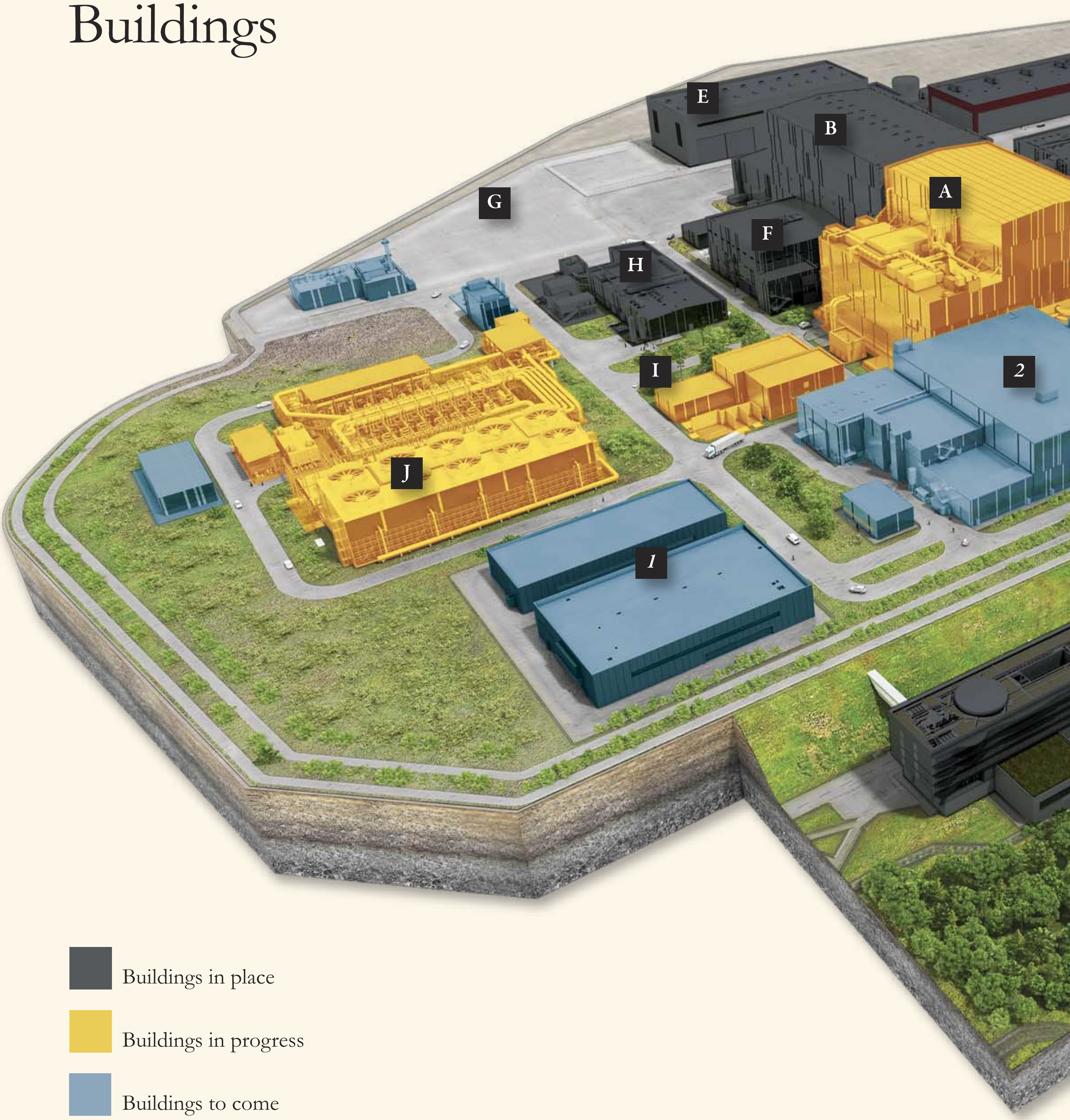




42-hectare	39 buildings	70%	1,900	14,000
construction platform	**and technical areas**	**construction completed (First Plasma scope)**	**workers**	**visitors**

2018 Construction update

Buildings

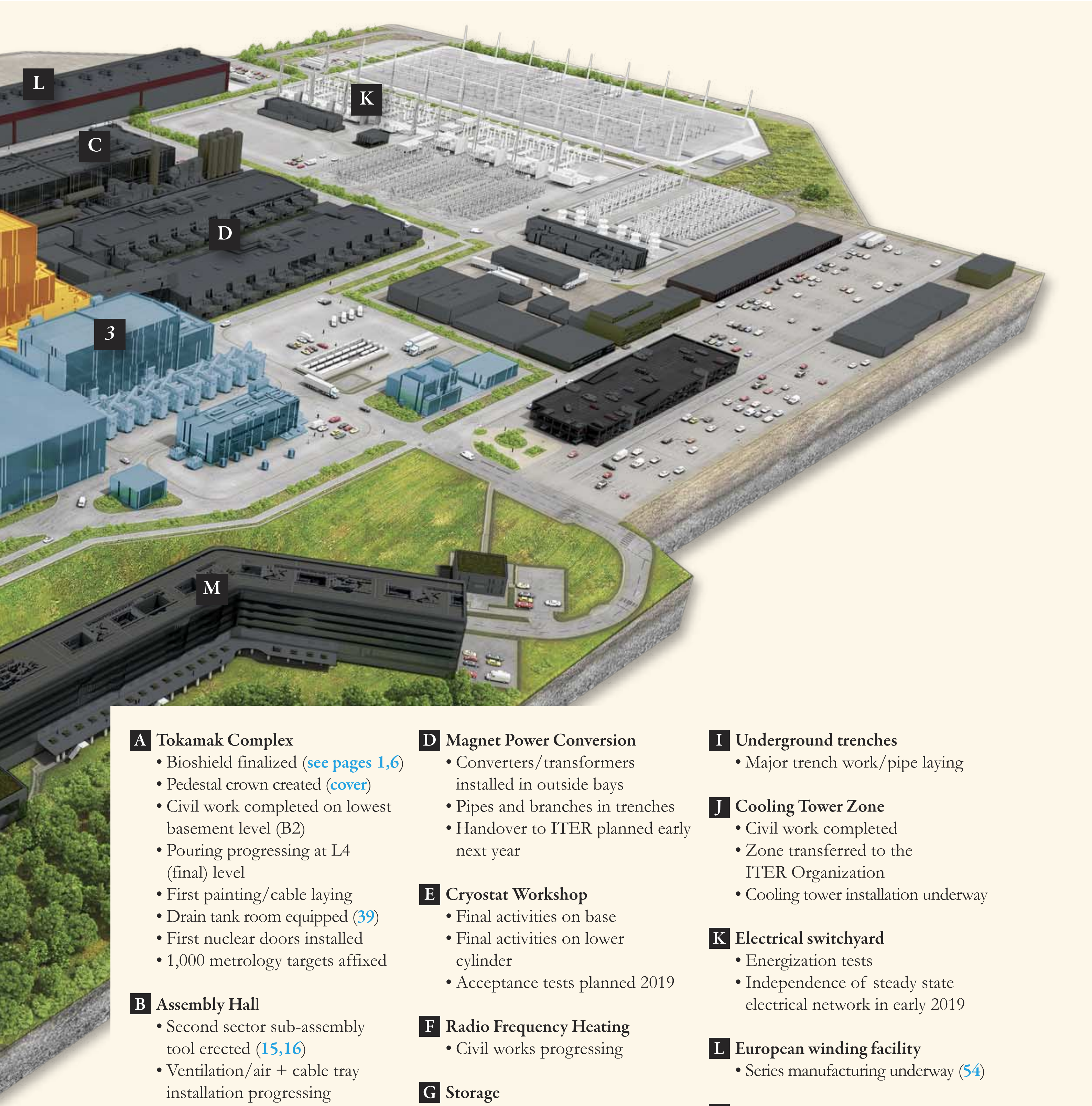


Buildings in place

Buildings in progress

Buildings to come

Site image courtesy of Fusion for Energy



A Tokamak Complex
- Bioshield finalized (see pages 1,6)
- Pedestal crown created (cover)
- Civil work completed on lowest basement level (B2)
- Pouring progressing at L4 (final) level
- First painting/cable laying
- Drain tank room equipped (39)
- First nuclear doors installed
- 1,000 metrology targets affixed

B Assembly Hall
- Second sector sub-assembly tool erected (15,16)
- Ventilation/air + cable tray installation progressing

C Cryoplant
- 11 storage tanks positioned
- Nearly half of all equipment installed (4)
- Commissioning begins in 2020

D Magnet Power Conversion
- Converters/transformers installed in outside bays
- Pipes and branches in trenches
- Handover to ITER planned early next year

E Cryostat Workshop
- Final activities on base
- Final activities on lower cylinder
- Acceptance tests planned 2019

F Radio Frequency Heating
- Civil works progressing

G Storage
- Surface prepared for storage of cryostat cylinders
- Warehouse erected

H Site Services Building
- First functional tests

I Underground trenches
- Major trench work/pipe laying

J Cooling Tower Zone
- Civil work completed
- Zone transferred to the ITER Organization
- Cooling tower installation underway

K Electrical switchyard
- Energization tests
- Independence of steady state electrical network in early 2019

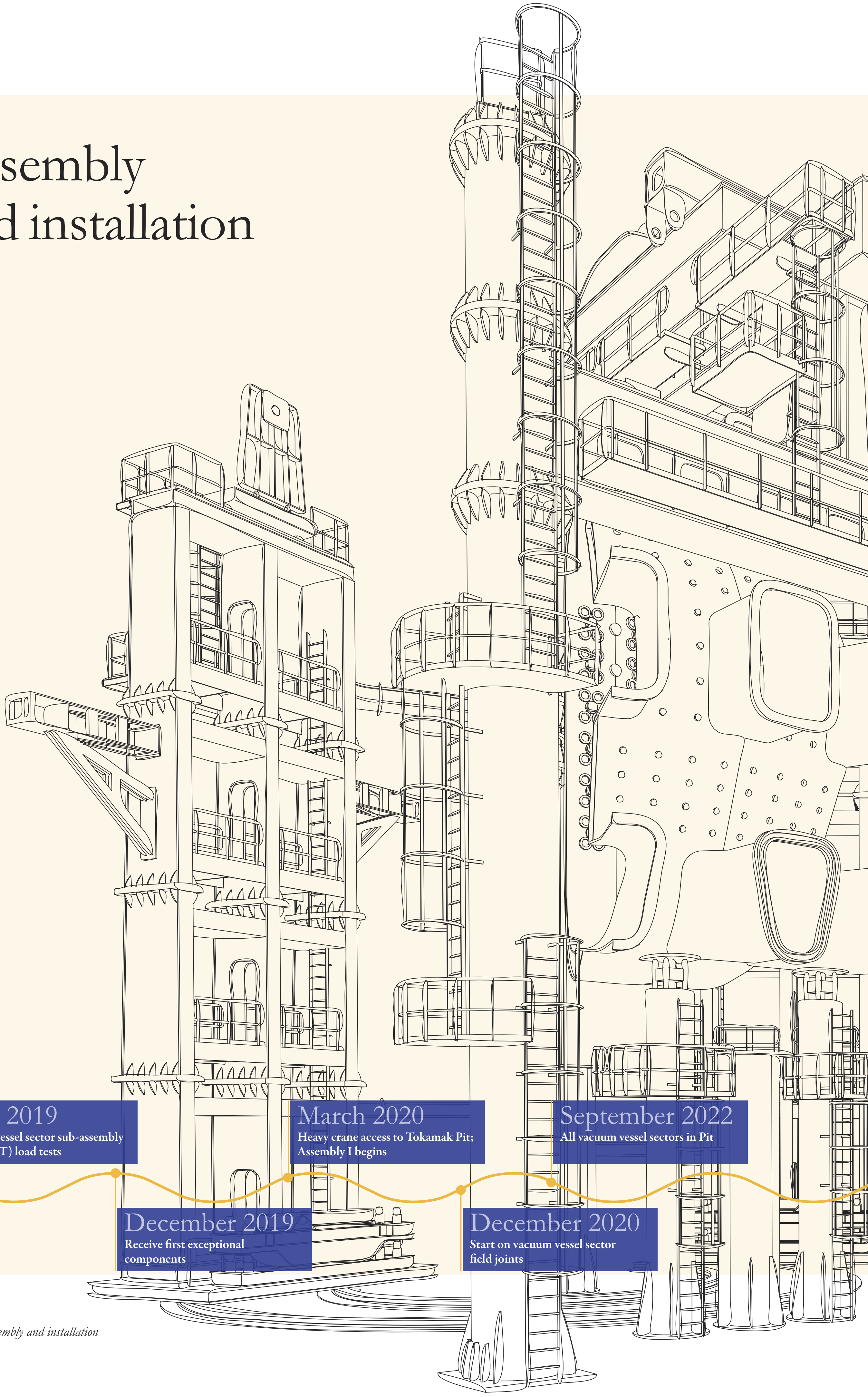
L European winding facility
- Series manufacturing underway (54)

M ITER Headquarters

Buildings to come

1 Control Building
2 Hot Cell
3 Neutral beam power supply

Assembly and installation



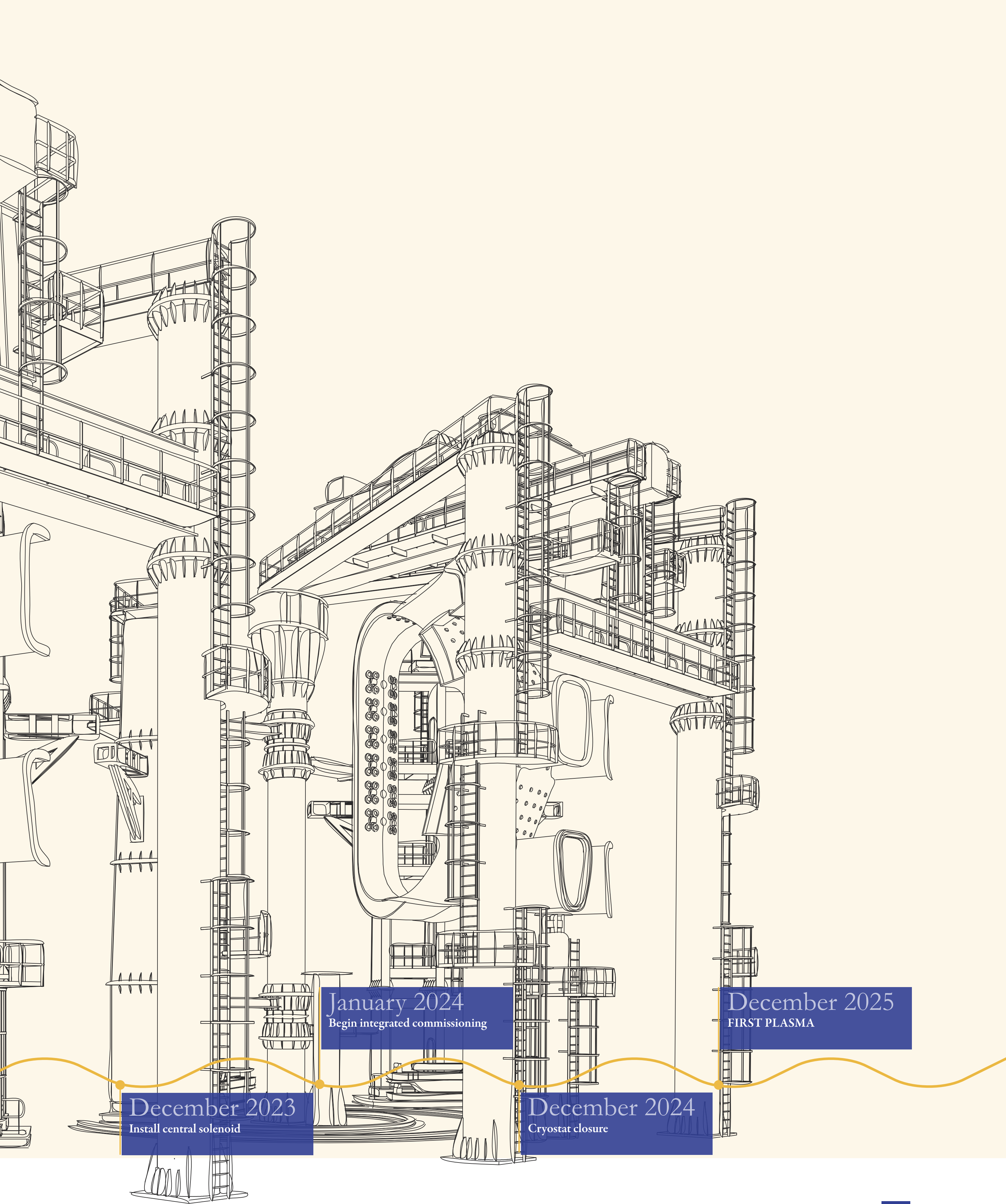
June 2019
Vacuum vessel sector sub-assembly tool (SSAT) load tests

December 2019
Receive first exceptional components

March 2020
Heavy crane access to Tokamak Pit; Assembly I begins

December 2020
Start on vacuum vessel sector field joints

September 2022
All vacuum vessel sectors in Pit


December 2023
Install central solenoid
January 2024
Begin integrated commissioning
December 2024
Cryostat closure
December 2025
FIRST PLASMA

Assembling the machine and plant

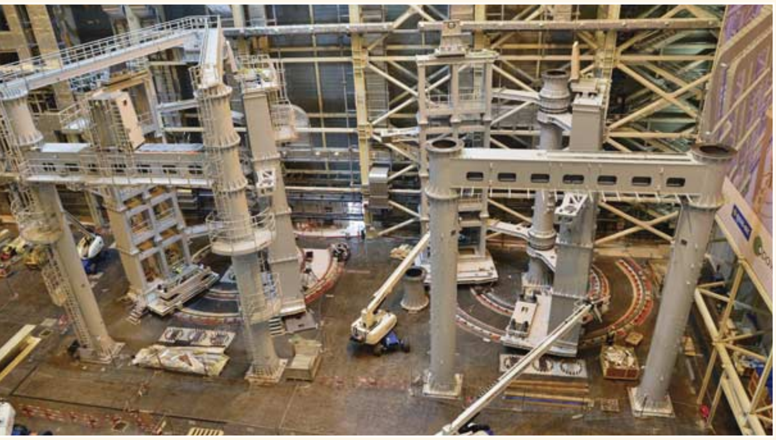
The ITER Organization has overall responsibility for the integration and assembly of components delivered to the ITER site by the seven ITER Members. Assembly Phase I will begin officially in March 2020, when crane access becomes possible over the Tokamak Pit. Preparatory activities are already underway.

Manufacturers will be completing a whole slate of major “firsts” in 2019 – the first section of the cryostat (1,250 tonnes), the first vacuum vessel sector (440 tonnes), the first D-shaped toroidal field magnet (360 tonnes), the first poloidal field coil (400 tonnes), and the first central solenoid module (110 tonnes).

In parallel, ITER construction and engineering teams are planning for the reception, handling, lifting and assembly of these major components and the one million or so others that make up the machine and support plant. In its role as overall assembly integrator, the ITER Organization will be assisted by:

- A Construction Management-as-Agent (CMA) – the MOMENTUM consortium – whose role is to plan, manage and supervise the works of the assembly phase (contract preparation, daily contract management, execution supervision, site coordination). The CMA contract entered its first implementation phase in February 2017, covering early plant installation and Tokamak assembly works.

Two giant tools will support 440-tonne vacuum vessel sectors as they are pre-assembled with other major components before being delivered to the Tokamak Pit. The final qualification activity for the tools – load testing – will take place in 2019.



- Contractors working under the nine major contracts to be issued for assembly and installation works or under contracts issued by the Domestic Agencies.

- The Holistic Integration Team, which was formed in 2018 to deliver a clash-free design and optimized system installation sequences for every area in the Tokamak Complex prior to installation activities.

- Project Teams that integrate ITER Organization and Domestic Agency staff to manage task execution in complex areas (buildings, cryoplant, vacuum vessel, Tokamak cooling water system, diagnostic port integration and (soon) blanket remote handling).

Early work is already underway in buildings/building areas that have reached “ready for equipment” milestones such as the cryoplant, the Assembly Hall, the Site Services building, the twin buildings for magnet power conversion, the cooling tower area, and the lowest B2 level of the Tokamak Complex. In other assembly and installation highlights this year:

- Negotiations were concluded for the transfer of selected assembly and installation scope in the Tokamak Complex from the Domestic Agencies to the ITER Organization in order to permit common oversight and efficient planning. Examples include mechanical and electrical installation activities (from the European Domestic Agency), cryoline installation (from the Indian Domestic Agency), and superconducting busbar installation (from the Russian and Korean Domestic Agencies). The ITER Organization is also centralizing, optimizing and integrating the design and delivery sequences for the cooling water systems under US and Indian scope.

- Systems owners continued to finalize the engineering work packages that reunite all necessary system and geographical information critical to the assembly process (tendering plus execution).

In November, the first machine component is lowered into the Tokamak Pit – a 10-metre, 6.6-tonne segment of magnet feeder delivered by China.

- A large number of bespoke assembly tools are in design/fabrication. A second sector sub-assembly tool (SSAT-2) was delivered by Korea and erected in the Assembly Hall (16) and other tools for lifting and handling specific components are in production. Tooling trials for the in-pit welding of the ITER vacuum vessel and ports are underway on a full-scale mockup at ITER Organization contractor ENSA (Spain) (22).

- A transversal Metrology Group under the joint supervision of the Construction Department and the European Domestic Agency is now in charge of all measurements in the Tokamak Complex, including "as-built" alignment and metrology information and 3D laser scan surveys. A network of approximately 2,000 fiducial targets is planned in the Tokamak Complex as a fixed reference base for all measurements.

- The first machine component – a magnet feeder segment delivered by China – was introduced by crane into the Tokamak Pit in November (17) and installed in a port gallery at B2 level (2-3).

- Mechanical installation in the cryoplant (4) has passed the 40 percent mark.

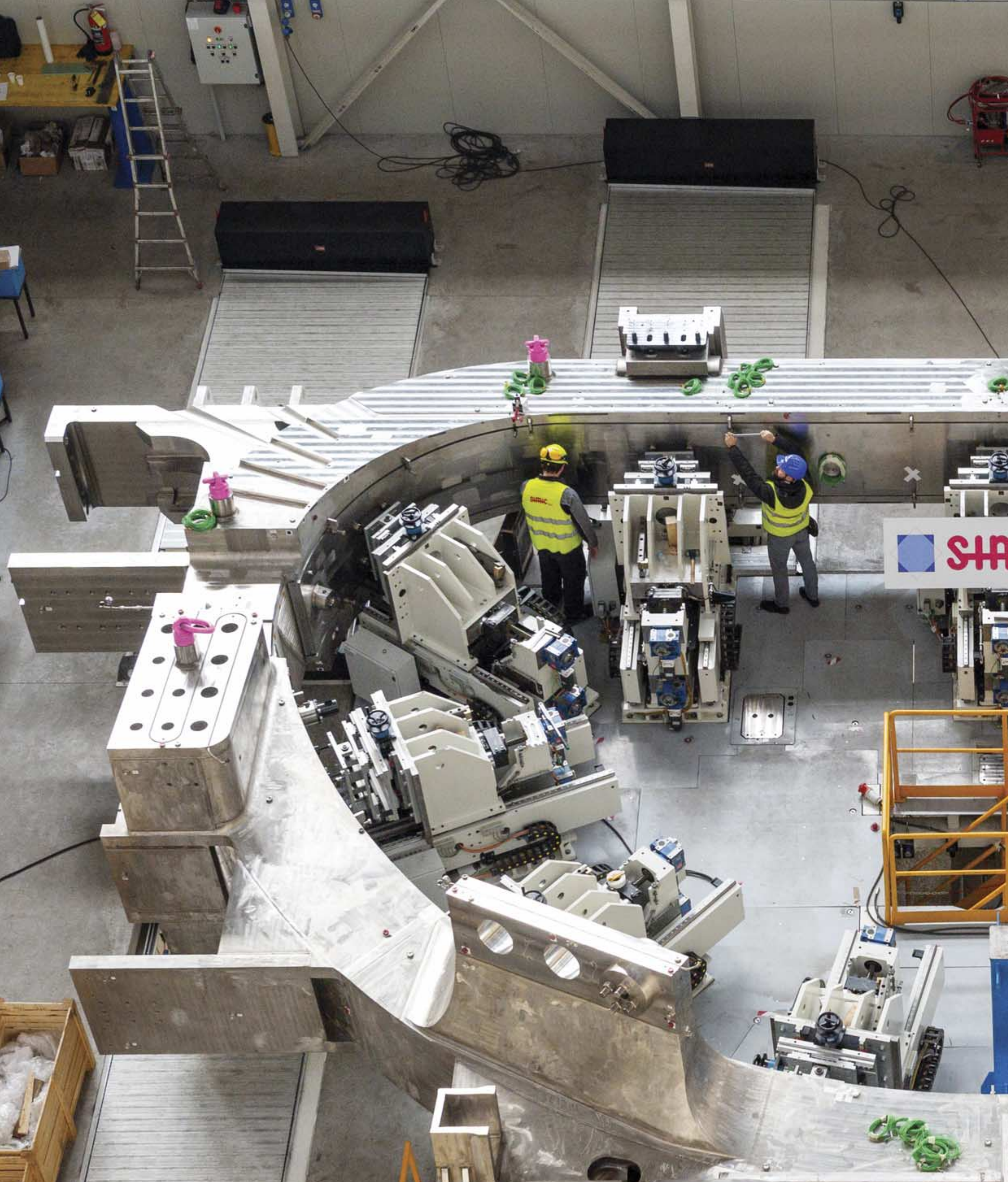
- The first buildings were handed over from the European Domestic Agency to the ITER Organization in December (the cooling tower zone).

- Three drain tanks for the Tokamak cooling water system (delivered by the United States) and four tanks for the pressure suppression system were installed in the drain tank room at B2 (lowest basement) level (39).

- Deliveries to the ITER site are increasing, as shown by these "monthly average" statistics: 2016 – 106; 2017 – 186; 2018 – 461; 2019 – 800 (planned). Twenty-one highly exceptional loads reached ITER in 2018.

How systems will enter the stage

The master commissioning schedule calls for systems to be brought into service in the following order – steady state electrical network (SSEN); central control system; liquid, gas and HVAC services; cooling water; cryoplant; electron cyclotron heating; vacuum pumping; fuelling; and coil power supplies. The SSEN network is on schedule for start-of-operation in early 2019 after successful commissioning tests this year.



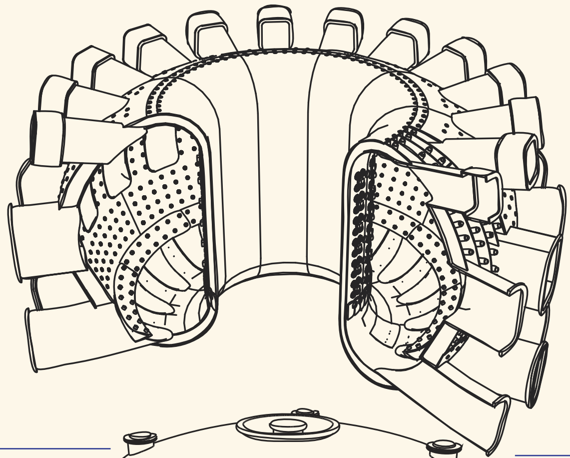
15	1,000,000	10,000,000	7	+3,000
major plant systems	components	parts	procuring Domestic Agencies	contracts (design, R&D, fabrication)

2018 Manufacturing update

The first toroidal field winding pack manufactured in Europe is now successfully ensconced in its 200-tonne protective case. The first-of-a-kind insertion operation was carried out at SIMIC, in northern Italy. Photo: SIMIC

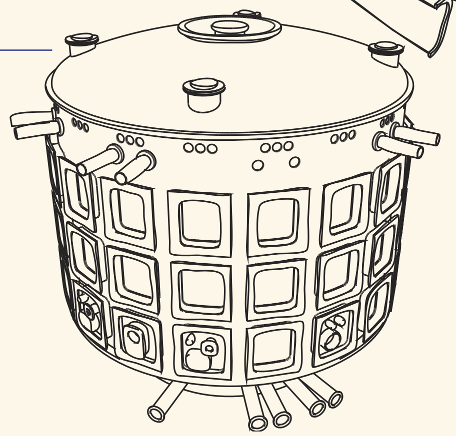
Key components

Ninety percent of Member contributions are delivered "in kind" to ITER, signifying that the ITER Domestic Agencies procure the components, systems or equipment under their responsibility through competitive contract - in most cases at home - before shipping the finished products to France. Through this unique procurement-sharing program, all Members are gaining direct industrial experience in key fusion technologies.



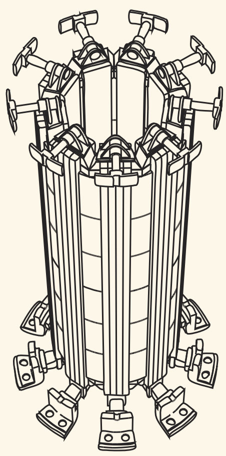
Vacuum vessel sectors **74%**

From manufacturing design and material procurement to cutting, forming, machining, welding, non-destructive examination, and final dimensional measurements, the industrial effort to forge the building blocks for ITER's double-walled steel plasma chamber is one of the most complex of the ITER Project (p. 25,35). Four Domestic Agencies are involved: **Korea** (four main sectors, equatorial ports, lower ports, gravity supports); **Europe** (five main sectors); **Russia** (upper ports); and **India** (in-wall shielding). The first sector will be finalized in 2019 in Korea.



Cryostat **71%**

With a total volume of 16,000 m³, the ITER cryostat is one of the world's largest vacuum chambers. It has hundreds of openings – some as large as four metres across – to provide access for piping, electricity, heating systems, diagnostics and remote handling systems. From 54 segments manufactured in **India**, the four principal sections are assembled in a dedicated workshop on site. The first two sections – the base and lower cylinder – will be finalized in 2019. The cryostat base will be the first major ITER component installed in the Tokamak Pit (beginning March 2020).

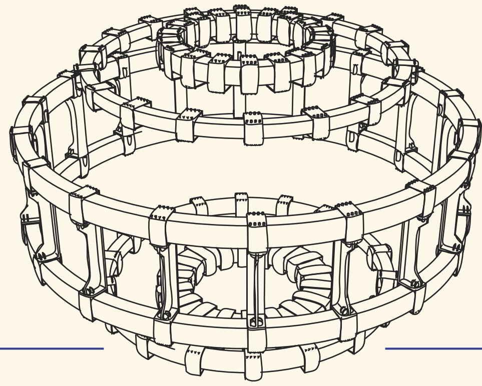


Central solenoid **91%**

ITER's giant central solenoid will be the world's largest pulsed electromagnet, designed to induce a powerful current in the ITER plasma and maintain it during long pulses. The **United States** is responsible for central solenoid procurement, including design, R&D, module fabrication (using conductor supplied by **Japan**), associated structures, and tooling. The manufacturing process takes approximately 22-24 months per module (26) plus an additional 5-6 months of testing. Five modules are currently in various stages of production and the first will be ready in 2019 for shipment.

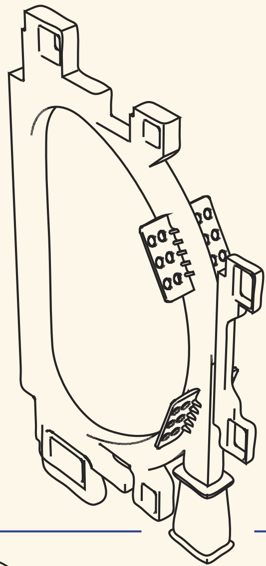
% complete statistics cover design and manufacturing

Poloidal field magnets **86%**



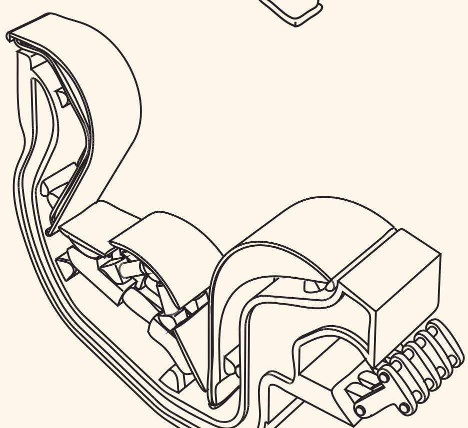
Six ring-shaped poloidal field coils ranging from 9 to 24 metres in diameter will shape the plasma and contribute to its stability by "pinching" it away from the walls. From niobium-titanium superconducting strand produced in China, Europe and Russia, two Domestic Agencies – **Europe** and **Russia** – are now procuring the final coils. Cold testing will begin on the first completed poloidal field coil in Europe's on-site manufacturing facility in late 2019.

Toroidal field magnets **89%**



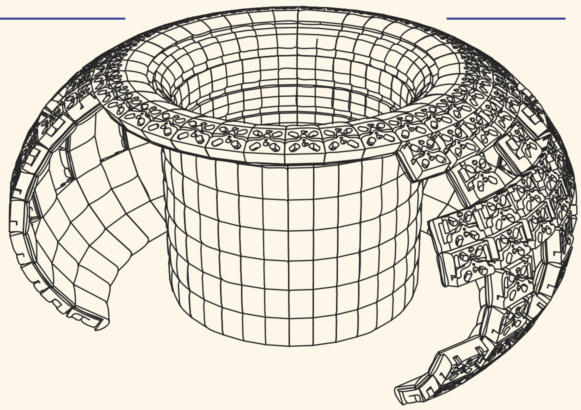
ITER's 18 "D"-shaped toroidal field magnets work together to produce a magnetic field whose primary function is to confine the plasma particles. Following the procurement by China, Europe, Japan, Korea, Russia and the United States of over 100,000 km of niobium-tin superconducting strand (the largest in industrial history) and subsequent cabling activities, the fabrication of the final coils is proceeding in **Japan** (9 toroidal field coils plus 19 coil case structures) and **Europe** (10 toroidal field coils). Each coil is made up of a superconducting winding pack and surrounding stainless steel coil case. State-of-the-art welding techniques, stringent tolerance and dimensional requirements, and the size and weight of the toroidal field coils make fabrication – especially of the first-of-a-kind units (18-19) – particularly challenging. **Japan** will deliver the first coil in late 2019.

Divertor **38%**



Qualification activities have been underway for years to prepare for the manufacturing of the tungsten-coated plasma-facing components of the ITER divertor, which will face the highest heat loads of the machine. In one of the final qualification steps, prototypes of the inner vertical target (**Europe**), outer vertical target (**Japan**) and dome (**Russia**) are being sent for high heat flux testing at the ITER Divertor Test Facility in Russia. Manufacturing began in 2018 on the divertor cassette bodies in Europe after the successful conclusion of the prototyping and testing phase; Europe is also developing a high-performance remote handling system to prepare for the installation of the ITER divertor during the Assembly Phase II.

Blanket **46 %**



Covering a surface of 600 m² inside of the ITER vacuum vessel, the blanket shields the vessel structure and superconducting magnets from the heat and high-energy neutrons of the fusion reaction. The Domestic Agencies of **China**, **Europe** and **Russia** are currently qualifying key technologies for the plasma-facing first wall. For the massive blanket shield blocks (located behind the first wall panels) the qualification phase is drawing to a close. China started series manufacturing in 2018; **Korea** will begin next year.

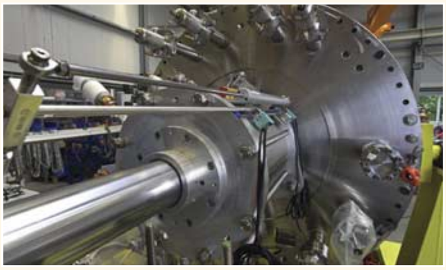
Manufacturing highlights

ITER contractor Equipos Nucleares SA (ENSA, Spain) uses a full-scale mockup of the joint between two vacuum vessel sectors to test the performance of specially designed welding tooling. The welding of the vacuum vessel will require 25 tonnes of filler metal.

2018

Pressure on the pre-compression rings

At the top and bottom of the machine, where the tapered ends of the toroidal field coil structures meet, large composite rings will be installed to help the coils resist electromagnetic forces during operation. Prototypes of these rings are about to be tested in this facility designed by the European Domestic Agency and procured by the ITER Organization.

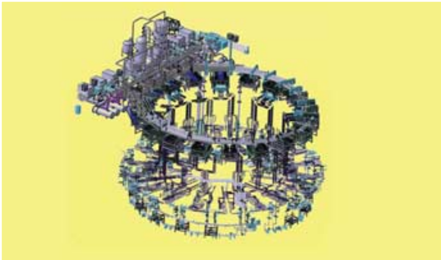


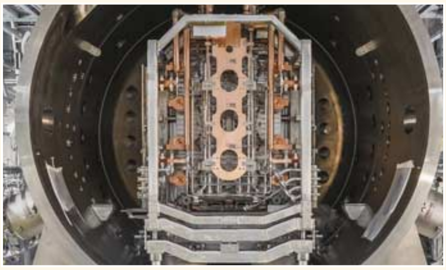
Cryopumps produce the ultimate vacuum

After more than 12 years of development in Europe, the ITER cryopump is ready for procurement. Eight of these high-performance components, which implement the world's largest all-metal, high-vacuum valve, will operate on the ITER machine to maintain an ultra-high vacuum – a vacuum that is about one million times lower than the density of air.

Final design for Tokamak cooling system

To remove the heat from the components closest to the plasma, the Tokamak cooling water system will rely on over 36 kilometres of nuclear-grade piping and fittings as well as a large number of supports, valves, pumps, heat exchangers and tanks – all integrated into the limited space of the Tokamak Complex. First Plasma components are now in production under the oversight of the US Domestic Agency.





First neutral beam testbed enters operation

The critical technologies behind ITER's most powerful heating system – neutral beam injection – will be tested at the ITER Neutral Beam Test Facility in Padua, Italy. In 2018 the SPIDER beam source – the world's most powerful negative ion source – was turned on for the first time (38). This ITER-like full-size radiofrequency-driven plasma source is capable of extracting a negative deuterium ion beam (D- beam) of 70A and accelerating it to energies of 100 keV.

Correction coils in production

In the manufacturing of ITER's correction coils – an array of small superconducting coils that will be inserted between the larger toroidal and poloidal magnet systems – gap tolerances of less than 0.3 mm are demanded. Manufacturers in China are working carefully to control weld shrinkage and case and lid machining tolerances as they finalize the first production unit (a bottom correction coil, pictured).

Power to the magnets

Component manufacturing is underway in China, Korea and Russia on the components of the magnet coil power supply and distribution system, which ensures that power received from the 400 kV transmission grid is converted into controlled DC power according to the specifications of the different magnet systems. (Pictured, the delivery of an AC/DC converter transformer from Korea.)

Manufacturing highlights

A barrier coated in silver

Between the (hot) vacuum vessel and the (cold) magnets, a layer of thin, silver-coated stainless steel will act to minimize the transfer of heat by radiation or conduction (silver is one of the most efficient "low-emissivity" materials that exists). Korea successfully pre-assembled the thermal shield for one vacuum vessel sector in 2018; once shipped to ITER, the panels will be mounted on the vacuum vessel using the sector sub-assembly tools in the Assembly Hall.

Cryolines – not just any pipes

Cryogenic fluids will circulate between the cryoplant and the Tokamak Building through a five-kilometre network of complex, multi-process, vacuum-insulated pipes that are full of angles, bends and turns. The sophisticated equipment – which must resist extreme cold, manage contraction, and limit thermal loss – is arriving in batches, procured by the Indian Domestic Agency.

The smallest of the ring magnets

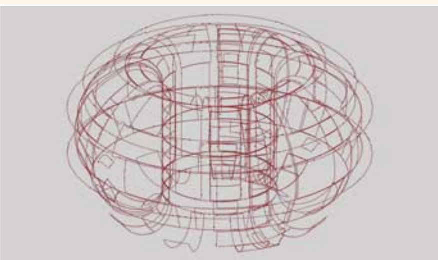
Specialists in Russia have completed the eight double pancake windings required for poloidal field coil #1 – the smallest of ITER's ring magnets (9 metres in diameter). In this image, the first five double pancakes have been stacked after vacuum pressure impregnation with epoxy resin, a technique that ensures electrical insulation and creates a hardened assembly.

Coil cases in series

Japan is procuring the structural cases for all ITER toroidal field coils. The two sides of the huge components – as tall as four-storey buildings and machined from 20-centimetre-thick steel – must match within gap tolerances of 0.25 mm to 0.75 mm. Series manufacturing is underway in a procurement program overseen by the Japanese Domestic Agency.

First gyrotron units

After lengthy prototyping, review, and verification phases, the first gyrotron units have passed factory acceptance testing in Russia (pictured, one of 2 units) and Japan (2 units). Twenty-four of these energy-generating devices – part of ITER's electron cyclotron resonance heating system – will inject 1 MW each of heating power to the plasma. Eight of them need to be installed for First Plasma.



2.5 km of diagnostic loops

An array of flux loops arranged as 234 individual sensors on the interior surfaces of the vacuum vessel will measure variations in the magnetic flux expelled by the plasma in order to infer information about the boundary shape, energy and stability of the plasma. The first batch of equipment arrived this year, ready to install inside the vacuum vessel sectors as they arrive.

2018

Hyundai Heavy Industries in Korea is manufacturing four of ITER's nine vacuum vessel sectors. In this image, technicians are inserting blocks of in-wall shielding into part of Sector #6 – the first sector expected at ITER.

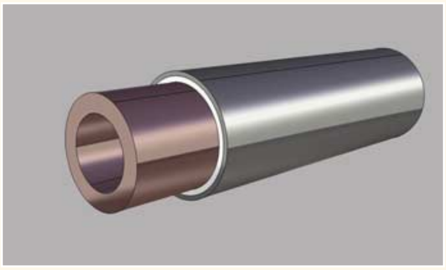
Manufacturing highlights

A central solenoid module enters the heat treatment furnace at General Atomics (US ITER contractor in California). Heat treatment is the step that makes the module superconducting, as niobium (Nb) and tin (Sn) react together to form the superconducting Nb3Sn alloy. Photo: GA

2018

In-vessel coil conductor qualified

A special type of mineral-insulated conductor will form the heart of the non-superconducting magnet coils operating inside the ITER vacuum vessel. The validity of conductor design and manufacturability were confirmed in 2018; the next phase will be to select the manufacturer for 5 kilometres of material.



Blanket prototype passes the test

An 18-month program to manufacture a full-size blanket shield block prototype ended in China in March after the success of hot helium leak testing. Series production has been launched for the 220 shield blocks under Chinese responsibility.

Eight pancakes already wound on site

European contractors completed the winding of all superconducting material required for poloidal field coil #5 – eight double pancakes in all, formed from 11.5 km of niobium-titanium conductor. Once impregnated with epoxy resin, these pancakes will be stacked and joined. After #5, Europe will be producing three other coils (#2, #3 and #4) in this facility.

Coil power switching network

A test program at the Efremov Institute in Russia has shown that the highly complex switching network system for the magnet coils performs to ITER specifications as designed. Switching equipment, busbars and energy absorbing resistors for power supply and the protection of the superconducting magnetic system must be on site by 2023.

Supported from below

The full gravity load of the ITER magnets (10,000 tonnes) will be transferred to the cryostat through the gravity supports under the toroidal field coils, which are engineered to resist the toroidal and vertical forces on the coils during Tokamak operation while allowing radial motion during cooldown and warmup. The first production unit was completed in China this year.

Inspecting cryostat welds

Different ultrasonic examination probes are being used by Indian Domestic Agency contractors to verify the leak tightness of cryostat welds. Approximately 1 km of weld joints will be carried out to assemble the sections in the Cryostat Workshop, and another 400 metres to assemble the four sections in the machine pit.


C2
C10
VOUS
ROULEZ A
December 2025
First Plasma
June 2026
Assembly II
(blanket, divertor, in-vessel coils)
June 2028
Assembly II ends
December 2028
Pre-Fusion Operation I
(hydrogen/helium)
June 2030
Assembly III
(neutral beams, test blanket modules)

ITER science

September 2031
Assembly III ends

June 2032
Pre-Fusion Operation II
(hydrogen/helium, full heating)

March 2034
Assembly IV
(full tritium plant, radwaste treatment)

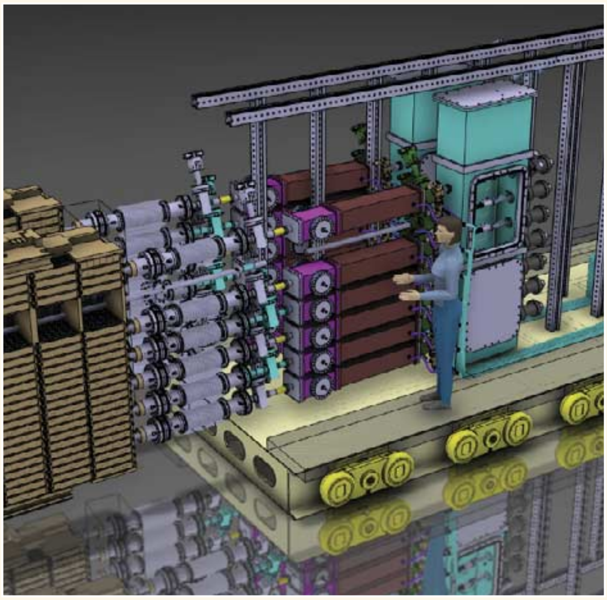
March 2035
Assembly IV ends

June 2035
FUSION POWER
OPERATION

ITER science

Research Plan updated

Scientists at ITER are planning now for the scientific exploitation of the ITER machine – a process that is informed in a rolling manner by the most recent advances in physics research and through the participation of the worldwide fusion community. In 2018, a new version of the ITER Research Plan was released, aligned with the updated ITER schedule. It describes the scientific goals of each stage of ITER operation, from First Plasma in 2025, through experimental studies in helium and hydrogen, and on to high-fusion gain in deuterium and tritium. The 400-page plan can be downloaded from the ITER website.

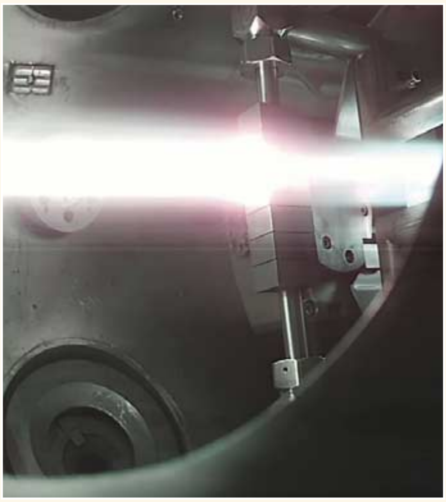


Protecting against disruptions

Beyond certain operational boundary conditions – for example, when plasma current, pressure or density rises above certain levels for a given magnetic field – the plasma can become unstable. One type of instability, disruptions, can cause the rapid loss of the plasma thermal and magnetic energy and lead to bursts of very high-energy electrons impacting in-vessel components. A reliable disruption mitigation system on ITER is therefore a high priority for the project. In 2018, the ITER Council approved a new approach to developing the ITER disruption mitigation system. An important element of the new strategy is the formation of an international task force to provide physics input to the ITER design and to demonstrate the selected technology (shattered pellet injection) through laboratory tests, tokamak experiments and supportive R&D programs in the ITER Members. Additional techniques will also be explored as backup.

Divertor lifetime

Plasma-wall interactions in the region of the ITER divertor are characterized by high fluxes/fluences of low-energy particles and elevated surface temperatures. ITER scientists and engineers are working together to study the long-term evolution of the front-facing tungsten monoblocks to predict material limits and component lifetimes. This year, for the first time, ITER-scale fluences become accessible in the laboratory at the Magnum-PSI facility at the Dutch Institute for Fundamental Energy Research (DIFFER), where small-scale mockups of ITER tungsten divertor components were exposed to the equivalent of a full-year of high power fusion operations. These experiments and additional modelling by ITER experts show that the lifetime of the first ITER divertor should be sufficient for the project to demonstrate its high-gain fusion goals (i.e., the first six years of deuterium-tritium operation), provided that transient power fluxes can be controlled.



2018

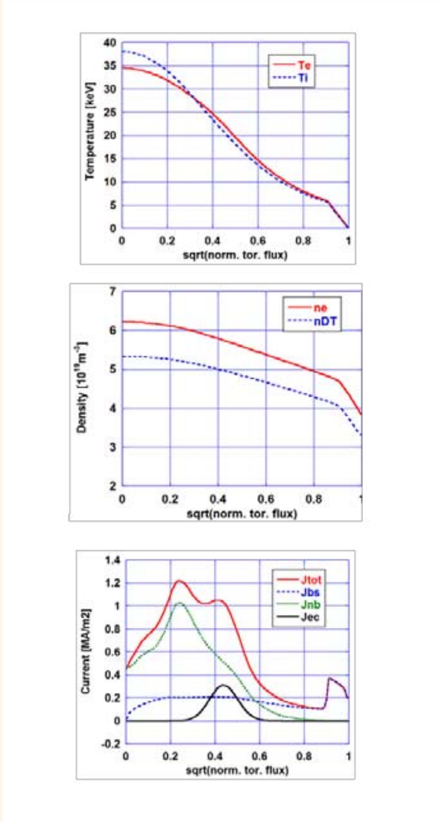
European industry has delivered the world's most powerful negative ion source to the ITER Neutral Beam Test Facility in Italy. Experiments there on the SPIDER testbed will help engineers finalize the ion sources for the ITER neutral beam injection system.

ITER science

The ITER central solenoid will allow a powerful current to be induced in the ITER plasma and maintained during long pulses. (Pictured, a wedge of the mockup coil that was produced to qualify all manufacturing stages.) Photo: GA

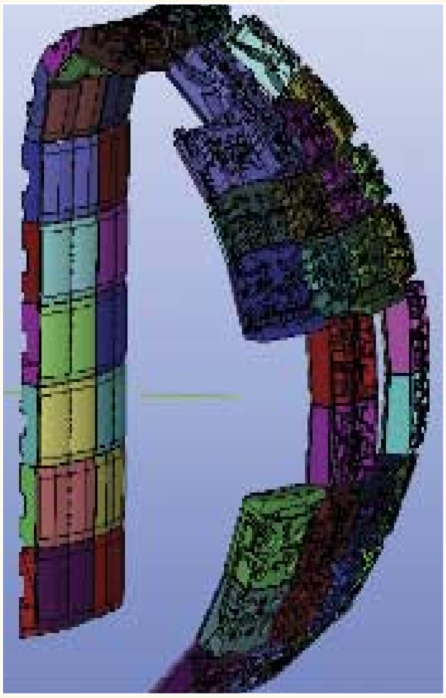
New steady-state analysis

A tokamak is intrinsically a pulsed device: the current in the plasma is induced by the central solenoid (comparable to the primary winding of a transformer) while the plasma is the secondary winding. However, it is possible to obtain regimes in which the plasma current can be sustained without the action of the central solenoid through external heating and current drive systems and through the self-driven currents in the plasma. This is called steady-state tokamak operation.



One of the high fusion gain goals of ITER is to demonstrate steady-state operation with fusion gain Q = 5, which requires the achievement of large plasma pressures to sustain the self-driven currents (very challenging from the point of view of plasma transport and stability) and very effective current drive systems.

It has long been considered that a range of upgrades to the baseline heating and current drive systems may be required, as well as the installation of new systems such as lower hybrid heating. New studies performed by ITER scientists and collaborators have shown that steady-state Q = 5 plasmas can potentially be achieved by upgrading the neutral beam injection and electron cyclotron heating systems to provide the necessary capabilities to drive the plasma current and to control its profile to ensure that the plasma is stable. On the basis of these studies, the ITER Organization proposal to remove lower hybrid heating and current drive as an upgrade option from the ITER Baseline was approved by the ITER Council after the favourable assessment of the Science and Technology Advisory Committee.



Modelling

The ITER Organization is building a world-class integrated modelling infrastructure (IMAS) to allow the application of modelling tools developed by ITER Member R&D institutions for the integrated modelling of ITER plasmas and to access the results of these simulations. In 2018, a database of scenario plasma conditions was compiled with more than 100 plasma conditions to be explored in ITER from the start of hydrogen/helium operation until the demonstration of ITER's high-fusion-gain goals.

In 2018, the further development of modelling tools and their integration into IMAS resulted in new higher-fidelity results for ITER plasma scenarios. The application of the SMITER-IMAS code provided the evaluation of power fluxes to the first wall taking into account its real 3D structure to a very high level of detail. The application of JINTRAC-IMAS and DINA-IMAS provided the first self-consistent simulation of an ITER Q = 10 scenario including the whole plasma from core to divertor as well as the voltages to be applied in the power supplies and the resulting currents in ITER superconducting phases to control the plasma shape and position throughout the scenario.

ITER science

Involving the community

The ITER Organization implements an extensive program of experimental and theoretical R&D and simulation through collaboration with Member fusion communities and the International Tokamak Physics Activity (ITPA), which coordinates experimental work in support of ITER high-priority physics needs. This work over the years has resulted in the achievement of a broad physics basis essential for ITER design and operation, but also useful for all fusion programs and for progress toward fusion energy generally.

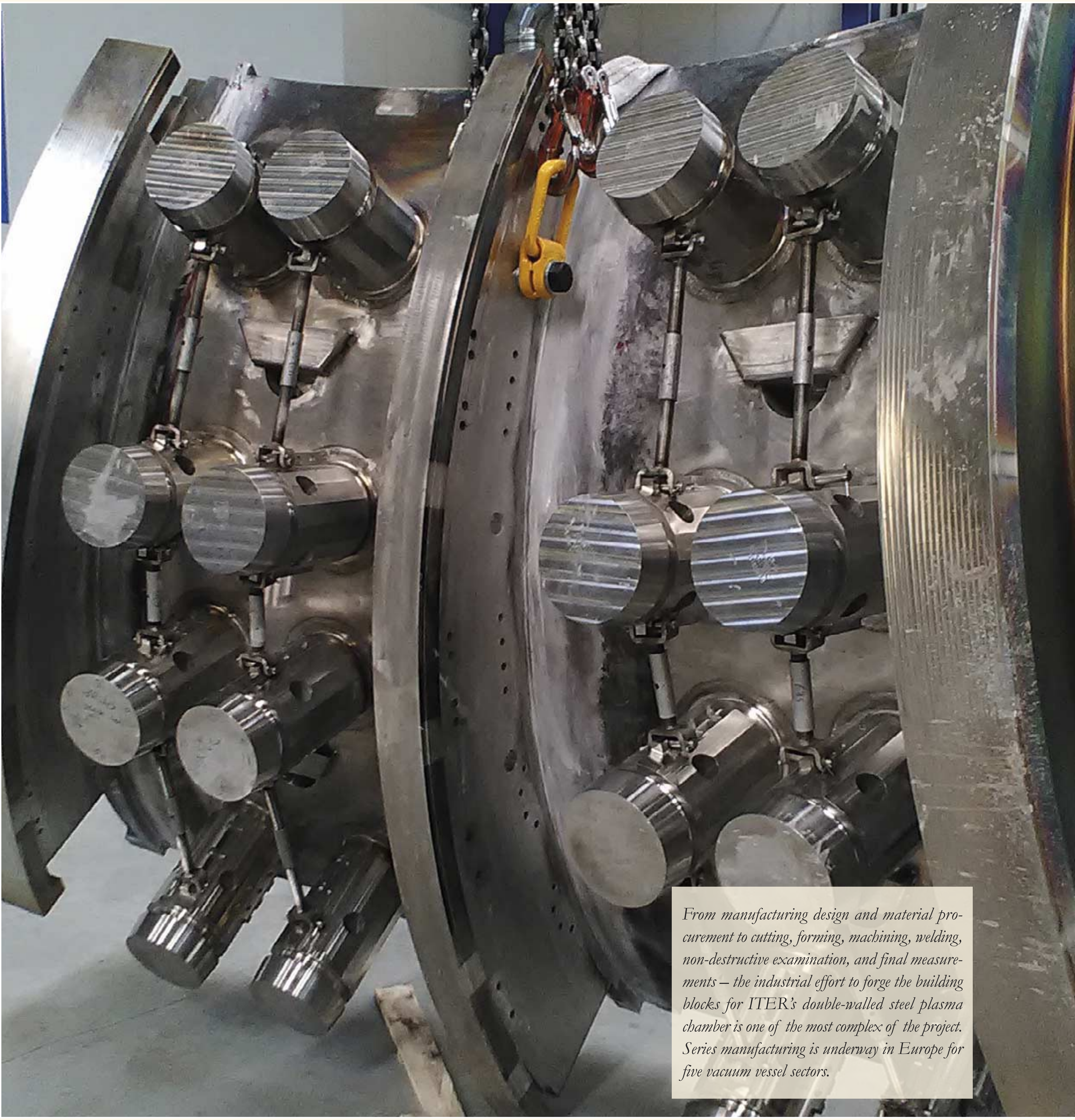
The operational phase of the ITER fusion device will undoubtedly open up significant new areas of fusion research. The achievement of high fusion performance and advanced operational regimes will make new demands on the experimental, theory and modelling expertise of the fusion community. To exploit the machine's potential and to optimize its performance, ITER will rely on major contributions from the experts in the Members' fusion communities.

To strengthen the involvement of the international fusion community directly in ITER, the ITER Organization has established a network of ITER Scientist Fellows in the research laboratories and academic institutions of the Members. These Fellows are supporting the ongoing scientific analysis of burning plasmas in ITER and helping to prepare for the scientific exploitation phase of ITER; currently about 70 researchers who have achieved international recognition for their contributions to fusion research are working in collaboration with ITER scientists and engineers. More than 30 experts from around the world are also assisting the ITER Organization with the detailed preparations required for the operational phase of the machine as part of the ITER Operations Network.

In 2018 ITER scientists and engineers published 58 papers as lead author or co-author in refereed journals. They also represented ITER science at fusion conferences worldwide and monitored fusion trainees from the ITER internship program, the European FUSION-DC PhD program and the Monaco-ITER Postdoctoral Fellowship program.

The role of the ITPA Coordinating Committee is to oversee the experimental work of the topical groups and to interface with the ITER Organization. (Pictured: the group's 2018 meeting at ITER.)

2018



From manufacturing design and material procurement to cutting, forming, machining, welding, non-destructive examination, and final measurements – the industrial effort to forge the building blocks for ITER's double-walled steel plasma chamber is one of the most complex of the project. Series manufacturing is underway in Europe for five vacuum vessel sectors.

At a glance

January

- Meeting at ITER of the International Energy Agency's Fusion Power Coordinating Committee

February

- Visit from the US Committee on Burning Plasma Research

April

- ITER Director-General accompanies French President Macron during his state visit to Washington D.C.

May

- European Commission pledges full budget support
- Open Doors Day
- ITER Robots competition, seventh edition

June

- 22nd ITER Council

September

- Updated ITER Research Plan released
- ITER Games: eighth annual

October

- Two-day media event for international journalists
- ITER Newsline celebrates issue #500
- Open Doors Day
- EIROforum convenes its Autumn Assembly at ITER
- Donations and sponsorship website opens

November

- 23rd ITER Council
- Fusenet PhD event at ITER
- Cooperation Agreement with the Thailand Institute of Nuclear Technology (TINT)

December

- 38 ITER Council milestones achieved since 2016
- 14,000 visitors tallied for 2018
- A multiyear US National Academies study recommends continued US participation in ITER

Corporate highlights

On the ITER site in southern France, the European Domestic Agency is 70% of the way to realizing the buildings and site infrastructure required for First Plasma.

Corporate highlights

The project is stable globally as the ITER Organization transitions from in-kind deliverable management to a focus on assembly and installation. In-depth external reviews have validated the project's approach to risk analysis and management, the freezing of design interfaces, and configuration management, and tools are now in place to monitor, report, and manage risks to the schedule. Project execution on the road to First Plasma has reached 59.7 percent.

Revised construction strategy – Project performance is measured against the Revised Construction Strategy that was proposed to the ITER Council (and approved in June 2018) as a way to optimize critical path activities and maintain First Plasma in December 2025, despite identified delay in the completion of the Tokamak Building and potential delay in the arrival of the vacuum vessel sectors and toroidal field coils. The Strategy relies on the holistic re-organization of assembly and installation sequences, including some transfer of Domestic Agency scope to the ITER Organization, and has the full buy-in of the Domestic Agencies.

Transparent reporting – The ITER Organization reports every two months to the ITER Council on performance against the Revised Construction Strategy and the achievement of high-level project and programmatic milestones (38 achieved since 1 January 2016). Tracked with particular attention are deliveries on the First Plasma critical path: the vacuum vessel, including in-wall shielding; toroidal field coils; and the Tokamak Building.

Science at the ITER Neutral Beam Test Facility in Padua, Italy, is officially launched in 2018 as the SPIDER testbed produces its first plasma in June.

Configuration management – An In-depth Independent Review (IIR) commissioned by the ITER Council was carried out in 2018 on the Organization's configuration management practices. The review resulted in 14 recommendations, which the ITER team is addressing in an action plan. Among the actions already implemented is the creation of a Configuration Management Core Team to monitor the correct implementation of configuration in the project's product lifecycle management (PLM) system, which must become the single point of entry and recovery for technical baseline documents.

External review – In addition to the 2018 IIR review of configuration management, there were IIR reviews in 2017 on risk management and the freezing of design interfaces, and an IIR review of the ITER Organization's assembly and installation strategy is planned in 2019.

World-class engineering practices – Major institutional reform since 2015 has resulted in the improvement of processes and systems and the implementation of industry-standard tools for project management and systems engineering.

Quality management – All quality-related activities (quality assurance, assessment and control) have been centralized into the newly created Quality Management Division to improve implementation efficiency.

Intellectual property sharing – As foreseen by the ITER Agreement and its Annex on intellectual property, the ITER Members support the widest possible dissemination of intellectual property generated in the course of project activities. The ITER intellectual property database is the central source for background declarations, generated intellectual property declarations, publications, and licenses, consultable by all Members. In 2018, all Domestic Agencies met their annual Generated Intellectual Property declaration targets, bringing the current total in the database to 115.

Seven large tanks now populate the two-storey drain tank room in the Tokamak Building, including this 10-metre cooling water tank delivered by US ITER.

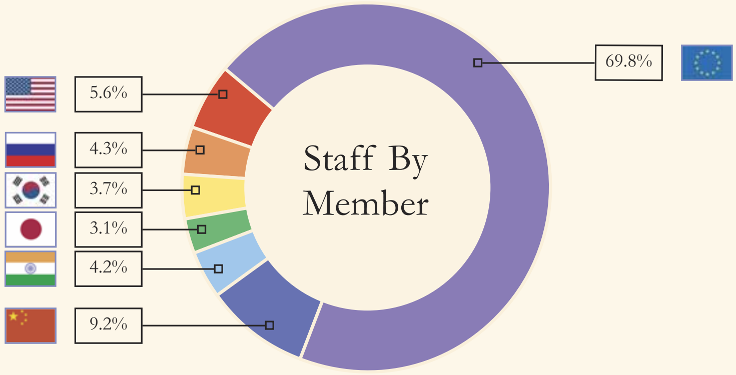
Regulatory environment – As a nuclear operator in France, it is the duty of the ITER Organization to ensure that the French nuclear safety requirements are understood and implemented by the Domestic Agencies, suppliers and contractors. The French Nuclear Safety Agency (ASN) verifies implementation through on-site inspection, factory visits, meetings and requests for information. Oversight is regular: in 2018 inspections took place on design and construction; building construction; compliance with environmental regulations; and vacuum vessel manufacturing in Europe. The ITER Organization also received notification during the year that the exemption requested from French regulations on pressure equipment (ESPN) for the Tokamak cooling water system had been granted.

International cooperation – The ITER Organization currently has 68 international cooperation agreements with the laboratories and educational establishments of the ITER Members, international organizations, or non-Member states (see the full list on page 55). In 2018, a Cooperation Agreement was signed with the Thailand Institute of Nuclear Technology (TINT); the 2008 Monaco Partnership Arrangement was renewed for 10 years; and the first Implementation Agreements were activated within the framework of the Cooperation Agreements signed with Australia (2016) and Kazakhstan (2017).

Staffing – ITER Organization staffing is progressing on pace with project resource estimates and projections. On 31 December 2018, 858 people were directly employed by the Organization; 31 experts, 3 visiting researchers, 54 interns, and 65 ITER Project Associates also contributed to the ITER Project in 2018.

Staffing and budget tables

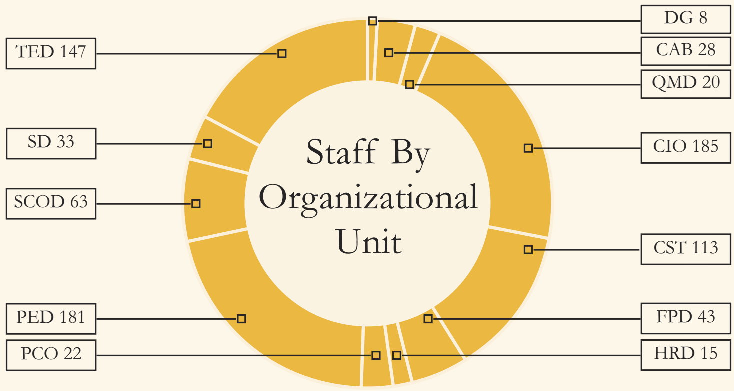
Staffing tables



Staff By Member as of 31 December 2018

	31/12/2012	31/12/2013	31/12/2014	31/12/2015	31/12/2016	31/12/2017	31/12/2018
China	18	30	50	55	67	77	79
European Union	312	339	412	446	512	571	599
India	30	25	19	22	30	36	36
Japan	35	33	29	25	25	25	27
Republic of Korea	30	32	33	32	32	32	32
Russian Federation	24	28	30	30	36	36	37
United States of America	28	28	36	32	38	48	48
Total	**477**	**515**	**609**	**642***	**740****	**825*****	**858******

**Includes 5 Monaco Postdoctoral Fellows and staff funded for work on the TCWS (Tokamak cooling water system, 24) and VAS (vacuum system, 1)*
***Includes 4 Monaco Postdoctoral Fellows and staff funded for work on the TCWS (23), VAS (2), and SCS-N (safety control system for nuclear, 1)*
****Includes 5 Monaco Postdoctoral Fellows and staff funded for work on the TCWS (27), VAS (2), and SCS-N (1)*
*****Includes 5 Monaco Postdoctoral Fellows and staff funded for work on the TCWS (25), VAS (2), and SCS-N (1)*



Staff By Organizational Unit as of 31 December 2018

	Professional & Higher	Support	TOTAL
Director-General	7	1	8
Cabinet	15	13	28
Quality Management Division	11	9	20
Central Integration Office	86	99	185
Construction Department	93	20	113
Finance & Procurement Department	19	24	43
Human Resources Department	9	6	15
Project Control Office	17	5	22
Plant Engineering Office	126	55	181
Science & Operations Department	53	10	63
Safety Department	24	9	33
Tokamak Engineering Department	124	23	147
Total	**584**	**274**	**858**

Main budgetary data

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

Amounts in thousands of Euro

	Total Commitment Appropriations 2018	Total Actual Commitments 2018	Unused Commitment Appropriations carried forward to 2019
Budget Headings	1	2	3 = 1 - 2
Title I: Direct Investment (Fund)	358,535	228,847	129,688
Title II: R&D Expenditure	1,338	95	1,243
Title III: Direct Expenditure	235,744	196,060	39,684
Total Commitments	**595,617**	**425,002**	**170,615**

* *Excluding Reserve Fund*

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

Amounts in thousands of Euro

	Total Payment Appropriations 2018	Total Actual Payments 2018	Unused Payment Appropriations carried forward to 2019
Budget Headings	1	2	3 = 1 – 2
Title I: Direct Investment (Fund)	195,823	110,242	85,581
Title II: R&D Expenditure	4,151	1,510	2,641
Title III: Direct Expenditure	241,479	187,936	53,543
Total Payments	**441,453**	**299,688**	**141,765**

* *Excluding Reserve Fund*

Contributions Received From Members 2018

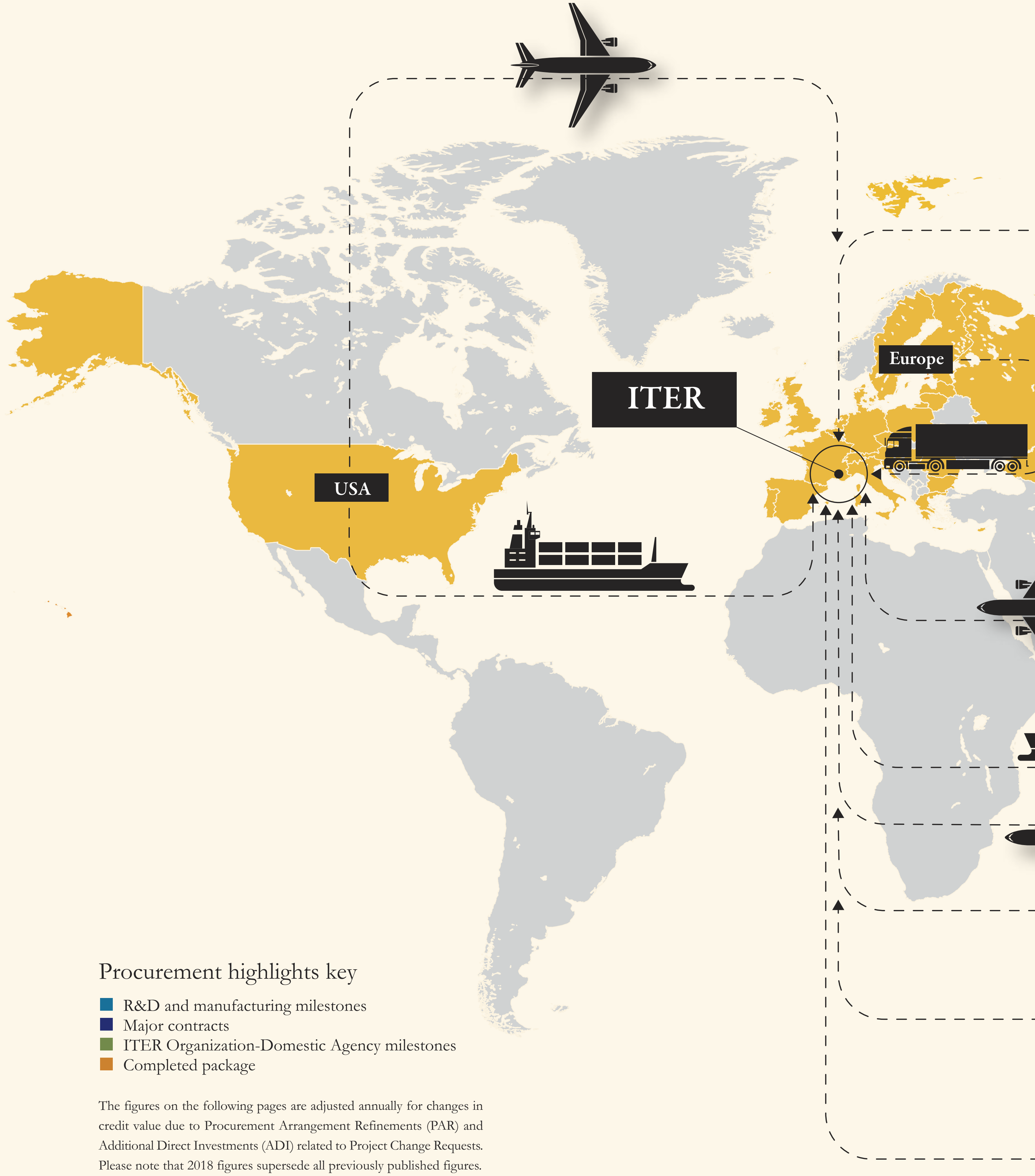
Amounts in thousands of Euro

	Cash and Short-Term In Kind			
Member	Cash 1	Task Agreements and Secondments 2	Procurement Arrangements 3	TOTAL 4 = 1 + 2 + 3
Euratom	223,987	2,421	170,391	396,799
People's Republic of China	35,564	-	38,207	73,771
Republic of India	12,000	-	1,863	13,863
Japan	31,380	-	27,264	58,644
Republic of Korea	36,560	-	12,391	48,951
Russian Federation	30,897	-	13,763	44,660
United States of America	12,837	1,175	18,031	32,043
Total Contributions	**383,225**	**3,596**	**281,910**	**668,731**

Cumulative In-Kind Payments Through 31 December 2018

	Procurement Arrangements	
Member	IUA**	in million EUR
Euratom	352,291	589.92
People's Republic of China	111,792	189.16
Republic of India	46,833	78.40
Japan	236,647	395.08
Republic of Korea	71,941	120.42
Russian Federation	86,865	146.47
United States of America	67,620	113.52
Total	**973,990**	**1,632.96**

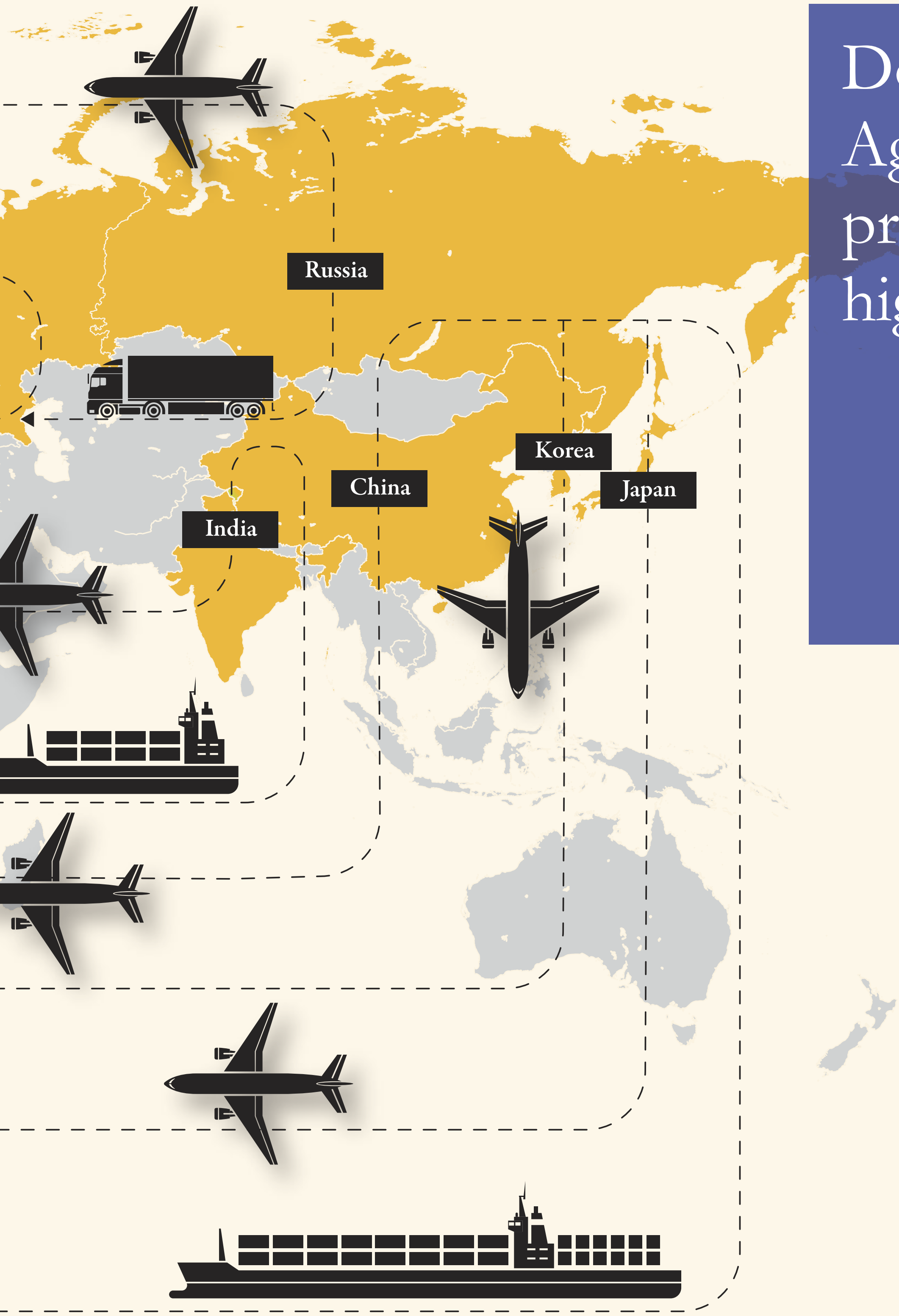
** *ITER Unit of Account*



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 2018 figures supersede all previously published figures.



Domestic Agency procurement highlights

ITER CHINA (CN-DA)

www.iterchina.cn

PROCUREMENT ARRANGEMENTS*

Fourteen PAs signed since 2007 representing…

in number

of the total value of CN-DA in-kind contributions

Over 84 design or fabrication contracts related to ITER procurement have been signed with laboratories and industry.

Chinese procurement highlights in 2018 — **% of ITER system procured by China**

MAGNET SYSTEMS

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

Poloidal Field Conductor — **65%**
- 60 conductor unit lengths produced; 57 shipped to EU-DA at ITER site by end 2018

Magnet Supports — **100%**
- 8 toroidal field coil gravity supports completed
- All parts manufactured for poloidal field coil supports #5 and #6
- Series manufacturing underway for calibration coil supports

Feeders — **80%**
- Qualification activities for Feeder Procurement Arrangement completed
- Coil termination box for poloidal field coil #4 manufactured
- Cryostat feedthrough STR03 manufactured
- In-cryostat feeders for bottom correction coils 1-4,3-6 manufactured

Correction Coils — **100%**
- Case enclosure welding with 20 kW laser welding successfully qualified
- Winding completed for six bottom correction coils (BCC); first vacuum pressure impregnation (VPI)
- Two BCC cases fabricated
- Case enclosure welding and second VPI for BCC1 finished

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

POWER SYSTEMS

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

AC/DC Converters — **55%**
- 13 rectified transformers have been delivered to ITER
- 13 sets of AC/DC converters passed FAT; 9 units shipped

Reactive Power Compensation — **100%**
- Second unit shipped after integrated test

BLANKET

Blanket First Wall — **12.6%**
- Enhanced heat flux panels: Task Agreement signed for validation of final design (FW04)

Blanket Shield Block — **50.2%**
- Successful hot helium leak test on full-scale prototype SB09A; process qualification completed
- MRR held for SB10 production; manufacturing underway

FUEL CYCLE

Gas Injection System — **100%**
- Manifold design model update underway; MRR partially closed
- Preparation for gas valve box and I&C PDR finished

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

DIAGNOSTICS

Diagnostics — **3.2%**
- Neutron flux monitor (NFM) #07: support frame FDR closed, MRR held; final design of fission chamber and electronics ongoing
- Preliminary design ongoing for NFM #1, #8, and #17
- Final design of radial x-ray camera underway
- PDR closed for EQ#12 port integration
- Preliminary design of divertor Langmuir probe ongoing

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* Does not include Complementary Diagnostic Arrangements

ITER INDIA (IN-DA)

www.iter-india.org

PROCUREMENT ARRANGEMENTS*

Fourteen PAs signed since 2007 representing…

100% in number

100% of the total value of IN-DA in-kind contributions

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

Indian procurement highlights in 2018 — **% of ITER system procured by India**

CRYOSTAT

Cryostat — **100%**
- Upper cylinder tier-1 and tier-2 components: manufacturing and FAT completed
- Sub-assembly (fabrication/welding) and testing activities progressing on base and lower cylinder in on-site Cryostat Workshop

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, shipped and delivered
- Manufacturing of cryoplant termination cold box (CTCB) completed

HEATING & CURRENT DRIVE SYSTEMS

Diagnostic Neutral Beam (DNB) Power Supply and Beam Line — **100%**
- Beam source and beam line components progressing
- Further R&D/testing activities carried out on acceleration grid power supply at ITER India lab

NBTF Components (beam dump and 100 kV power supply) — **2%**
- Final acceptance of 100 kV power supply completed on site

Ion Cyclotron Radio Frequency (RF) Power Sources — **100%**
- Further R&D activities and high power operation carried out on tetrode-based system

Ion Cyclotron Heating & Current Drive RF Power Supply (8 out of 10) — **44%**
- Further R&D/testing activities carried out on high voltage power supply at ITER India lab

Electron Cyclotron High Voltage Power Supply — **30%**

Electron Cyclotron RF Power Sources (2 gyrotrons out of 24) — **8%**
- Test gyrotron system contract finalized for ITER India lab
- Other R&D/experimental activities in progress

COOLING WATER SYSTEMS

Heat Rejection System, Component Cooling Water System, Chilled Water System — **100%**
- Piping and equipment manufacturing ongoing; 80% piping and 70% equipment delivered to ITER
- Major equipment delivered: chillers, heat exchangers, cooling tower components, pumps, valves

VACUUM VESSEL

In-wall Shielding (IWS) Block Assemblies — **100%**
- Manufacturing and FAT successfully conducted for several batches of IWS components
- Batches of IWS components shipped to EU-DA and KO-DA
- Balance of components in fabrication

DIAGNOSTICS

Diagnostics — **3.1%**
- PDR for electron cyclotron emission diagnostic has been completed
- Continued R&D/experimentation on fast-scanning Fourier transform spectrometer

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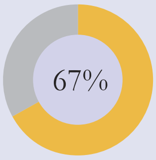
ITER JAPAN (JA-DA)

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

PROCUREMENT ARRANGEMENTS*

Twelve PAs signed since 2007 representing…



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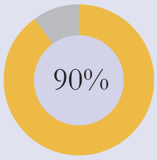

of the total value of JA-DA in-kind contributions

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

Japanese procurement highlights in 2018	% of ITER system procured by Japan
MAGNET SYSTEMS	
Toroidal Field Conductor	25%
■ All conductor unit lengths completed	
Toroidal Field Magnet Windings (9 out of 19)	47%
■ Final leak and insulation tests on first toroidal field winding pack	
■ Second winding pack ready for final tests	
Toroidal Field Magnet Structures	100%
■ Two sets of toroidal field coil structures (TFCS) delivered to Europe; third set shipped	
■ First TFCS set for Japan ready for assembly with winding pack; second set ready for final fitting tests	
Central Solenoid Conductor	100%
■ All conductor unit lengths delivered	
HEATING & CURRENT DRIVE SYSTEMS	
ITER & Neutral Beam Test Facility (NBTF) High Voltage Bushing	100%
and Accelerator	33%
■ Procurement of high voltage bushing completed	
Neutral Beam Power Supply System for ITER and NBTF	59%
■ Installation work 97% completed for power supply components	
■ High-voltage test underway	
Electron Cyclotron Radio Frequency Power Sources (8 gyrotrons out of 24)	33%
■ FAT completed for one of first two gyrotrons	
■ Fabrication underway on gyrotrons #3 and #4	
■ Anode and body power supplies in fabrication	
■ Control cubicles in fabrication	
■ Manufacturing of mirror optical units and cooling manifolds completed	
Electron Cyclotron Equatorial Launcher	71%
■ Multilayer bellows prototype test ongoing for movable mirror steering mechanism	
■ Final design of equatorial launcher in progress	
REMOTE HANDLING	
Blanket Remote Handling System	100%
■ Major change for in-vessel atmosphere (dry air to 25% relative humidity) in discussion. Project Team formed to resolve design issues	
■ Procurement strategy to be updated	
DIVERTOR	
Outer Target	100%
■ Material procurement underway for tungsten monoblocks, stainless steel forgings, CuCrZr-IG cooling tubes, NiAl bronze bar	
TRITIUM PLANT	
Atmosphere Detritiation System	50%
■ Progress on qualification activities: evaluation of Deoxo catalyst kinetics in humid conditions completed	
■ Joint JA-DA/IO procurement activities proceeding	
DIAGNOSTICS	
Diagnostics	14.2%
■ Feedthrough welding demonstration completed for microfission chamber	
■ Shutter development underway to protect edge Thomson scattering first mirror	
■ Laser alignment system prototyping and tests completed for poloidal polarimeter	
■ Development of multi-channel optical connector for divertor impurity monitor; two-colour temperature measurement system for divertor IR thermography	

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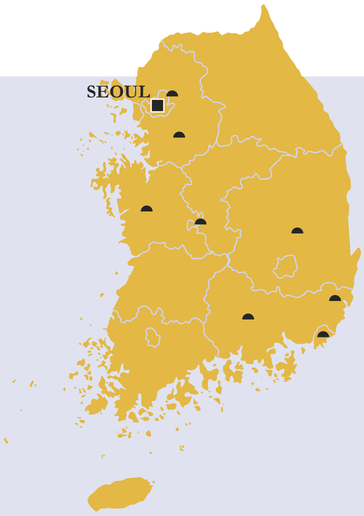
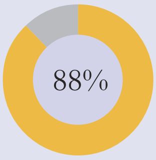
ITER KOREA (KO-DA)

www.iterkorea.org



PROCUREMENT ARRANGEMENTS*

Eight PAs signed since 2007 representing…



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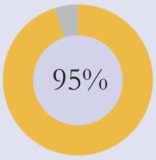

of the total value of KO-DA in-kind contributions

Over 157 design or fabrication contracts related to ITER procurement have been signed with laboratories and industry.

Korean procurement highlights in 2018 — **% of ITER system procured by Korea**

VACUUM VESSEL

Main Vessel (2 of 9 segments)** — 21.26%

- Advanced manufacturing activities continue on Sector #6 (85.6% complete); this is the first sector expected at ITER
- Fabrication progresses for Sectors #7, #8, and #1

Equatorial Ports — 100%

- In-wall shielding completed for neutral beam port stub extension
- Manufacturing of neutral beam port stub extension in progress
- Start of fabrication activities for neutral beam port extension, connecting duct, regular port

Lower Ports — 100%

- Lower port stub extension (LPSE) and port extension manufacturing underway
- LPSE #10 manufactured and packed
- Manufacturing of local penetrations in progress

BLANKET

Blanket Shield Block — 49.82%

- Manufacturing of first full-size prototype (SB06 type A) ongoing
- Completion of process qualification for raw materials; series production launched

POWER SYSTEMS

AC/DC Converters — 37.17%

- FAT completed for AC/DC converter VS1-1
- FAT completed for 13 AC/DC converter transformers (5 CS, 5 CCU/L, 2 CCS, 1 VS1)
- 17 AC/DC converter transformers (6 CS, 6 CCU/L, 3 CCS, 2 VS1) now delivered
- Master controller FAT completed for poloidal field power supply

MAGNET SYSTEMS

Toroidal Field Conductor — 20.18%

- All conductor unit lengths delivered

THERMAL SHIELD

Vacuum Vessel Thermal Shield and Cryostat Thermal Shield — 100%

- Final machining and preassembly of vacuum vessel thermal shield sector #6 completed; silver coating started
- Preassembly and silver coating completed for lower cylinder thermal shield

ASSEMBLY TOOLING

Machine Assembly Tooling — 79.01%

- Completed and delivered: vacuum vessel gravity supports; toroidal field gravity support assembly tools; and vacuum vessel thermal shield joint tools
- Assembly tools delivered for poloidal field coil #4 cryostat feedthrough (PF4 CFT)
- FAT completed for sector sub-assembly tool (SSAT) #2; tool delivered to ITER
- Prototype for inner intercoil structure installation tool completed and delivered

TRITIUM PLANT

Tritium Storage & Delivery — 94.24%

- Full-scale experimental getter bed fabrication completed
- Process and instrumentation diagram draft version prepared
- Tritium inventory calorimetry, helium 3 recovery process validation ongoing

DIAGNOSTICS

Diagnostics — 2%

- FDR held for neutron activation system (NAS) captive components (Tritium Building)
- Safety and vacuum components of vacuum ultra violet (VUV) spectrometer designed
- Prototype test of VUV spectrometer and NAS at KSTAR

***Plus two sectors manufactured on behalf of the ITER Organization*

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ITER RUSSIA (RF-DA)

www.iterrf.ru

PROCUREMENT ARRANGEMENTS*

Twelve PAs signed since 2007 representing…

in number

of the total value of RF-DA in-kind contributions

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

Russian procurement highlights in 2018 | **% of ITER system procured by Russia**

POWER SYSTEMS

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

- FDR 2.2 held
- Manufacturing continues on busbars, copper links, supports; 38 trailers of equipment sent to ITER
- FAT procedures and type test reports issued and approved for a number of components
- FAT completed on radio frequency power source 1 + 2 (**IC milestone**)
- MIP issued and approved for a number of prototypes and production units
- Credit request forms for a number of activities approved by IO
- Materials and components for future production purchased; manufacturing underway

MAGNET SYSTEMS

Toroidal Field Conductor — 19.3%

- All conductor unit lengths delivered

Poloidal Field Conductor — 20%

- All conductor unit lengths delivered

Poloidal Field Magnet No.1 — 100%

- All 8 double pancakes wound; 4 impregnated

BLANKET

Blanket First Wall — 40%

- TGP-56FW and S-65C beryllium (Be) armour tiles brazed to bimetallic supports with optimized induction technology
- Large-scale first wall mockups with brazed Be armour successfully tested at enhanced heat flux of 4.7 MW/m²
- Full-scale mockups manufactured for first wall beam (with mechanical attachment of first wall fingers)

Blanket Module Connectors — 100%

- Choice made on production route for CuCrZr/316L bonded joint (hot isostatic pressing)
- Qualification report approved for CuCrZr/316L series production
- Ceramic insulation, AS/LF coatings, bolt locking in development
- Fabrication of electrical strap pedestals (CuCrZr/316/L blanks) started

DIVERTOR

Dome — 100%

- Developed new dome design following the results of thermo-mechanical analysis on the previous version; success of final structural verification
- CATIA model and manufacturing drawings of improved dome design developed and approved
- Manufacturing launched on full-scale prototype

Plasma-Facing Component Tests — 100%

- Inner vertical target: tests run on full-tungsten plasma-facing units (PFUs) from EU-DA
- Dome: tests run on full-scale prototype inner particle reflector plate PFUs

VACUUM VESSEL

Upper Ports — 100%

- Upper ports #12 and #2 delivered to KO-DA
- Upper port #10 delivered to EU-DA

Port Plug Test Facility (PPTF) — 100%

- Procured 15% of stainless steel for the test tank, 80% of vacuum system components, and 60% of heating system components
- Procurement completed for two non-nuclear stands
- Completed sealing mockup testing; started testing of different helicoflex gaskets

DIAGNOSTICS

Diagnostics — 17%

Port Plug Integration Engineering

- Preliminary design continues for upper port integration (#02, #07, #08)
- Equatorial port #11 PDR closed; final design in progress

Diagnostics

- PDRs held for vertical neutron camera (VNC) I&C and gamma-ray spectrometer; CDR of neutron spectrometer passed
- Development underway on all systems; tests started on VNC front-end electronics, mirrors and spectroscopic devices, and divertor Thomson scattering mockups
- Redesign and relocation (from divertor to vessel floor) studies underway for divertor neutron flux monitor

HEATING & CURRENT DRIVE SYSTEMS

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

- Third gyrotron set manufactured, fourth set started

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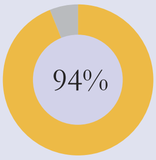
US ITER (US-DA)

www.usiter.org

PROCUREMENT ARRANGEMENTS*

Sixteen PAs signed since 2007 representing…



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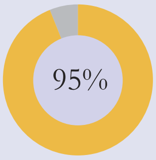

of the total value of US-DA in-kind contributions

The US has awarded over 600 design or fabrication contracts to US industry, universities, and national laboratories in 45 states plus the District of Columbia.

US procurement highlights in 2018	% of ITER system procured by US
COOLING WATER SYSTEM	
Tokamak Cooling Water System	100%
■ First Plasma final design complete	
■ Piping fabrication underway	
MAGNET SYSTEMS	
Central Solenoid (CS) Modules, Structure and Assembly Tooling	100%
■ Mockup module testing complete	
■ First module completes vacuum pressure impregnation	
■ Five (of seven) modules in different stages of fabrication	
■ Lower key block fabrication finished	
■ Early need components completed	
■ Assembly platform completed	
■ All contracts awarded for CS structure and CS assembly tooling fabrication	
Toroidal Field Conductor	8%
■ All conductor unit lengths delivered	
DIAGNOSTICS	
Port-Based Diagnostic Systems	14%
■ PDR complete for low field side reflectometer	
HEATING & CURRENT DRIVE SYSTEMS	
Ion Cyclotron Transmission Lines	88%
Electron Cyclotron Transmission Lines	88%
FUEL CYCLE	
Vacuum Auxiliary and Roughing Pump Stations	100%
Pellet Injection System	100%
Disruption Mitigation System	up to a capped value
■ Final design of vacuum auxiliary system (01 scope) completed	
■ First Plasma pellet injector hardware preliminary design complete	
■ Shattered pellet injection prototype installed on JET	
TRITIUM PLANT	
Tokamak Exhaust Processing System	88%
POWER SYSTEMS	
Steady State Electrical Network	75%
■ All components delivered	

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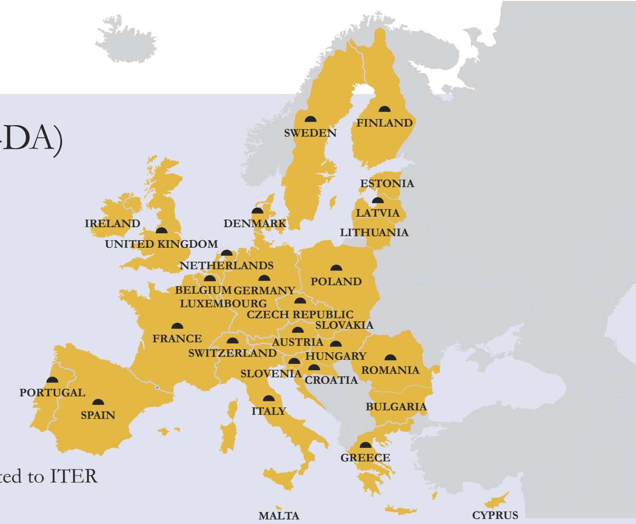
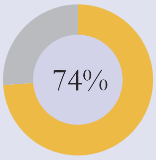
FUSION FOR ENERGY (EU-DA)

www.fusionforenergy.europa.eu



PROCUREMENT ARRANGEMENTS*

Thirty-seven PAs signed since 2007 representing…



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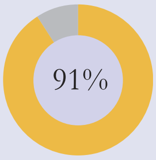

of the total value of EU-DA in-kind contributions

The EU has awarded 725 design or fabrication contracts (71 in 2018) related to ITER procurement to universities, laboratories and industry.

EU procurement highlights in 2018 | **% 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
- Tokamak Complex civil works completed at levels B2 (**IC milestone**), B1, L1, L2
- Civil works completed on Tokamak crown (**IC milestone**), bioshield
- Central pit delivered for assembly preparations (**IC milestone**)
- Handover of cooling tower zone to IO

Architect Engineer Services — 100%
- Tokamak Complex construction design delivered

ITER Headquarters — 53.5%
- Headquarters building completed in 2012

MAGNET SYSTEMS

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

Toroidal Field Magnet Windings (10 out of 19) — 53%
- All 70 double pancakes tested and accepted
- Winding packs: 5 tested, 3 delivered for insertion, 2 cold tested and accepted
- Insertion: welding mockups commissioned; tooling installed and commissioned
- First winding pack inserted

Pre-Compression Rings — 100%
- Pultrusion technology selected for series manufacturing
- Winding tooling line commissioned
- Successful tests on reduced-scale mockups and full-scale slice

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

Poloidal Field (PF) Magnets No. 2-6 — 100%

PF2-5 (manufactured at ITER site):
- Cold test facility and PF5 cryostat installed
- Winding pack mockup: stacking completed
- 7 out of 8 double pancake windings completed; 4 out of 8 impregnated; stacking underway

PF6 (manufactured for EU-DA in China):
- All 9 windings impregnated and stacked; ground insulation underway

HEATING & CURRENT DRIVE SYSTEMS

Power Supply Heating Neutral Beam — 35%
- MITICA ion source and extraction power supplies (ISEPS) delivered after successful FAT
- SAT completed for MITICA acceleration grid power supply (AGPS)
- Assembly on site of MITICA ground related power supply (GRPS) after successful FAT

Neutral Beam Test Facility (NBTF) Components — 64.7%
- SPIDER beam source, handling tool, vacuum vessel and cooling plant transferred to IO
- SPIDER ready for integrated commissioning (**IC milestone**); first plasma in June
- FAT completion for MITICA cryoplant
- Manufacturing contract awarded for MITICA beam source

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%
- Simplified design delivered to IO
- ATLIS and transition frame underway

Electron Cyclotron Control System — 100%
- FDR stage 2 completed
- Control plant model completed
- Task Order for plant control prototypes completed; start of stage 2 prototype

Electron Cyclotron High Voltage Power Supply — 62%
- FAT of the first unit successfully completed
- Start of manufacturing for sets 2 to 5

Electron Cyclotron Upper Launchers — 76%
- Diamond disk FDR completed
- Characterization performed of CuCrZr windows under thermal cycle
- Framework contract signed for testing of windows/window prototypes

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EU procurement highlights in 2018 — **% of ITER system procured by EU**

- Framework contract signed for launcher manufacturing design support
- Manufacturing design initiated: port plugs, isolation valve prototype
- Qualification of blanket shield module mockups and inspection methodology completed
- Corrugated waveguide mockups fabricated
- FALCON test facility: 20-channel radio-frequency load delivered; Gycom gyrotron accepted

Electron Cyclotron Radio Frequency Power Sources (6 gyrotrons out of 24) — 25%

- Tests performed on continuous wave gyrotron industrial prototype

VACUUM VESSEL

Main Vessel (5 of 9 sectors) — 56%

- Sub-assembly manufacturing progressing on all sectors
- First installation of in-wall shielding from IN-DA
- Steep ramp-up of performance in Q3-Q4 on first sector to be delivered (S5)

DIVERTOR

Inner Vertical Targets — 100%

- First all-tungsten prototype passes high heat flux testing at RF-DA Divertor Test Facility
- Three additional full-scale prototypes in fabrication

Cassette Body and Assembly — 100%

- Full-scale cassette body prototypes completed
- Contract signed for cassette body series production Stage 1

Divertor Rail — 100%

- FDR held successfully

BLANKET

Blanket First Wall — 47.4 %

- Beryllium armour joining completed on all three full-scale prototypes

Blanket Cooling Manifolds — 100%

- Manufacturing and thermomechanical tests of bolted blanket cooling manifold prototypes

REMOTE HANDLING

In-vessel Divertor Remote Handling System — 100%

- PDR held successfully

Cask and Plug Remote Handling System — 100%

- Subsystem specifications completed; design of first assembly casks underway

Neutral Beam Remote Handling System — 100%

- Good progress on preliminary design of monorail crane

In-Vessel Viewing System — 100%

- Good progress on preliminary design

Common Technologies — 100%

- Design and R&D phase 2 started for rad-hard digital cameras
- Stage 3 development for GENROBOT framework software for equipment controllers

POWER SYSTEMS

Steady State Electrical Network (SSEN) and Pulsed Power Electrical Network (PPEN):

Detailed System Engineering Design — 100%

Installation and Commissioning` — 100%

Emergency Power Supply — 100%

SSEN Components — 25%

- Four 400kV substation transformers energized and connected

FUEL CYCLE

Front End Cryo-Distribution: Warm Regeneration Lines — 100%

- Branch lines: manufacturing and factory testing completed

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

- Final design, fabrication and testing contracts for: warm regeneration box torus/cryostat cold valve boxes, cryojumpers, couplings

Cryopumps, Torus (6) and Cryostat (2) — 100%

- Procurement Arrangement for Torus and Cryostat Cryopumping System signed in November

Cryopumps, Neutral Beam — 100%

- Contract signed for manufacturing and factory testing of MITICA cryopump

Leak Detection — 100%

- Procurement Arrangement for Leak Detection System signed in December

TRITIUM PLANT

Water Detritiation System — 100%

- Water detrition system holding and feeding tanks delivered to IO

Hydrogen Isotope Separation System — 100%

CRYOPLANT

Cryoplant: LN2 Plant and Auxiliary Systems — 50%

- Component installation progressing well

DIAGNOSTICS

Diagnostics — 25%

- Contracts signed for analysis software algorithm design and bolometer sensor prototypes
- Full-scale vacuum electrical feedthrough prototype successfully manufactured/tested
- Electrical feedthrough PDR closed
- Remote handling compatibility demonstrated for port plug diagnostic shield modules
- Cleaning of full-size prototype mirrors tested successfully using a flux of energetic particles
- Full-scale prototype of diagnostics remote handling connector manufactured/tested
- Procurement Arrangement for magnetic Inner Vessel Coil assemblies signed in March

RADIOACTIVE MATERIALS

Waste Treatment and Storage — 100%

Radiological Protection — 100%

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The first of four poloidal field coils is taking shape in the European winding facility on site. All eight double pancakes have been wound for coil #5 (PF5) and vacuum pressure impregnation is proceeding.

International cooperation

The following entities have signed cooperation agreements with the ITER Organization.

International Organizations	Country
CERN (European Organization for Nuclear Research)	Switzerland
International Atomic Energy Agency	Austria
National Laboratories	
Commissariat à l'Energie Atomique et aux Energies alternatives (CEA)	France
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 (NRFI)	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
Wuhan Institute of Technology	China
Belgian Nuclear Research Centre (SCK-CEN)	Belgium
Wigner Research Centre for Physics	Hungary
Budker Institute of Nuclear Physics, Siberian Branch, Russian Academy of Sciences (BINP SB RAS)	Russian Federation
Institute of Nuclear Physics, Polish Academy of Sciences (IFJ PAN)	Poland
Universities	
Seoul National University	Korea
The National Research Nuclear University (Moscow Engineering Physics Institute- MEPhl)	Russian Federation
Universidad Carlos III de Madrid (UC3M)	Spain
Universidad Politécnica de Madrid	Spain
Université Aix-Marseille	France
University of Beihang (BUAA)	China
University of Durham	United Kingdom
University of Ghent (Ughent)	Belgium
University of Illinois	United States
Keio University	Japan
Kyoto University	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
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
Kyushu University	Japan
Tohoku University	Japan
University of Seville	Spain
University of Columbia	United States
University of Peter the Great St. Petersburg Polytechnic	Russian Federation
Huazhong University of Science and Technology	China
University of Wisconsin-Madison	United States
University of Texas-Austin	United States
University of Basel	Switzerland
University of Nirma	India
The Southwest Jiaotong University	China
University of Leuven	Belgium
Anhui University of Science and Technology	China
Shanghai Jiao Tong University (SJTU)	China
National Schools	
Ecole Centrale de Marseille (ECM)	France
Politecnico di Milano	Italy
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
Government of Canada (Memorandum of Understanding)	Canada
Thailand Institute of Nuclear Technology	Thailand

Organization chart

ITER COUNCIL

ITER Council Secretariat ICS

Director-General Bernard Bigot
Chief Operating Officer/DDG1
Relations Coordinating Officer/DDG2

ITER Organization Central Team IO-CT and ITER Domestic Agencies IO-DAs

ITER Organization Executive Project Board EPB

Quality Management Division QMD

Cabinet CAB

Legal Affairs LGA

Communication COM

Internal Audit Service IAS

Deputy to the Site Construction Director (SCDD)

External Relations & Action Plan Implementation Office (ORAP)

Finance & Procurement Department (FPD)

Finance & Budget
- Accounting, Treasury & Systems
- Budget Management
- Financial Control

Procurement & Contracts
- Procurement Construction, Assembly and Logistics
- Procurement Engineering, Plant and Support

Human Resources Department (HRD)
- Talent & Competencies Development
- Remuneration, Performance & Employment

Project Control Office (PCO)

Component Delivery Project Control

Project Control Construction

Central Integration Office (CIO)

Information Technology
- IT Application and Development
- IT System and Operation

Configuration Management
- Design and Configuration Control
- Document Control

Analysis Section

Design & Construction Integration
- Design Integration
- System Integration

Design Office
- CAD
- CAD Infrastructure

Safety Department (SD)

Security, Health & Safety
- Occupational Health & Safety
- Physical Protection

Environmental Protection & Nuclear Safety
- Safety Analysis & Assessment
- Safety Control

Tokamak Engineering Department (TED)

Magnet
- Magnet Instrumentation & In-Vessel Coil
- Poloidal Field Coil & Correction Coil
- Central Solenoid, Supports and Performance

Vessel
- Vacuum Vessel Procurement

Internal Components
- Blanket
- Divertor
- Tritium Breeding Blanket Systems

Port Plugs & Diagnostics Integration
- In-Vessel Diagnostics
- Ex-Vessel Diagnostics
- Common Port Plug Engineering

Heating & Current Drive
- Electron Cyclotron
- Ion Cyclotron Lower Hybrid
- Neutral Beam

Plant Engineering Department (PED)

Electrical Engineering
- Coil Power Supply
- Electrical Power Distribution
- Cable Management

Cooling Systems Engineering
- Cooling Water System
- Cryogenic System
- Vacuum Vessel Pressure Suppression Systems & Auxiliary Functions

Tokamak Cooling Water System
- Tokamak Cooling Water System Design

Fuel Cycle Engineering
- Tritium Plant
- Fuelling & Wall Conditioning
- Vacuum

Remote Handling & Radioactive Materials
- Hot Cell & Radwaste
- Remote Handling

Field Engineering Installation

Construction Department (CST)

Tokamak Assembly
- Assembly Support
- In-Cryostat Assembly
- Sector Module Assembly

Tokamak Complex

Facilities, Logistics & Materials
- Facilities Management
- Buildings & Civil Works

Construction Management

Science & Operations Department (SCOD)

Science
- Tungsten Divertor & Plasma-Wall Interactions
- Confinement & Modelling
- Stability & Control

Control System
- CODAC
- Plant Control & Instrumentation

Operations

Cover image… This "crown" at the bottom of the Tokamak Pit is designed to support the full mass of the machine. The concrete used to create the ring and 18 radial walls is the most heavily reinforced of the Tokamak Complex.

Looking ahead: 2019

- an independent review of ITER's assembly and installation strategy, as mandated by the ITER Council
- load testing of the giant SSAT assembly tools
- the arrival of the first ITER magnets
- the completion of 50% of the cryostat (two of four sections)
- the award of several major assembly contracts
- a new construction-based organization chart

Twice every year, the ITER Organization and the European Domestic Agency organize Open Doors Days to introduce members of the public to ITER and fusion. These events, plus daily tours for smaller groups, combined to bring 14,000 people on site in 2018.

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china eu india japan korea russia usa