ITER ORGANIZATION ANNUAL REPORT 2019

iter
china eu india japan korea russia usa

7
members
35
nations
42
years
929
staff
2025
First Plasma

WHAT IS ITER?

ITER is the project of many superlatives.

It is the most ambitious and well-funded **fusion energy project** in the world. It has the broadest international participation of any science project on record. The ITER device – **a tokamak** – will be the grandest in history – fully twice the linear dimensions of any fusion device operating today, with a **vacuum vessel** sized to permit ITER **scientists and engineers** to create **plasmas** approximately one order of magnitude larger than any that have been achieved to date. This exceptional laboratory will be the first on Earth to create **net energy** from fusion.

The objective of the ITER Project is to propel **fusion research** out of the realm of laboratory sciences and into the fusion industrial era – the ultimate reactor-scale experimental device conceived to demonstrate the **proof-of-concept** fusion regimes and fusion technologies that will show us the way to designing the fusion plants of the future.

Project Members **China**, the **European Union, India, Japan, Korea, Russia** and the **United States** are pooling their human and financial resources to design, construct and operate the ITER machine and plant through a **42-year collaboration** headquartered in the south of France. First Plasma is planned in December 2025.

Fusion, the energy that powers the **Sun and stars**, has the potential to become a **new source of baseload energy** – more powerful than nuclear fission, free from the carbon emissions of fossil resources, and based on fuel that will be available for thousands, if not millions, of years.

There is one form of energy that may completely change the way we fuel our future: **fusion energy**.

Cooling fluids will be delivered to the Tokamak Building through a 2.7-kilometre network of cryolines – high-technology components that host up to seven individually insulated pipes. Installation has started in the Tokamak Complex.

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.

The ITER Agreement

Signed by all Members in November 2006, the ITER Agreement 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)*

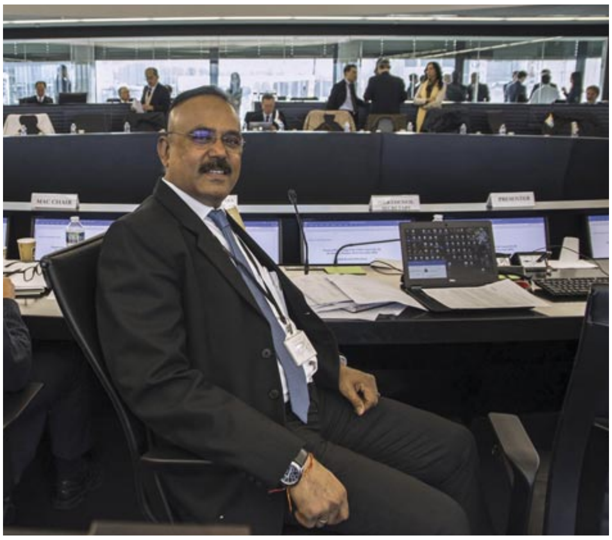
Management Assessor

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

Contents

Thousands of components procured by Europe, the ITER Organization, and India are in place in the ITER cryoplant and the first commissioning activities are scheduled for next year.

Foreword from the Chair of the ITER Council



As Chair of the ITER Council from 1 January 2018 to 31 December 2019, I am pleased to say that I have been a first-hand witness to the strength of the collaboration that is the core of the ITER Project. Every new challenge and its potential mitigation is discussed by stakeholders in all transparency. External expertise is solicited wherever needed, and a path forward is selected by all Parties as a "One-ITER" team.

It is for this reason I am confident that the ITER Organization and the seven ITER Domestic Agencies, with the support of the Members, will succeed in building the world's most ambitious energy project, which is the future of clean and limitless electrical power generation.

Substantial progress has been achieved for every major ITER component, system, and structure over the past years and deliveries are accelerating as per schedule. Physical progress to First Plasma – including design, manufacturing, building on site, and assembly and installation – is approaching 70 percent. Two international consortia have been selected to carry out the thousands of complex lifting, positioning, inspection, and joining activities over the next five years for the assembly of the ITER core machine and their teams are already active on site. A page in ITER's history has turned as the focus has moved from engineering and design to plant assembly and operational planning.

The re-structured ITER Organization is navigating this critical period from a position of strength and efficiency, with full respect of safety, quality and cost parameters. Management has been working to clearly define the roles and responsibilities of the central ITER Organization, the Domestic Agencies and assembly contractors. In 2019, an In-Depth Independent Review Panel, mandated by the ITER Council, shared important recommendations with the ITER Organization on its assembly and installation strategy, which have now been formulated into a targeted action plan.

By jointly managing risks and issues affecting critical deliveries, the ITER Organization and the Domestic Agencies have maintained the First Plasma date at December 2025. As we get closer to the delivery need dates for critical components, it will become progressively more challenging to maintain this date, as any slippage in the delivery of one critical component affects the machine assembly sequencing and as a result the entire project schedule, which may also affect the cost of the project.

Every ITER Project Member is aware of its responsibilities. Without full and timely support by all Members in the form of contributions in accordance with commitments, the capacity to remain on schedule for First Plasma will be at high risk.

In 2019, the Members unanimously renewed their confidence in Director-General Bernard Bigot by appointing him to a second five-year term (2020-2025). He has lived up to the expectations of the Members and has shown great project leadership skills over the last five years.

COVID-19, which has affected the whole world, has had its effect on the ITER Project also. It is worth complimenting the Director-General and management for preserving the health of staff and contractors while making every step forward that can be made during these challenging times.

I wish Director-General Bernard Bigot, the ITER Organization, and the Domestic Agencies as "One-ITER" team the very best success in the realization of First Plasma by 2025.

Arun Srivastava
St. Paul-lez-Durance
July 2020

The large quantities of heat generated during ITER operation will be removed by cooling water circulating under pressure. ITER contractors are installing the cooling towers, heat exchangers, pumps (pictured) and pipes that are part of the high-performance heat rejection system.

Foreword from the Director-General

More than two decades of planning in the worldwide fusion community is about to come to fruition as the ITER Tokamak is assembled from components shipped from all around the world by the seven ITER Members. The thousands of scientists and engineers who have played a role in the conception of the world's largest fusion device, the ITER Members, all industry stakeholders, and the public at large are turned towards Saint Paul-lez-Durance/Cadarache as the ITER Tokamak – starting with the installation of the cryostat base only two months ago – begins to take shape before our eyes. It is my honour to lead the effort of the ITER Organization for a second term (2020-2025) as Director-General, following the renewal decision made by the ITER Council in 2019.

A remarkably dense series of arrivals of Tokamak components is scheduled in the next three years as the largest machine components are finalized, factory tested, loaded on oceangoing vessels, and delivered to the ITER site. The logistics have been painstakingly coordinated and planned, the reception teams are ready, and the installation sequences in the Tokamak pit have been carefully programmed.

The European Domestic Agency completed civil works on the Tokamak Building in 2019 and handed over the assembly theatre, with fully commissioned heavy lift cranes, in March 2020. Complex systems integration is progressing in the Tokamak Complex and in every corner of the ITER worksite, plant installation continues to meet overall project schedule needs.

Major advancements in safety requirements and interface management, physical and functional integration, equipment qualification, product lifecycle management (PLM), and clash-free systems integration have been achieved, all vital elements for the success of the challenging assembly phase that is before us. Also critical is the shape of our new internal organization at ITER Headquarters, which was reworked for the optimized execution of assembly and installation. The re-organization, including four new Domain Head positions, has been in place since 1 January 2020 and is working well.

When the COVID-19 pandemic struck Europe, we were able to take into full consideration the lessons learned by ITER Members that had been impacted first: China, Korea and Japan. We moved 1,300 of our staff and associated contractors to teleworking, while maintaining a minimum presence on the worksite to sustain activities critical to the ITER schedule. We are fortunate to say that, to date, we have had no cases of COVID-19 among our staff or our contractors working on site. Extended shutdowns at some key manufacturing sites in the countries of the ITER Members may have some consequences for the project schedule; the Council will review a full assessment at its next meeting in November.

The continuous strong support and commitment of the Members is critical for keeping the ITER Project on track towards First Plasma in 2025 and full fusion power in 2035 as the project faces increasing technical challenges on critical and non-critical items expected from the Domestic Agencies as well for assembly and installation. Cash contributions from Members also must reach the ITER Organization in a timely manner in order to enable the successful implementation of the construction strategy. The achievement of First Plasma in December 2025 is an important milestone for all of our stakeholders. The next three years are absolutely critical for ITER's overall success.

To conclude, I would like to thank the Chair of the ITER Council, Arun Srivastava, the Chairs of the ITER Council advisory boards, as well as all the members of these bodies for their dedication and commitment during their terms, which ended in December 2019. Their continuous support and constructive attitudes have been crucial to the progress we have accomplished. They deserve our highest recognition.

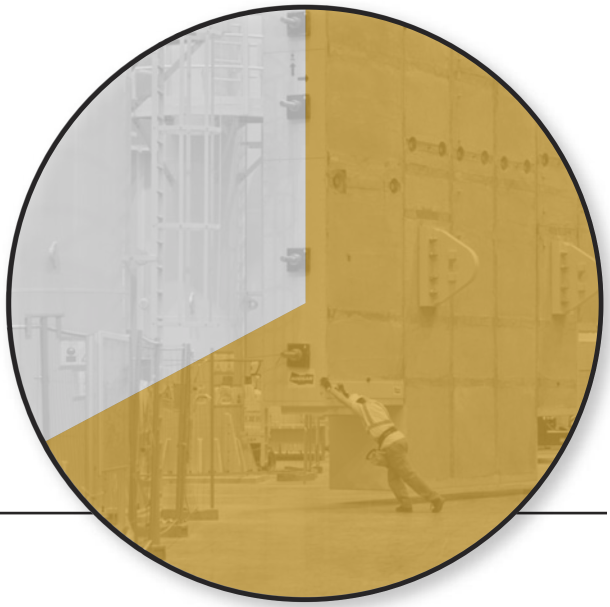
Bernard Bigot
St. Paul-lez-Durance
July 2020

Year in review

PHYSICAL WORK ACHIEVED TO FIRST PLASMA

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

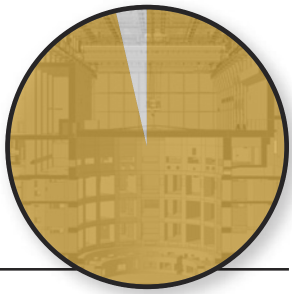
67.3%



PROGRESS TOWARD THE REALIZATION OF FIRST PLASMA SYSTEMS AND COMPONENTS

96.4%

of design completed



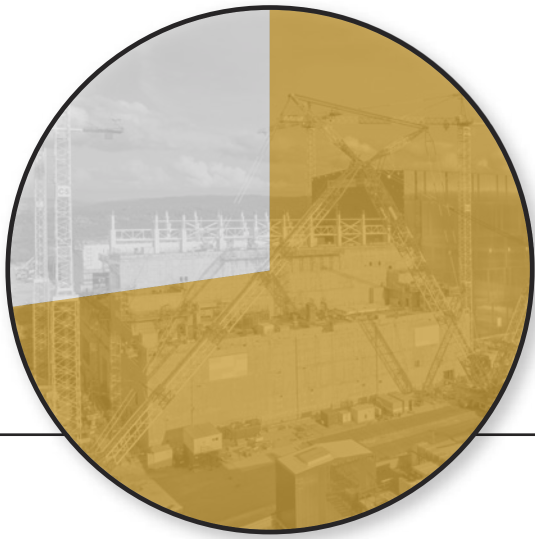
77.6%

of manufacturing completed

BUILDING CONSTRUCTION COMPLETED ON SITE

73%

First Plasma scope

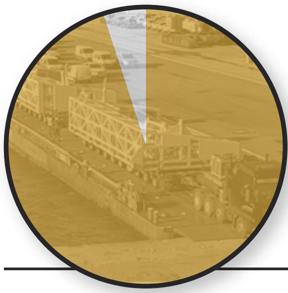


All figures and graphics as of 31 December 2019

2019

PROCUREMENT ARRANGEMENT SIGNATURES

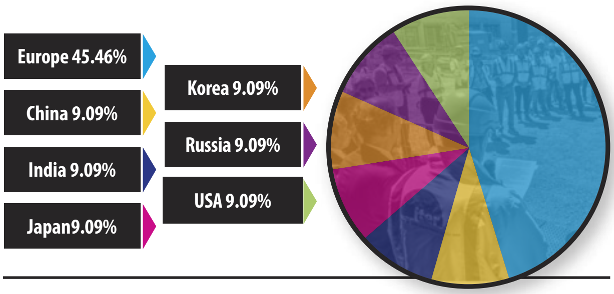
86.5%
in number



95%
in value

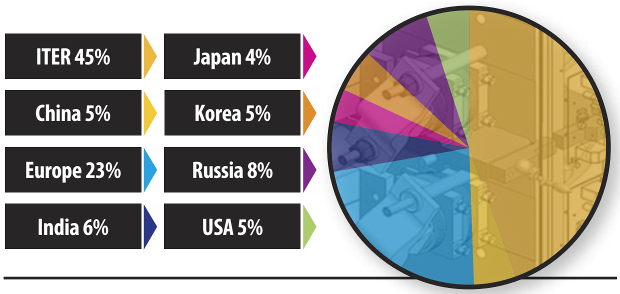
PROJECT SHARING BY MEMBER

(Construction phase)



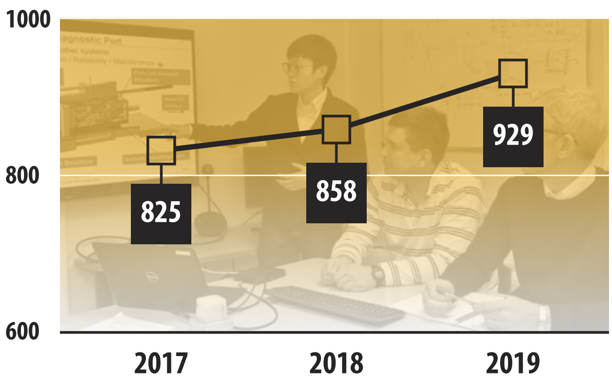
INTELLECTUAL PROPERTY DECLARATIONS

Declaration of "Generated Intellectual Property," cumulative



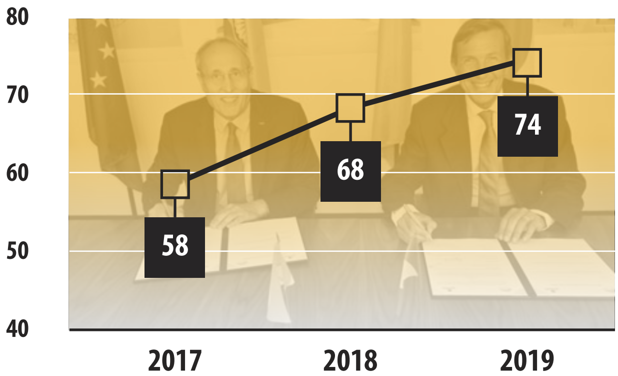
STAFF

(see page 42)



COOPERATION AGREEMENTS

(see page 55)



Fusion for Energy, the European Domestic Agency, has completed a five-year effort to construct the critical Tokamak Building. Only the steel-frame crane hall remains to be installed before the building can be transferred to the ITER Organization for machine assembly.

42-hectare
construction platform

39 buildings
and technical areas

73%
construction completed (First Plasma scope)

1,700
construction and assembly workers per day

16,000
visitors per year

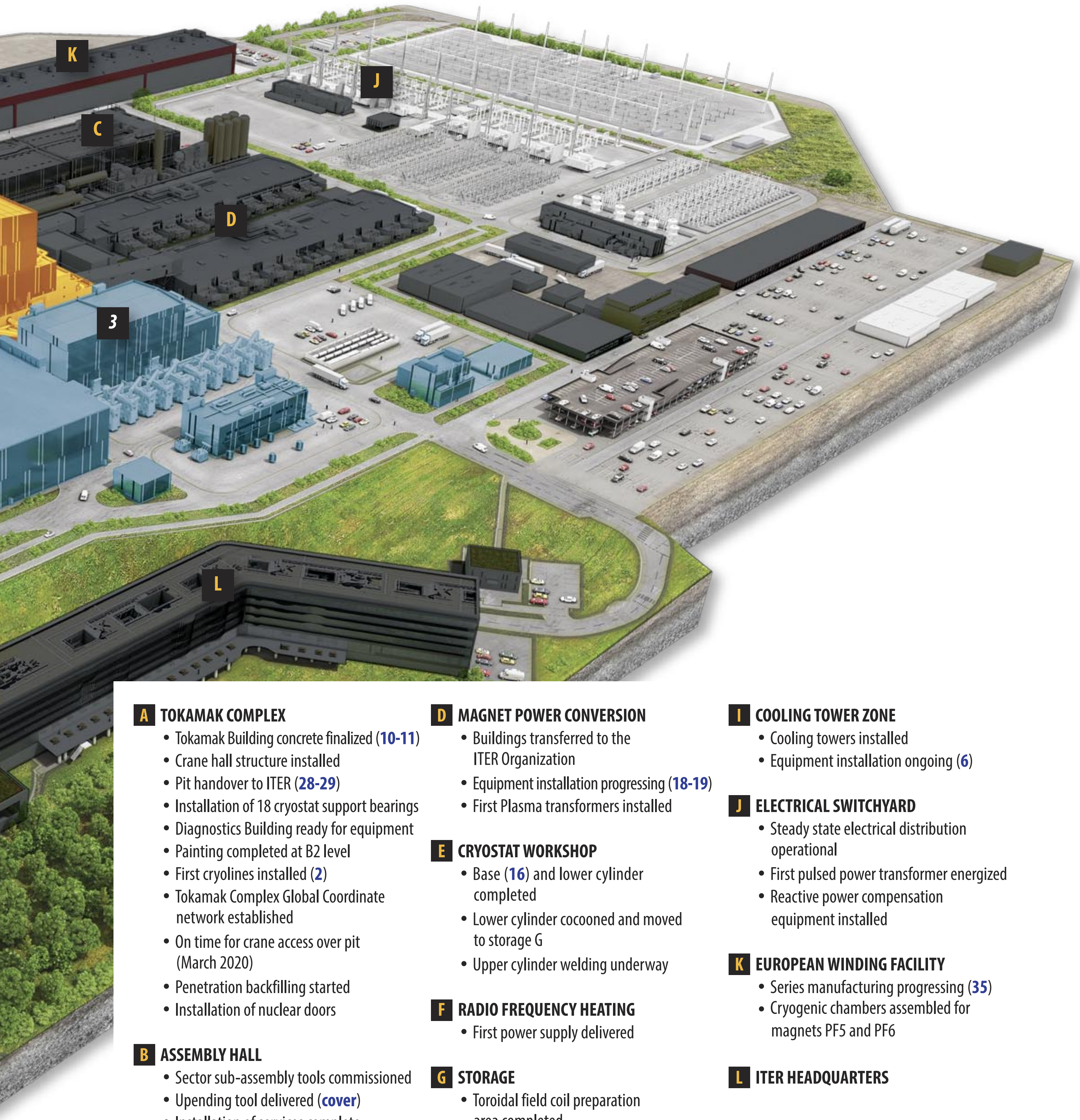
2019 CONSTRUCTION UPDATE

Buildings

Civil structures and building services are constructed by the European Domestic Agency, Fusion for Energy, in conjunction with its Architect Engineer ENGAGE. Each area or building is handed over to the ITER Organization at an agreed level-of-completion milestone.

Buildings in place **Buildings in progress** **Buildings to come**

Site image courtesy of Fusion for Energy



A TOKAMAK COMPLEX
- Tokamak Building concrete finalized (10-11)
- Crane hall structure installed
- Pit handover to ITER (28-29)
- Installation of 18 cryostat support bearings
- Diagnostics Building ready for equipment
- Painting completed at B2 level
- First cryolines installed (2)
- Tokamak Complex Global Coordinate network established
- On time for crane access over pit (March 2020)
- Penetration backfilling started
- Installation of nuclear doors

B ASSEMBLY HALL
- Sector sub-assembly tools commissioned
- Upending tool delivered (cover)
- Installation of services complete; commissioning ongoing
- Floor painting underway

C CRYOPLANT
- 65% of equipment installed (4)
- Sub-system commissioning begins in 2020

D MAGNET POWER CONVERSION
- Buildings transferred to the ITER Organization
- Equipment installation progressing (18-19)
- First Plasma transformers installed

E CRYOSTAT WORKSHOP
- Base (16) and lower cylinder completed
- Lower cylinder cocooned and moved to storage G
- Upper cylinder welding underway

F RADIO FREQUENCY HEATING
- First power supply delivered

G STORAGE
- Toroidal field coil preparation area completed
- Excavation finalized for Tokamak Assembly Preparatory Building
- First cryostat section stored

H SITE SERVICES BUILDING
- All equipment installed

I COOLING TOWER ZONE
- Cooling towers installed
- Equipment installation ongoing (6)

J ELECTRICAL SWITCHYARD
- Steady state electrical distribution operational
- First pulsed power transformer energized
- Reactive power compensation equipment installed

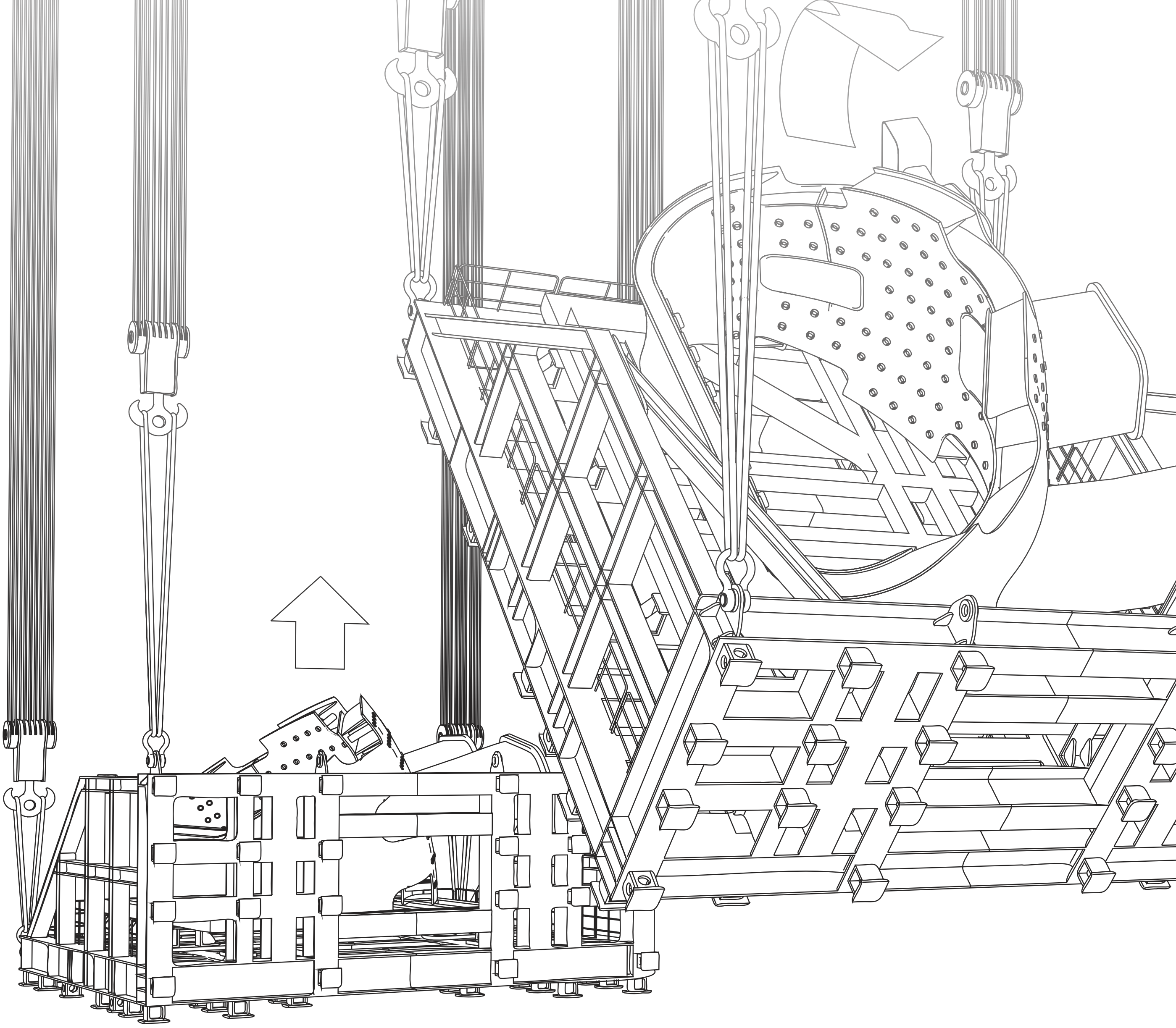
K EUROPEAN WINDING FACILITY
- Series manufacturing progressing (35)
- Cryogenic chambers assembled for magnets PF5 and PF6

L ITER HEADQUARTERS

Buildings to come

1 Control Building
2 Hot Cell
3 Neutral beam power supply

Assembly and installation



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

July 2020
Sector sub-assembly activities begin

February 2021
Start on vacuum vessel sector field joints

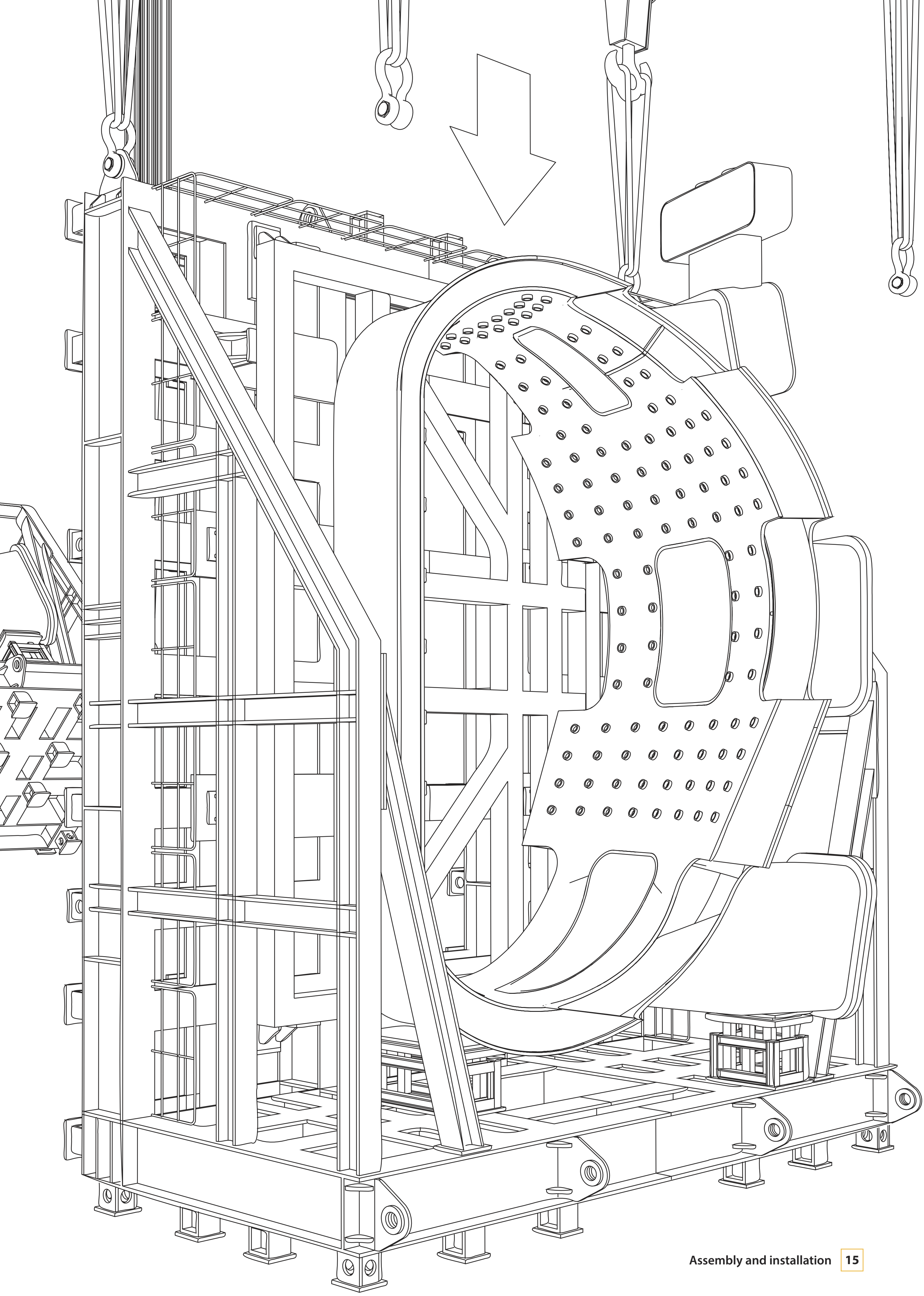
December 2022
All vacuum vessel sectors in pit

December 2023
Install central solenoid

December 2024
Cryostat closure

January 2025
Begin integrated commissioning

December 2025
FIRST PLASMA



Assembling the machine and plant

Starting with the installation of the cryostat base and ending with the lid, ITER Assembly Phase I encompasses the construction of the core machine in the Tokamak pit and the installation of First Plasma plant systems in the Tokamak Complex and across the site.

The ITER Organization is responsible for the surveillance of all assembly and installation activities and for final compliance with requirements, including nuclear safety requirements in France. Daily work is carried out by contractors selected for their industrial know-how, experience, resources, skills and proven track record.

Nine major assembly and installation contracts cover the total scope of Assembly I work *(see list, next page)*.

Under the overall management of the ITER Organization construction teams and the operational coordination and supervision of MOMENTUM (ITER's Construction Management-as-Agent contractor), early installation activities are intensifying:

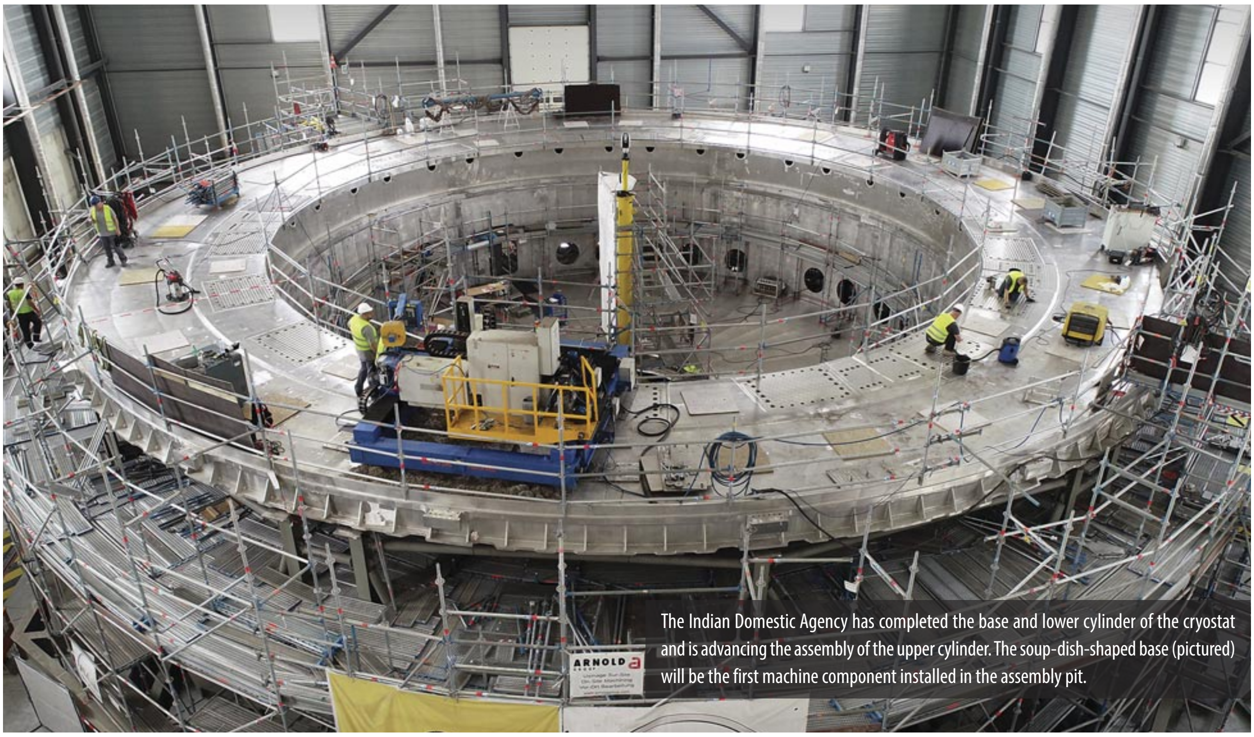
■ Preparation for the installation of the cryostat base is nearly complete, as contractors have finalized the installation of captive components and installed toroidal lugs, lower pit feedthroughs and stubs, attachment plates for metrology targets, and components on the cryostat base (cooling water bellows and skirt supports).

■ Tokamak Complex early works – including the installation of cable trays and cables, piping, fittings, wall sleeves, ducts, and common supports – are underway in the basement. For major Tokamak Complex installation activities, the Holistic Integration Team (formed in 2018 to deliver optimized, clash-free installation sequences) is releasing the detailed integration of systems and Tokamak Complex services room by room, beginning with the B2 basement level of the Diagnostics Building.

■ The first cryoline sections (**2**) have been installed in the Tokamak Building. Each one weighs 1 to 3 tonnes and hosts multiple cryopipes; 500 sections must be installed.

■ Large-scale assembly tooling procured by Korea (**cover**) is ready: the twin sector sub-assembly tools have been commissioned successfully and another large tool – the upending frame – has been received and assembled. The critical in-pit column tool, which will support the weight of the vacuum vessel during welding, has passed factory acceptance testing.

■ A large number of bespoke handling tools are arriving at ITER or expected next year. Tools for lifting the central solenoid modules, the cryostat lower cylinder, thermal shield panels, upper port extensions, pre-compression rings, and lower poloidal field coils are all at an advanced stage of manufacture and testing.



The Indian Domestic Agency has completed the base and lower cylinder of the cryostat and is advancing the assembly of the upper cylinder. The soup-dish-shaped base (pictured) will be the first machine component installed in the assembly pit.

Nine Phase 1 assembly contracts

Tokamak Assembly (organized by system)

- TAC/1 - cryostat and cryostat thermal shield, magnet feeders, magnets, cooling structures and instrumentation
- TAC/2 - main vessel and ports, sector sub-assembly, welding

Tokamak Complex (organized by system, location, sequence)

- TCC/1 - heating and current drive, diagnostics, fuelling, secondary cooling, vacuum components
- TCC/2 - primary machine cooling water, test blanket module equipment, some vacuum pipework, vacuum vessel pressure suppression

Balance of Plant

- Group 1 - equipment installation in the Magnet Power Conversion buildings
- Group 2 - installation of cooling water plant
- Group 4 - installation of multi-process lines
- Group 5 - installation of DC busbars, switching network and fast discharge units
- Group 6 - installation of converters, transformers, reactive power compensation units, and harmonic filters

■ Metrologists have established the Tokamak Complex Global Coordinate network for the alignment of installed components, as well as a local coordinate system in the Assembly Hall for vacuum vessel sector sub-assembly.

■ Transversal support contracts have been placed for scaffolding, general services, lifting and handling, and minor civil works as a cost-saving measure for all teams.

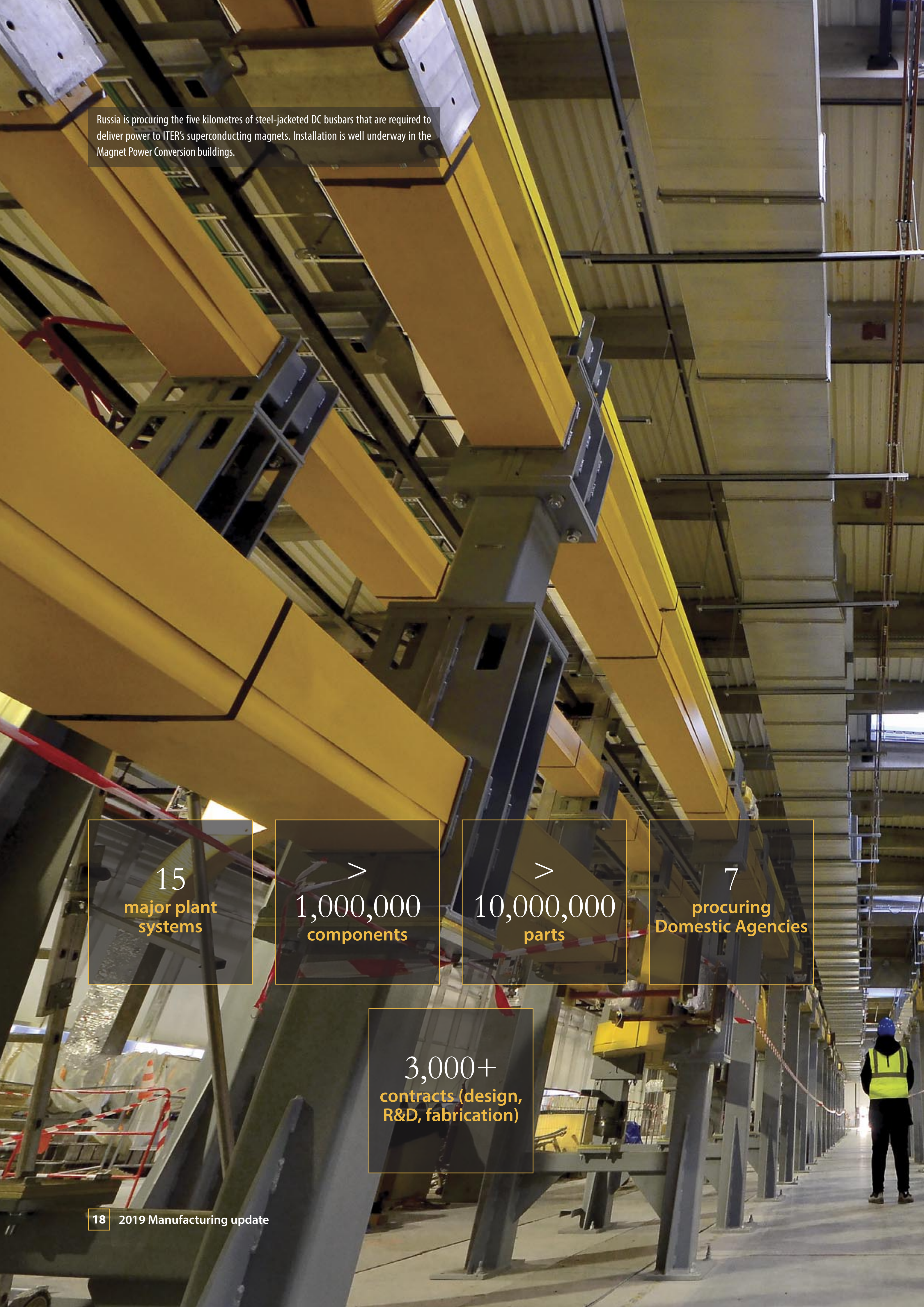
■ The first ITER system – electrical distribution – entered operation in January. The ITER site is now independently powered by an electrical substation that draws power directly from the 400 kV French national grid. Energization activities are underway for ITER's second network – pulsed power.

■ The European Domestic Agency handed over the twin Magnet Power Conversion buildings and a smaller facility for reactive power compensation in March. Equipment installation is well advanced. (**18-19**)

■ The heat rejection zone was totally transformed during the year, as cooling towers, piping, pumps (**6**), and heat exchangers were installed.

■ Sixty-five percent of mechanical assembly in the cryoplant is complete and planning has been initiated for 2020 commissioning activities.(**4**)

■ A temporary building was erected near the Assembly Hall for the reception and preparation of toroidal field coils.



Russia is procuring the five kilometres of steel-jacketed DC busbars that are required to deliver power to ITER's superconducting magnets. Installation is well underway in the Magnet Power Conversion buildings.

15
major plant systems

> 1,000,000
components

> 10,000,000
parts

7
procuring Domestic Agencies

3,000+
contracts (design, R&D, fabrication)

2019 MANUFACTURING UPDATE

Key components

The ITER Members are manufacturing the components and systems needed to complete the construction of the ITER installation based on the technical specifications included in 133 Procurement Arrangements. For the longest-lead items – the superconducting magnets – procurement began over ten years ago with the qualification of suppliers and processes. Today, 77.6% of the manufacturing scope for First Plasma components and systems has been finalized and component deliveries to the ITER site are accelerating.

A. VACUUM VESSEL 84%

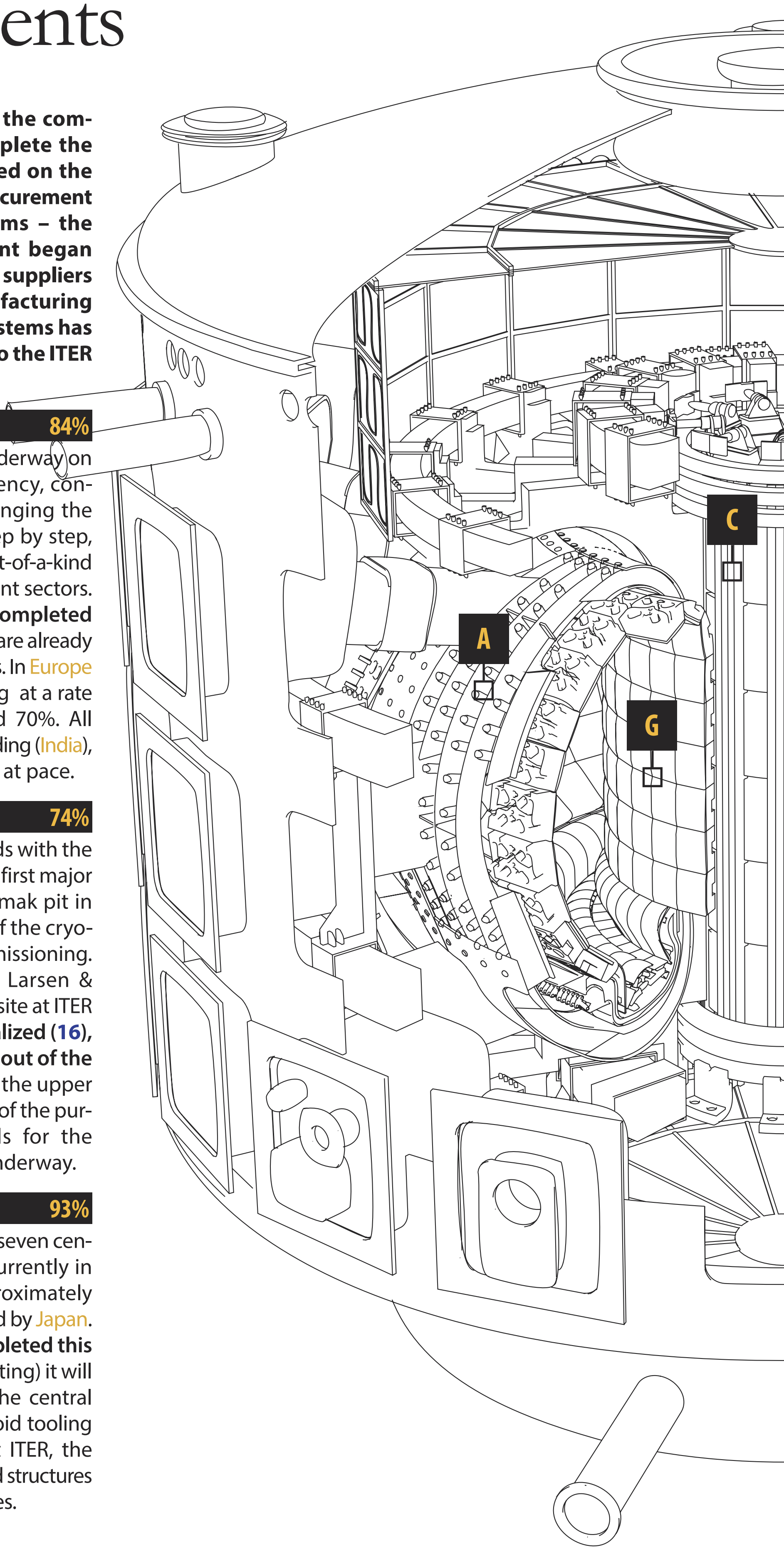
In Korea and Europe – where fabrication is underway on nine vacuum vessel sectors – Domestic Agency, contractor and ITER Organization teams are bringing the first-of-series components to completion step by step, learning from challenges and ensuring that first-of-a-kind industrial experience will benefit all subsequent sectors. **In a major project milestone, Korea (22) completed Sector #6 in 2019 (97.5%);** three other sectors are already over 70% complete at Hyundai Heavy Industries. In Europe (**54**), the fabrication of five sectors is advancing at a rate of execution that ranges between 50% and 70%. All vacuum vessel ports (Korea, Russia), in-wall shielding (India), and gravity supports (Korea) are progressing at pace.

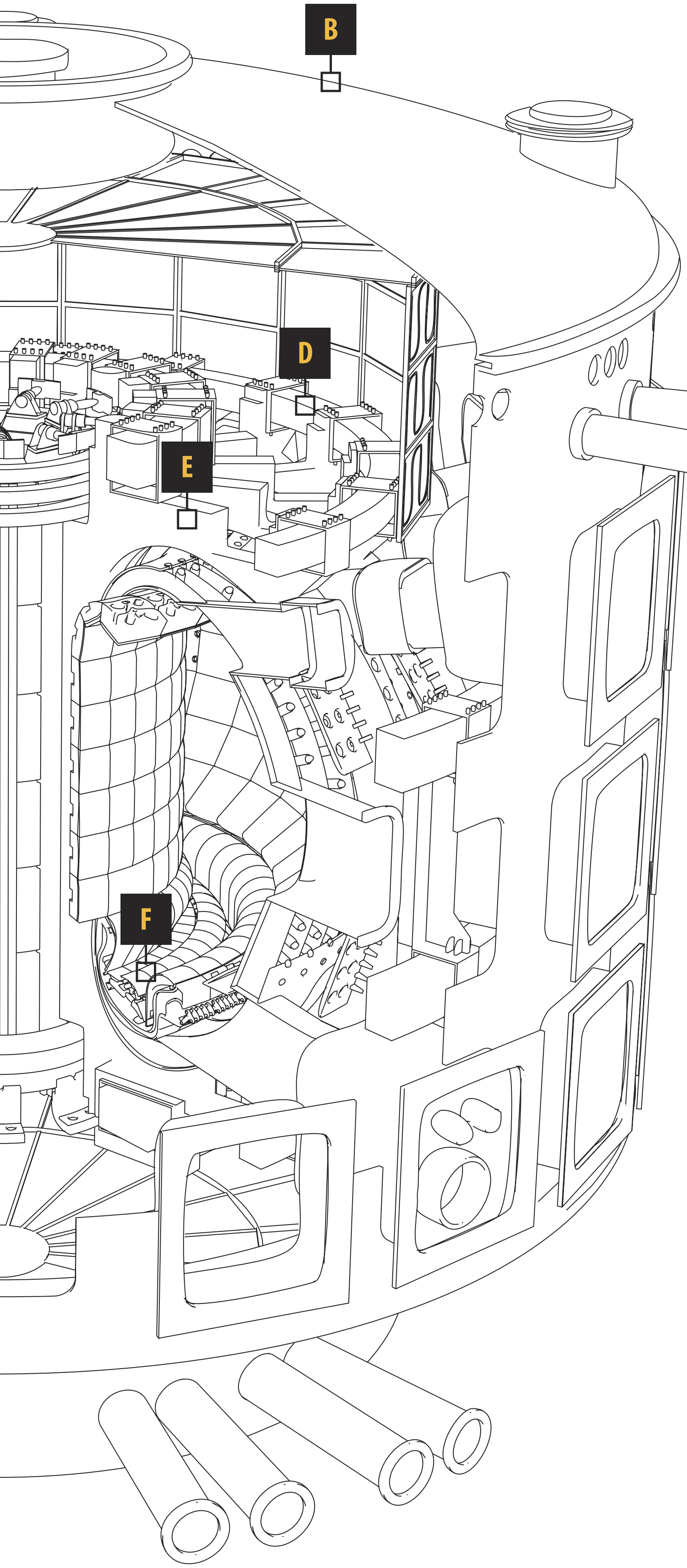
B. CRYOSTAT 74%

First-phase machine assembly begins and ends with the ITER cryostat (31). The base section will be the first major machine component inserted into the Tokamak pit in 2020; four and a half years later, the closure of the cryostat lid will signal the start of integrated commissioning. Steel segments manufactured in India by Larsen & Toubro have been assembled and welded on site at ITER since 2016. **In 2019, the base section was finalized (16), the lower cylinder was finalized and moved out of the workshop**, and the assembly and welding of the upper cylinder advanced on schedule. Procurement of the purpose-built transportation and lifting tools for the installation of each cryostat section is also underway.

C. CENTRAL SOLENOID 93%

United States contractor General Atomics has seven central solenoid modules (six plus one spare) currently in production – each one fabricated from approximately 6,000 metres of niobium-tin conductor supplied by Japan. **Manufacturing of the first module was completed this year (39)**; after final testing (including cold testing) it will be delivered to ITER in 2020. Elements of the central solenoid support structure and central solenoid tooling are also in production. When assembled at ITER, the stacked central solenoid modules and associated structures will stand 18 metres tall and weigh 1,000 tonnes.





D. POLOIDAL FIELD MAGNETS 92%

Four of ITER's six poloidal field coils are in production under the oversight of the Domestic Agencies of Europe and Russia. Built from niobium-titanium conductor produced in China, Europe and Russia, these coils are expected for assembly in the Tokamak pit in a precise order – from PF6 to PF1. **The first coil to be inserted – PF6 – was completed this year by Europe's contractors in China** and is soon expected at ITER for cold testing. In Europe's winding facility at ITER: PF5 is ready for impregnation, the elements of PF2 have been wound, and tooling stations are in adjustment for start-of-work on PF3 and PF4. The smallest coil and last to be inserted – PF1 – has entered the stacking stage in Russia.

E. TOROIDAL FIELD MAGNETS 95%

From lengths of niobium-tin conductor supplied by China, Europe, Japan, Korea, Russia and the United States, two ITER Members – Europe (26) and Japan – are manufacturing the powerful, high-field magnets that will be responsible for confining the plasma inside the vacuum vessel. After winding pack completion, insertion into a structural steel case provided by Japan, closure welding, gap filling, final machining, and testing, **the first coils will be delivered to ITER in 2020** where they will be joined, by pair, with one vacuum vessel sector and vacuum vessel thermal shielding in the Assembly Hall. All toroidal field coils (18 plus one additional coil as a spare) are expected at ITER by 2022.

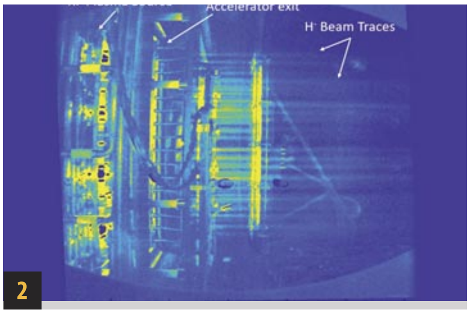
F. DIVERTOR 40%

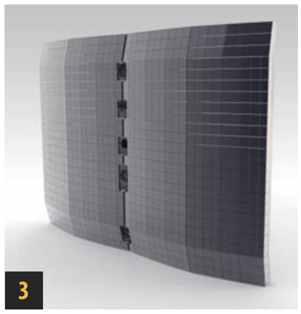
Three Domestic Agencies are collaborating to procure the ITER divertor: Europe (cassette bodies, inner vertical targets), Japan (outer vertical targets), and Russia (dome). European suppliers have launched the manufacturing of the first cassette bodies – the chassis for the tungsten-coated plasma targets; in another 2019 milestone, **the first full-scale industrial prototype of the inner vertical target passed a rigorous campaign of thermal testing** at the ITER Divertor Test Facility in Russia. Prototype qualification advanced in Japan and Russia on the other plasma-facing targets, and a high-performance remote handling system for the installation and subsequent maintenance of the ITER divertor passed the preliminary design phase in Europe.

G. BLANKET 49%

On the inner wall of the vacuum vessel, 440 blanket modules – each one made of a main shield block and detachable plasma-facing first wall – will protect the steel vessel and magnets from the high-energy neutrons produced during fusion. Shield block fabrication is underway in China and Korea, based on CAD models transferred row by row by the ITER Organization blanket team. **Europe reached the end of its industrial qualification program for the normal heat flux first wall panels** in 2019, while Russia and China advanced the fabrication and testing of small-scale high heat flux mockups. Japan is designing and procuring the remote handling system for first wall replacement activities.

Korean contractor Hyundai Heavy Industries is performing the final assembly activities on vacuum vessel Sector #6. This 440-tonne, first-of-a-kind component is expected next year at ITER.

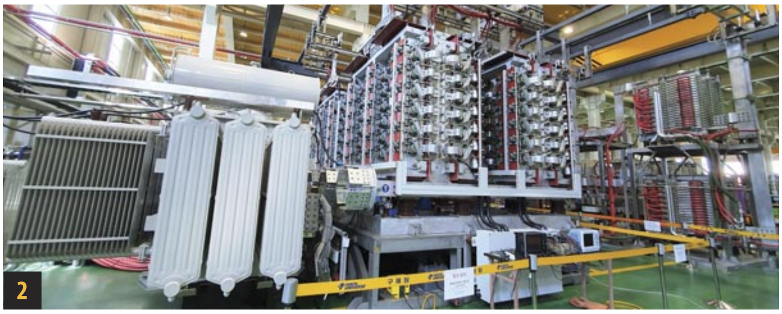




- Because they reduce the input power requirement for plant operation, high-temperature superconducting (HTS) current leads are one of the enabling technologies for large-scale fusion power plants. At 68 kA, ITER's toroidal-field-type HTS current leads will be the largest ever operated. Series production is underway in China. **[1]**
- ITER is testing the key technologies of neutral beam heating at the ITER Neutral Beam Test Facility in Padua, Italy. Just one year after its inauguration, the SPIDER testbed (**32**) – the world's largest negative ion source – successfully accelerated its first ion beam in May. **[2]** Europe, Japan, India and Italy are all contributing voluntarily to the Test Facility.
- A shattered pellet injector designed for disruption mitigation at ITER has entered testing on the JET tokamak (UK). Two others have been installed on the Korean tokamak KSTAR for dual injection testing (**30**).
- The European agency for ITER, Fusion for Energy, is procuring 215 normal heat flux first wall panels for the ITER blanket. These high-technology components, coated with a layer of beryllium armour, have been the object of a thorough qualification program including the fabrication and testing of small-scale mockups, semi-prototypes, and finally full-scale prototypes. The next step in Europe is to select an industrial supplier. **[3]**
- All Domestic Agencies are working to advance the diagnostics that will be necessary for First Plasma and to engineer their integration into plasma-facing port plugs.
- The first production central solenoid module completed by US contractor General Atomics is in testing (**39**). Six others are in various stages of production, each one requiring approximately 24 months to wind, heat treat, insulate, impregnate, and finalize. *Photo: General Atomics* **[4]**
- Indian Domestic Agency contractors have started to assemble the 430-tonne cryostat upper cylinder at ITER. Two other sections of the cryostat – the base (**16**) and the lower cylinder **[5]** – were finalized in 2019.
- The main components of the reactive power compensation system have been delivered by China.
- Eight energy-generating devices called gyrotrons will be employed by ITER's electron cyclotron resonance heating system at First Plasma. Japan (pictured) and Russia have each produced four and final tests are underway. **[6]**
- All equipment has arrived for the ITER cryoplant and mechanical installation is 65% complete (**4**).

MANUFACTURING HIGHLIGHTS


1


2


3


5


4

- Custom-made “port stub extensions” will be welded to openings in the vacuum vessel sectors before the sectors are shipped to ITER. This upper port stub extension, procured by Russia, is now part of Korea's vacuum vessel Sector #6. **[1]**
- Russia is procuring 1,000 connectors (bimetal "pedestals" and electrical "straps") that will provide low-impedance electrical bridges between the blanket modules and the vacuum vessel. Fabrication is underway.
- Thirty-two AC/DC converter units will be needed to power the magnets at First Plasma (and another 12 for full operation). Korea's first central solenoid converter unit has successfully passed factory acceptance tests. **[2]**
- The central solenoid magnet – formed from six stacked superconducting modules – will be assembled in the ITER Assembly Hall using tooling provided by US ITER. This specialized lifting fixture has successfully passed factory acceptance testing. **[3]**
- Four bottom correction coils will be ready for delivery next year from China.
- Two layers of silver-coated thermal shields interposed between the vacuum vessel and the cryostat are designed to minimize heat load transfer by thermal radiation and conduction from warm to cold components. The panels for vacuum vessel Sector #6, pictured, have been received at ITER. **[4]**
- High voltage tests for the test bed MITICA have been performed at ITER’s Neutral Beam Test Facility after the successful integration of components supplied by Europe and Japan.
- Every 23 seconds during fusion operation, a probe beam will penetrate deep into the core of the ITER plasma to aid in the detection of helium ash – one of fusion’s products and a reliable indicator of reaction efficiency. The system that will generate the beam – the diagnostic neutral beam system – is being tested in advance of shipment in a dedicated facility in Ahmedabad, India. **[5]**

Without pre-compression rings to support the toroidal field coil structures at top and bottom, forces exerted during operation would result in stress and, over time, fatigue. Europe has nearly completed the procurement of nine high-strength composite rings after a lengthy research and development program.

In Italy, a toroidal field coil winding pack is inserted into its structural steel case. The European Domestic Agency is responsible for the procurement of ten toroidal field coils; the Japanese Domestic Agency is producing eight complete coils plus one spare, as well as all structural steel cases. The first completed units arrive at ITER in 2020.


1


2


3


4


5

- China is procuring the 31 magnet feeders that will deliver electrical power and cryogens to the superconducting magnets. Production and deliveries are accelerating. (In the photo, one feeder segment travels by night from Hefei to Shanghai port.) **[1]**
- The first power supply for the electron cyclotron heating system has been delivered by Europe.
- Two European contractors have finalized full-size, fully functional prototypes of the divertor cassette bodies (the "structures" that will support plasma-facing targets, diagnostics, operational instrumentation and cooling manifolds). Following this conclusive step, both have been awarded contracts for series production. (Photo: a prototype manufactured by Walter Tosto.) **[2]**
- Japan is designing a powerful bolting tool that will be used to install ITER's in-vessel blanket modules robotically. It will provide 10 kilonewton metres (kNm) of torque to tighten the massive bolts of the blanket first wall panels.
- The trunk-like central column of the in-pit assembly tool has passed factory acceptance tests in Korea. During in-pit assembly operations, this mammoth tool – capable of supporting a total nominal weight of 5,400 tonnes – will support, align, and stabilize the vacuum vessel sub-assemblies as they are joined and welded. **[3]**
- China is advancing the series production of an extensive array of gravity supports and clamps for the ITER magnet systems – more than 1,600 tonnes of equipment in all.
- European contractors are busy producing double pancake windings for poloidal field coil #2 on site at ITER. **[4]** In the same building, preparations are underway for the finalization and cold testing of poloidal field coil #5.
- ITER's 6,000-square-metre cooling tower zone is filling up with equipment, as ITER contractors install the cooling towers, heat exchangers and piping delivered by India (**6**).
- Fabrication has started in China on the manifold system required for delivering fuelling gases to the ITER Tokamak.
- Because the leak tightness of the large metallic vacuum seals around the vacuum vessel ports is absolutely critical, the ITER Organization is verifying vacuum sealing on a real-size test rig. Results from the first tests in 2019 were excellent. **[5]**
- Contractors to the US Domestic Agency are manufacturing nearly 40 km of special-grade piping for ITER's Tokamak cooling water system.
- In India, Larsen & Toubro is completing the segments for the final component of the cryostat – the top lid. The segments will ship in 2020.

The ITER Tokamak is the first in the world to be completely integrated into, and supported by, the surrounding building. Machine assembly begins in this vast space next year.

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)

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

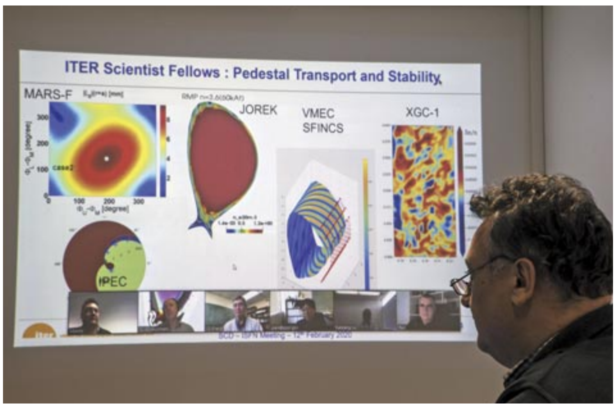
TESTING SHATTERED PELLET INJECTION

When operating tokamaks of the size of ITER, one of the key systems to ensuring reliable and successful operation from the very first campaign is the disruption mitigation system.

A disruption occurs when an instability grows in the tokamak plasma to the point where there is a rapid loss of the stored thermal and magnetic energy. This rapid loss can also accelerate electrons to very high energy (so-called "runaways"). To lessen the impact of high-energy plasma disruptions that can lead to significant thermal loading of in-vessel components, ITER will need a robust disruption mitigation strategy.

ITER's disruption mitigation strategy is based on the injection of cryogenic pellets from different toroidal locations into plasmas that are unstable and will disrupt – a technique called shattered pellet injection. Just before they enter the plasma chamber, these pellets are shattered into small fragments. This shattering ensures that the frozen deuterium and neon is ablated and assimilated by the plasma to achieve the high densities that are required for disruption mitigation. The plasma thermal and magnetic energy will be dissipated through radiation rather than leading to large heat loads and electromagnetic forces.

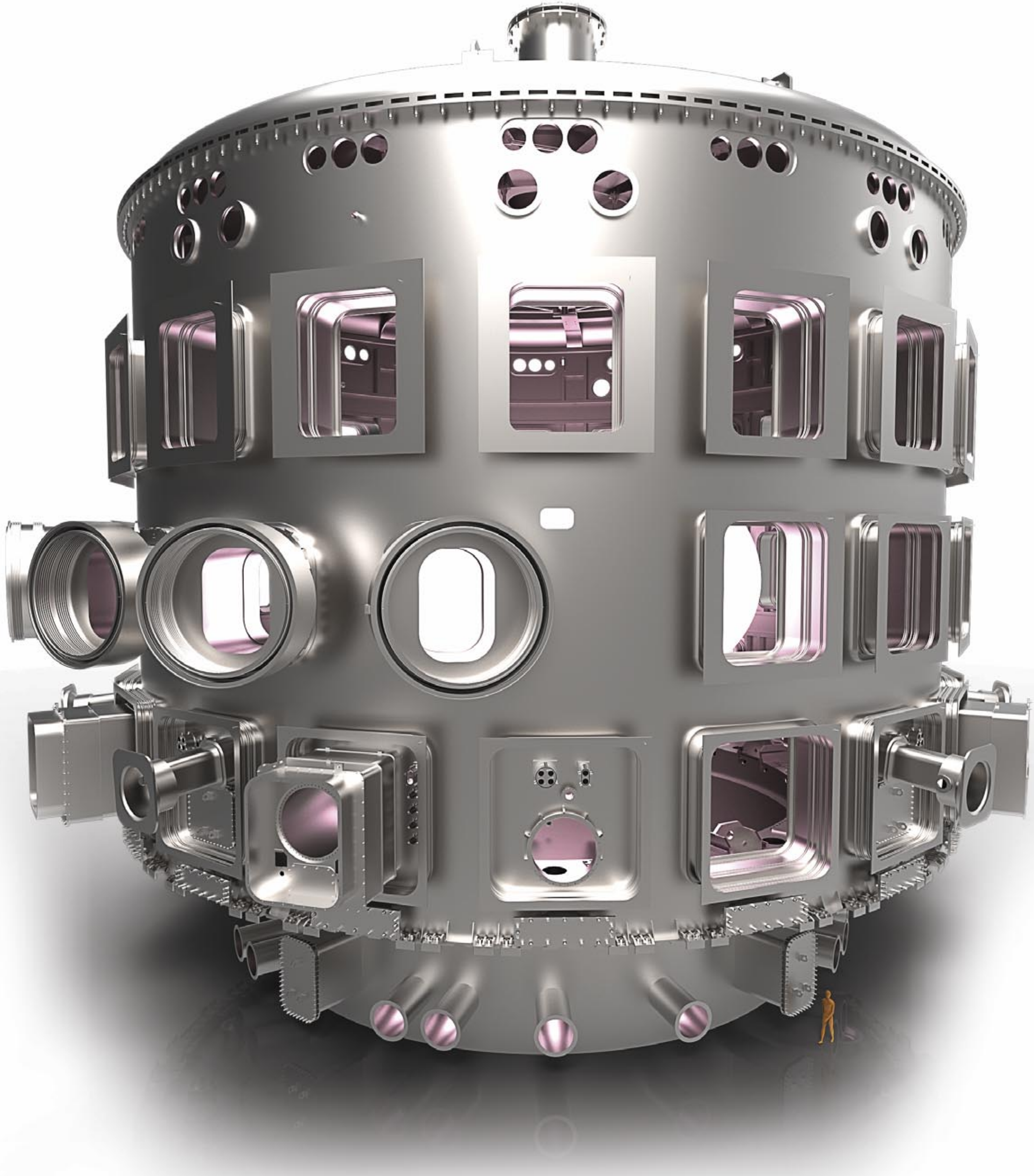
In 2019, a single shattered pellet injector started operating on the European JET tokamak, while an ITER-like dual-injection configuration was installed on the KSTAR tokamak in Korea (photo). Experiments on these two devices will help to design ITER's disruption mitigation system by exploring the optimum configuration of the injectors, the amount of shattered pellet material, the timing and the penetration of the pellets.



AN ARMY OF EXPERTISE FOR ITER

In the area of cutting-edge research – and particularly the sophisticated modelling of plasmas – the project is benefitting from the assistance of world-renowned experts through the ITER Scientist Fellow Network program. Now into its fourth year, the program is beginning to produce concrete results.

Since the launch of the ITER Scientist Fellow Network in 2016, more than 60 experts from the fusion laboratories and universities of the ITER Members have agreed to apply



Each opening in the cryostat lines up with a similar opening in the concrete bioshield (page 28-29). A detailed experimental program is planned in stages, from 2025 through 2041.

According to an agreement concluded this year with host Consorzio RFX, first-phase results at the ITER Neutral Beam Test Facility in Padua, Italy, (pictured) will inform the procurement of ITER's neutral beam injection components. In a second phase, the facility will serve as a testbed for enhancing system performance.

their expertise to solving some of ITER's high-priority research needs in the areas of simulation and theory. While remaining employed by their home institutions, they have long-term access to ITER Headquarters and spend part of their time on site working with ITER staff.

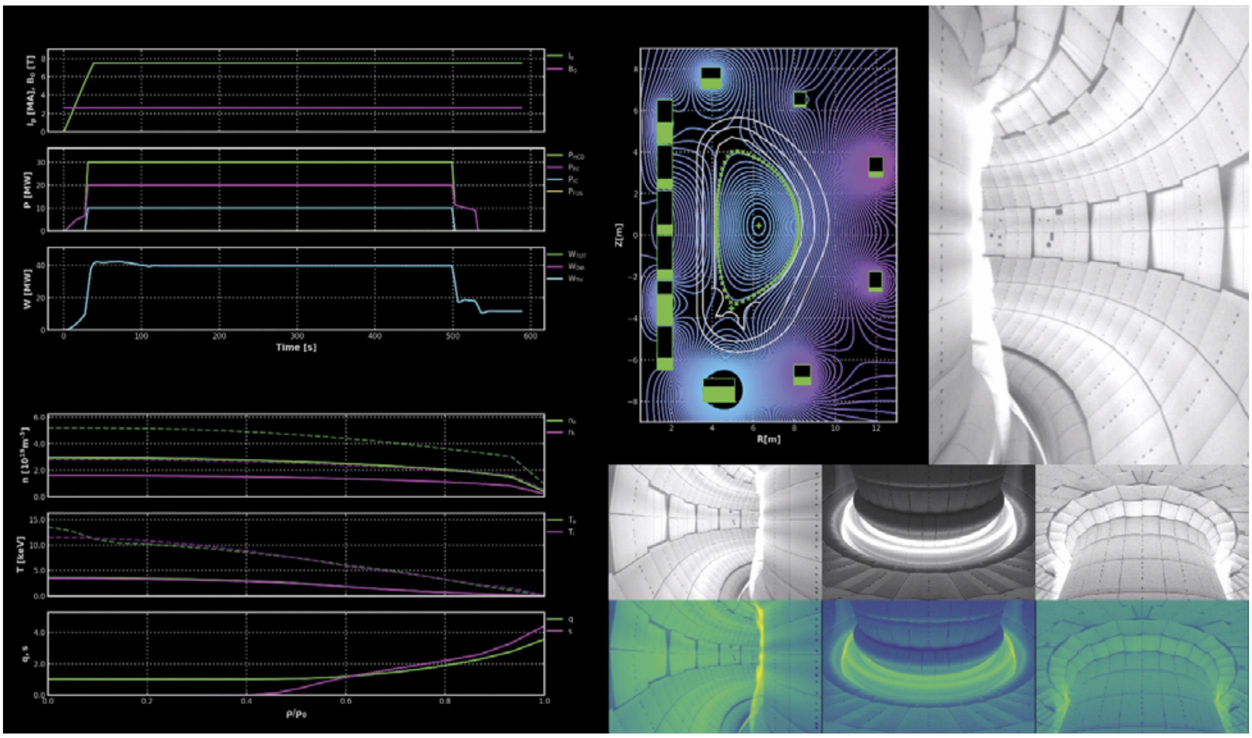
The Fellows focus on areas of interest to the ITER team but that also advance their own research objectives – for example, developing new models to apply to plasma simulations or using known codes in novel ways. Every scientist has an annual work plan, and attends one or two coordination meetings per year at ITER with other Fellows working in the same area.

Output from the ITER Scientist Fellow program was featured at major conferences and specialized workshops in 2019, including invited presentations and publications in high-impact journals in the field such as *Nuclear Fusion, Physics of Plasmas* and *Plasma Physics and Controlled Fusion*. This brings recognition to the individual scientists as well as to their home labs; as a result, the ITER Organization is seeing a rise in nominations.

A NEW TOOL FOR INTEGRATED MODELLING

As part of the goal of developing a high-fidelity plasma simulator to predict ITER performance, a comprehensive heating and current drive workflow capable of describing all of the ITER heating systems, as well as synergistic effects between them, has been developed. The effort involved ITER staff, interns, Scientist Fellows and voluntary contributions from within the ITER Member research programs, and built upon extensive earlier work carried out within the EUROfusion program, in particular extending the algorithm and changing the implementation language to Python. The new workflow exemplifies the use of the Integrated Modelling & Analysis Suite (IMAS) paradigm of coupling physics components by passing standard Interface Data Structures (IDSs) between them. Its development has also driven further refinements in the IMAS infrastructure.

Predictive simulations of ITER plasma scenarios are stored in an IMAS scenario database that continued to expand in 2019 to include simulations of all phases of the ITER Research Plan. These simulations are used to support other project activities including ongoing design work. The figure below shows an example simulation of a Pre-Fusion Operation II helium plasma scenario with a plasma current of 7.5 MA from within the IMAS scenario database presented as it may appear at run-time in the ITER Master Control Room in the form of a live display.



ITER SCIENCE

MAKING THE PLASMA BEHAVE

A holistic and robust plasma control system is essential to sustained nuclear fusion. ITER is applying the most advanced computer and communications technologies to design a system capable of evolving with the different phases of ITER operation.

A fundamental part of the control, data access and communication (CODAC) system, ITER's plasma control system is responsible for ensuring that each pulse is executed correctly. It does this by taking data from sensors and applying sophisticated algorithms to generate commands that it sends to actuators controlling plasma parameters such as position, shape or stability.

In the past, most systems had simple input and simple output. But control problems have become more complex, requiring a new generation of algorithms that model much more than just a set of independent sensors and actuators. Changes in one component affect the behaviour of other components; not only do the new systems have to model the dependencies among the different components, but they also have to model the system as a whole.

Employing some of the latest advances in control engineering, ITER's plasma control system is architected to handle both the basic control functions for early commissioning and the advanced control functions that will be needed for future high performance operation. In preparation for each stage of operation, new functions will be added and existing functions will be adapted to new types of plasmas. All modifications will be integrated into the existing system.

Wendelstein 7-X plasma (credit IPP Greifswald)

In 2019 the design team completed a major part of the work required for the final design of the system for First Plasma operation, which will be the first fully integrated use of all basic machine functions. By the end of 2019 many of the controllers had been designed and the framework in which the controllers will work was basically completed. The plasma control system for First Plasma will undergo its Final Design Review in summer 2020 marking the successful completion of a multi-year development program supported by control experts from the ITER Members.

SUPPORTING THE ITER RESEARCH PLAN

Following the public release in 2018 of the updated ITER Research Plan, which describes the experimental research to be carried out to achieve the project's fusion power production goals, ITER Organization experts identified a series of issues where experimental and modelling R&D is required to complete the design of ITER systems (e.g., diagnostics, disruption mitigation), clarify the options considered in the Plan, and refine the Research Plan itself. In the course of 2019 a series of meetings took place with the International Tokamak Physics Activity (ITPA), a body whose aim is to improve quantitative predictions of all aspects of plasma behaviour in ITER scenarios and to resolve outstanding R&D issues. The meetings led to a new and coherent ITPA R&D program focused on high-priority issues identified in the various areas of ITPA expertise. This re-focused program was reviewed and endorsed at the annual meeting of the ITPA Coordinating Committee in December 2019 (photo).

Europe is procuring five poloidal field coils, including four manufactured at ITER; Russia is procuring a sixth. The ring-shaped coils, installed horizontally around the vacuum vessel and toroidal field magnets, will shape the plasma and contribute to its stability by "pinching" it away from the walls.

AT A GLANCE

January
- The ITER Council reappoints Bernard Bigot to a second five-year term (2020-2025)

February
- 10th ITER International School in Korea

March
- ITER Business Forum (IBF/19) in Antibes, France

April
- ITER co-hosts "500 Years of Innovation: from da Vinci to ITER" with the Consul General of Italy in Marseille.

May
- Open Doors Day
- ITER Robots competition, eighth edition

June
- 24th ITER Council
- ITER and the International Atomic Energy Agency (IAEA) deepen longstanding cooperation through the signature of Practical Arrangements

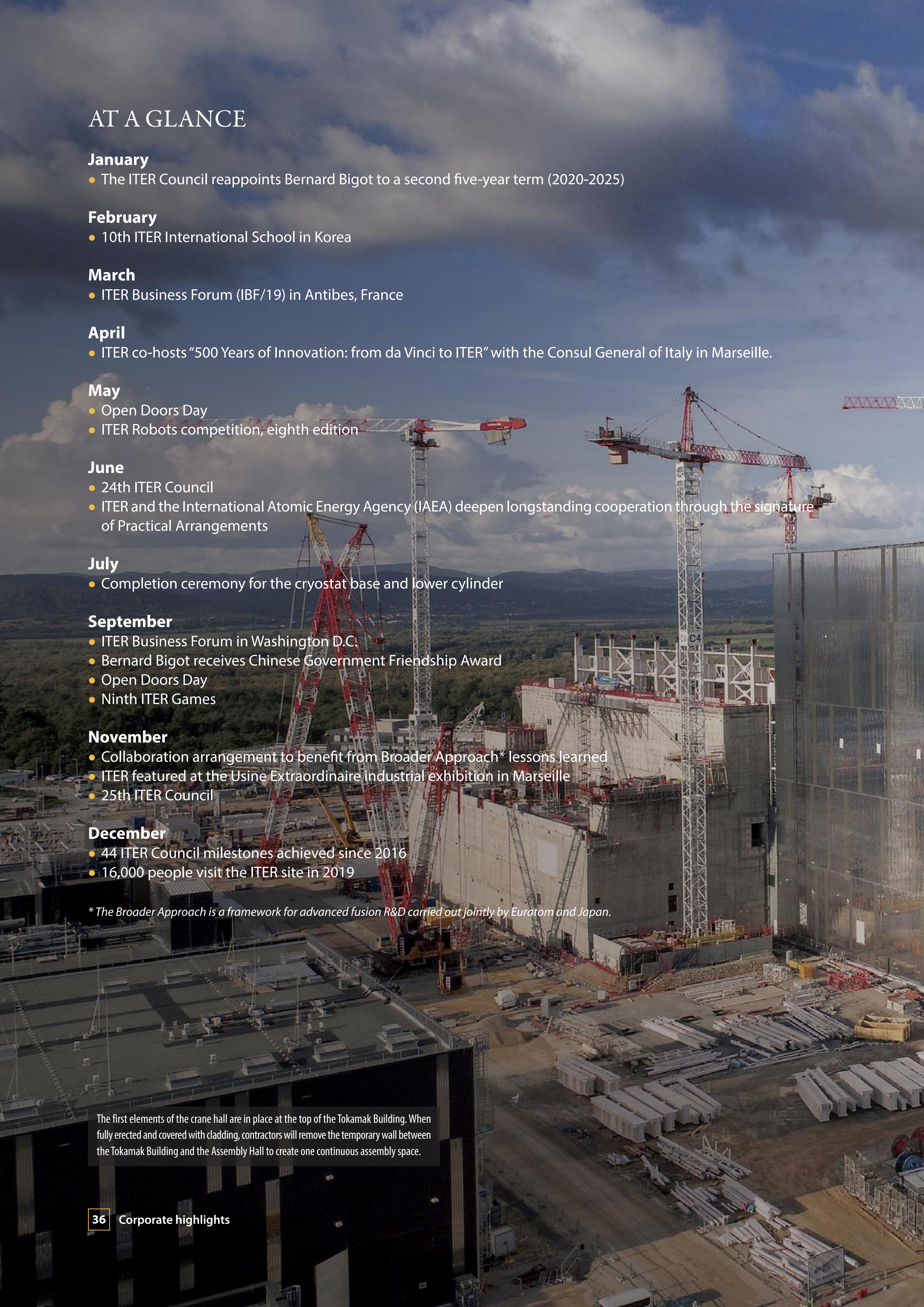
July
- Completion ceremony for the cryostat base and lower cylinder

September
- ITER Business Forum in Washington D.C.
- Bernard Bigot receives Chinese Government Friendship Award
- Open Door Day
- Ninth ITER Games

November
- Collaboration arrangement to benefit from Broader Approach* lessons learned
- ITER featured at the Usine Extraordinaire industrial exhibition in Marseille
- 25th ITER Council

December
- 44 ITER Council milestones achieved since 2016
- 16,000 people visit the ITER site in 2019

** The Broader Approach is a framework for advanced fusion R&D carried out jointly by Euratom and Japan.*



The first elements of the crane hall are in place at the top of the Tokamak Building. When fully erected and covered with cladding, contractors will remove the temporary wall between the Tokamak Building and the Assembly Hall to create one continuous assembly space.

CORPORATE HIGHLIGHTS

Corporate highlights

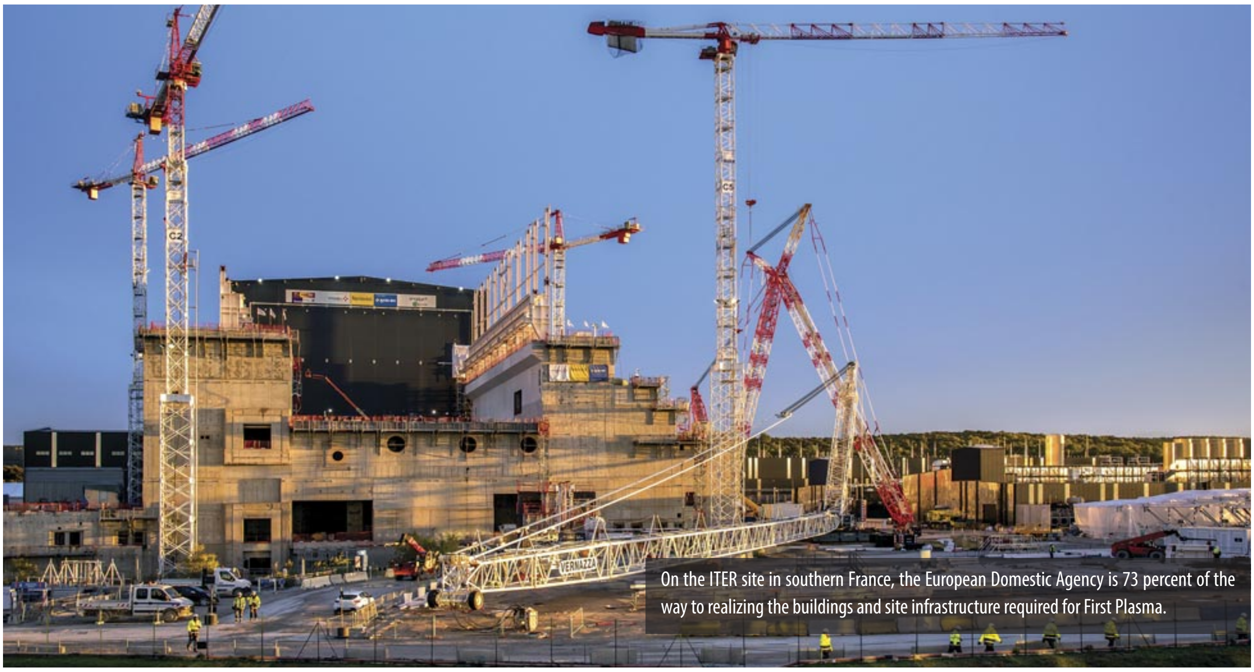
The ITER Organization and the ITER Domestic Agencies continue to implement the Revised Construction Strategy as approved by the ITER Council. As the need dates for critical items approach, the continuous strong support of the Members is critical for keeping the project on track. Project execution on the road to First Plasma stands at 67.3 percent (31 December 2019).

A new term for the Director-General – The ITER Council decided unanimously in January 2019 to reappoint Bernard Bigot to a second five-year term as Director-General of the ITER Organization (2020-2025).

Reorganization – The ITER Organization is on schedule for rolling out a new construction-focused management and organizational structure, better aligned with the challenges of the assembly phase. Heads have been recruited for the new Construction, Engineering and Corporate Domains, and structural implementation – including staff re-assignment, recruitment, and office moves – is underway.

Revised construction strategy – Since June 2018, the Revised Construction Strategy has allowed the ITER Organization to optimize its approach to assembly and installation through tighter coordination, optimized assembly sequencing, and an increase in parallel activity. Substantial progress was made in 2019 in the installation of building services (formerly under the scope of the European Domestic Agency) and in the detailed planning for plant system commissioning. The critical path to First Plasma continues to pass through the availability of the Tokamak pit and heavy lift cranes, the sub-assembly of the vacuum vessel sectors and matching toroidal field coil pairs, and the in-pit welding of the sector sub-assemblies. Any delay against critical need dates means that other opportunities must be exploited to maintain First Plasma in December 2025. During the year, for example, a task force was established to exploit schedule reduction opportunities not previously explored for near-critical installation activities. Milestones agreed with the ITER Council continue to be carefully tracked and reported; since 1 January 2016, 44 high-level project milestones have been achieved.

First-of-a-kind components – Challenges inherent to the manufacturing of first-of-a-kind components, especially the main ITER magnet systems and the vacuum vessel – have resulted in some slippage against Revised Construction Strategy need dates which the ITER Organization and the Domestic Agencies are working to mitigate. In parallel, however, uncertainty linked to the next components in each series is diminishing, as the first-of-a-kind challenges are resolved one after the other. In 2020, the first vacuum vessel sector from Korea (Sector #6) and associated toroidal field coils #12 and #13 from Japan are expected on site. These three components, plus thermal shield panels, will make up the first vacuum vessel sub-assembly to be created on the specialty tools of the Assembly Hall.



On the ITER site in southern France, the European Domestic Agency is 73 percent of the way to realizing the buildings and site infrastructure required for First Plasma.

The first central solenoid module is tested in the United States. Contractor General Atomics is supplying seven modules to the ITER program (six plus one spare), wound from niobium-tin superconductor supplied by Japan. *Photo: GA*

External review – An In-Depth Independent Review (IIR) commissioned by the ITER Council was held in 2019 on the ITER Organization's assembly and installation strategy. The panel remarked that the overall selected schedule for assembly and installation was logical, well developed and well structured, and that the "no contingency, just-in-schedule" approach would depend heavily on the success of the Domestic Agencies in meeting need dates for critical contributions. The Review resulted in a series of recommendations, which the ITER Organization is addressing in an action plan. The 2019 Management Assessment will be held in early 2020.

"Engineered with Pride" – As a preamble to the assembly of each system into the machine or plant, ITER systems engineers must reunite all necessary system and geographical information into transferable documents called engineering work packages. These are used by contractors to assign controllable batches of work (construction work packages), which in turn are broken down into detailed installation instructions. Because any delay in the transfer of engineering data can cause delay in installation works, the ITER Organization is running a project-wide "Engineered with Pride" campaign to ensure the standardization of the process, and the quality and timeliness of production. Machine assembly alone is the subject of 1,200 engineering work packages.

Quality management – The ITER Organization and Domestic Agencies have implemented robust manufacturing quality supervision activities – with multiple gate reviews and control points – to ensure that technical and safety requirements are met. Ideally, this quality control permits non-conformities to be identified and addressed before the component is shipped; however, in the case of non-standard components with complex interfaces and the involvement of multiple Domestic Agencies, some non-conformities may be identified on reception. The ITER Council has approved a mechanism – the Inter-Organization Non-Conformity Resolution Mechanism – for acting on and resolving these situations without delay.

Regulatory environment – The construction of key ITER buildings, the fabrication of safety-important components, the start of assembly, and each operational phase are all subject to a set of controls and authorizations under French nuclear safety regulations. Fourteen inspections took place in 2019, including one off-site inspection of ITER vacuum vessel Sector #6 in Korea. Following a lengthy and rigorous procedure, the ITER Organization successfully passed an audit to be able to act as an Agreed Notified Body for components or systems under pressure (Module H); the internalization of this formerly contracted strategic function will translate into considerable savings. The project is also preparing to meet a regulatory hold point in 2021 that will authorize the start of the machine assembly phase.

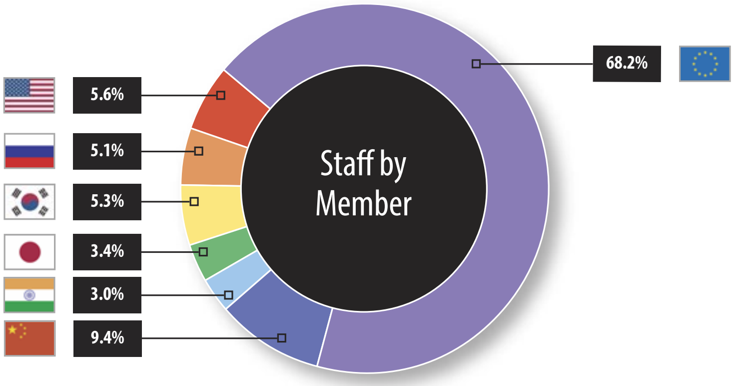
International cooperation – The ITER Organization currently has 74 international cooperation agreements with the laboratories and educational establishments of the ITER Members, international organizations, and others *(see the full list on page 55*). In 2019, agreements were signed with the Italian consortium Consorzio RFX for the operation of the ITER Neutral Beam Test Facility; with the International Atomic Energy Agency (IAEA) for continued and expanded cooperation; and with the partners of the Broader Approach – Japan's National Institutes for Quantum and Radiological Science and Technology (QST) and the European Domestic Agency Fusion for Energy – in order to benefit from the assembly, installation, integrated commissioning and operational experience of the JT-60SA tokamak.

Staffing – ITER Organization staffing is progressing on pace with project resource estimates and projections. On 31 December 2019, the ITER Organization employed 929 staff, as well as 10 experts, 4 visiting researchers, 9 interns, and 160 ITER Project Associates.

ITER staff members gather in late November for a group photo. Just over 900 people are directly employed by the ITER Organization. Photo: ITER Organization/Gérard Lesénéchal

STAFFING AND FINANCIAL DATA

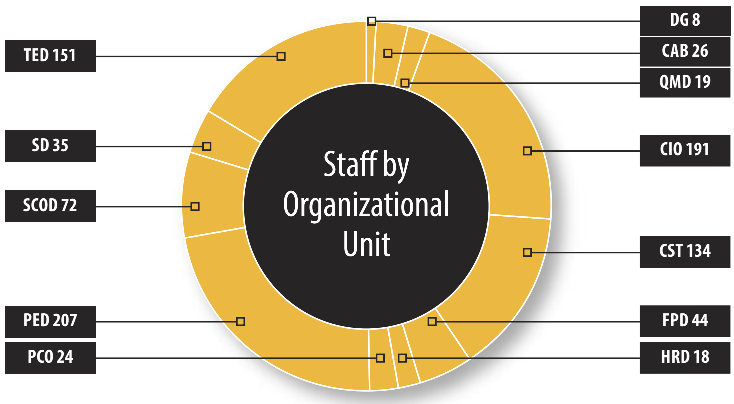
STAFFING TABLES



Staff by Member as of 31 December 2019

	31/12/2013	31/12/2014	31/12/2015	31/12/2016	31/12/2017	31/12/2018	31/12/2019
China	30	50	55	67	77	79	87
European Union	339	412	446	512	571	599	634
India	25	19	22	30	36	36	28
Japan	33	29	25	25	25	27	32
Republic of Korea	32	33	32	32	32	32	49
Russian Federation	28	30	30	36	36	37	47
United States of America	28	36	32	38	48	48	52
TOTAL	**515**	**609**	**642**[1]	**740**[2]	**825**[3]	**858**[4]	**929**[5]

[1] Includes 5 Monaco Postdoctoral Fellows and staff funded for work on the TCWS (Tokamak cooling water system, 24) and VAS (vacuum system, 1)
[2] 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)
[3] Includes 5 Monaco Postdoctoral Fellows and staff funded for work on the TCWS (27), VAS (2) and SCS-N (1)
[4] Includes 5 Monaco Postdoctoral Fellows and staff funded for work on the TCWS (25), VAS (2) and SCS-N (1)
[5] Includes 5 Monaco Postdoctoral Fellows and staff funded for work on the TCWS (29), VAS (3) and SCS-N (1)



Staff by Organizational Unit* as of 31 December 2019

	Professional & Higher	Support	TOTAL
DG	7	1	8
CAB	13	13	26
QMD	10	9	19
CIO	93	98	191
CST	114	20	134
FPD	21	23	44
HRD	8	10	18
PCO	17	7	24
PED	154	53	207
SCOD	60	12	72
SD	26	9	35
TED	130	21	151
TOTAL	**653**	**276**	**929**

* For the full names of units, see the Organization chart on page 56.

MAIN FINANCIAL DATA

COMMITMENTS EXECUTION

Amounts in thousands of Euro

	Total Commitments Appropriations 2019	Total Actual Commitments 2019	Unused Commitments Appropriations carried forward to 2020
Budget Headings	1	2	3 = 1 - 2
Title I: Direct Investment (Fund)	478,904	303,116	175,789
Title II: R&D Expenditure	1,242	(398)	1,641
Title III: Direct Expenditure	277,401	243,009	34,392
TOTAL COMMITMENTS	**757,548**	**545,726**	**211,822**

PAYMENTS EXECUTION

Amounts in thousands of Euro

	Total Payments Appropriations 2019	Total Actual Payments 2019	Unused Payments Appropriations carried forward to 2020
Budget Headings	1	2	3 = 1 - 2
Title I: Direct Investment (Fund)	510,248	162,759	347,489
Title II: R&D Expenditure	3,008	999	2,009
Title III: Direct Expenditure	279,199	205,741	73,458
TOTAL PAYMENTS	**792,455**	**369,499**	**422,956**

CONTRIBUTIONS RECEIVED FROM MEMBERS IN CASH

Amounts in thousands of Euro

Members	2019	Cumulative
Euratom	221,232	1,398,841
People's Republic of China	43,467	258,577
Republic of India	-	159,146
Japan	36,510	251,836
Republic of Korea	28,021	257,235
Russian Federation	37,788	270,222
United States of America	40,726	178,282
TOTAL CONTRIBUTIONS	**407,743**	**2,774,139**

CONTRIBUTIONS RECEIVED FROM MEMBERS IN KIND

	Amounts in ITER Unit of Account (IUA)		Amounts in Thousands of Euro	
Members	2019	Cumulative	2019	Cumulative
Euratom	54,675	423,208	94,907	712,736
People's Republic of China	11,171	138,521	19,985	235,649
Republic of India	47,024	98,881	81,893	168,933
Japan	38,389	277,936	67,175	467,242
Republic of Korea	11,361	88,765	19,803	149,583
Russian Federation	6,875	99,578	11,851	168,354
United States of America	13,104	80,975	22,744	136,695
TOTAL CONTRIBUTIONS	**182,598**	**1,207,864**	**318,359**	**2,039,192**

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 2019 figures supersede all previously published figures.

Increasing numbers of components are arriving from the Domestic Agencies by road, rail, canal, sea and air. This convoy is carrying an Indian contribution to the cryoplant that was manufactured in Switzerland.

DOMESTIC AGENCY PROCUREMENT HIGHLIGHTS

ITER CHINA (CN-DA)

www.iterchina.cn

PROCUREMENT ARRANGEMENTS*

Fourteen PAs signed since 2007 representing. . .

100% in number

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

Over 85 design or fabrication contracts related to ITER procurement have been signed with laboratories and industry.

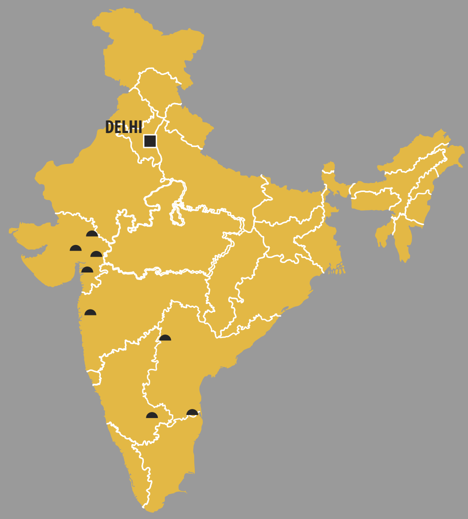
Chinese procurement highlights in 2019	% of ITER system procured by China
MAGNET SYSTEMS	
Toroidal Field Conductor	7.5%
- All conductor unit lengths delivered	
Poloidal Field Conductor	65%
- All conductor unit lengths delivered	
Magnet Supports	100%
- Base clamps of first toroidal field coil set (TFC12 and TFC13) completed and delivered	
- Clamps for poloidal field coils PF5 and PF6 completed and delivered	
Feeders	80%
- Series production in process	
- First exceptional-load (HEL) components delivered to ITER: in-cryostat feeders for bottom correction coils 1-4,3-6	
- Coil termination box for poloidal field coil #4 delivered	
Correction Coils	100%
- Completion of first three bottom correction coils (BCC1, BCC5,BCC6)	
- Cold test for BCC1 completed successfully	
- Qualification case section for side correction coils fabricated with proper tolerance control	
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%
- Last set of converter modules/bypass completed and delivered	
Reactive Power Compensation	100%
- All main components of reactive power compensation sub-package delivered	
BLANKET	
Blanket First Wall	12.6%
Blanket Shield Block	50.2%
- First facility for hot helium leak tests delivered to shield block manufacturer; successfully tested to ITER requirements	
FUEL CYCLE	
Gas Injection System	100%
- First batch of 17 manifold spools completed	
- PDR completed on gas valve boxes	
Glow Discharge Cleaning	100%
- PDR for glow discharge cleaning Phase 1 completed	
DIAGNOSTICS	
Diagnostics	3.2%
- Neutron flux monitor (NFM) #07: support frame structure delivered	
- FDR completed for radial x-ray camera	
- FDR completed for EQ#12 port integration	
- Preliminary design of diverter Langmuir probe ongoing	
- Preliminary design of remaining NFMs ongoing	

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

* Does not include Complementary Diagnostic Arrangements

ITER INDIA (IN-DA)

www.iter-india.org



PROCUREMENT ARRANGEMENTS*

Fourteen PAs signed since 2007 representing…

in number

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 2019 — **% of ITER system procured by India**

CRYOSTAT

Cryostat — 100%

- Completion and acceptance of base section
- Completion and acceptance of lower cylinder section **(IC milestone)**
- Upper cylinder tier-1 and tier-2 sectors delivered to Cryostat Workshop; sub-assembly in progress
- Top lid manufacturing underway in India

CRYOGENIC SYSTEMS

Cryolines & Cryodistribution — 100%

- Lower pipe chase cryolines completed in 2019
- Cryoplant termination cold box (CTCB) delivered to ITER site
- Installation of first cryolines in Tokamak Building basement (B2)
- FDR for cryolines (lots X1, X5) and FDR for warmlines (lots W1, W2) completed
- Manufacturing and shipment of other cryolines in progress

HEATING & CURRENT DRIVE SYSTEMS

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

- Manufacturing of beam line components in advanced stage
- Deep drilling and electron beam welding on neutralizer panels; complete extractor grid set realized in "angled" configuration for the first time
- Acceptance tests of DNB acceleration grid power supply concluded at ITER India lab in less than one week (for a 100 kV, 7 MW system)

NBTF components (beam dump & 100 KV power supply) — 2%

- NBTF components completed in 2019
- SPIDER 100 kV power supply on SPIDER test facility in operation since last year

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

- R&D phase for power sources successfully completed

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

Electron Cyclotron High Voltage Power Supply — 30%

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

- A gyrotron test facility with ITER-like test gyrotron and auxiliaries is in advanced stage of development to test and establish the integrated system as a whole

COOLING WATER SYSTEMS

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

- Plate-type heat exchanger delivered **(IC milestone)**
- 90% piping and equipment delivered (about 600 spools and 100 tonnes of supports)
- E-house and several bellows, plate-type heat exchangers, water polishing units, strainers, vacuum release cum air release valves delivered (about 95% of overall supplies)

VACUUM VESSEL

In-wall Shielding (IWS) Block Assemblies — 100%

- IWS blocks for 4 out of 9 vessel sectors manufactured
- All deliveries to Korea completed successfully; a majority of deliveries to Europe also completed

DIAGNOSTICS

Diagnostics — 3.1%

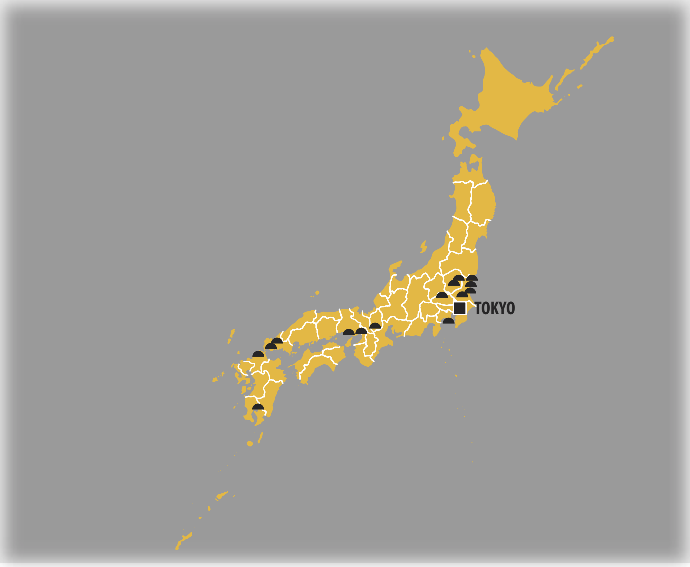
- Complementary Diagnostic Arrangement signed for CXRS (Charge eXchange Recombination Spectroscopy) pedestal
- X-ray anode source developed as prototype work
- PDR of X-Ray crystal spectroscopy (XRCS) survey diagnostic completed
- Prototype transmission line (including polarization splitter unit) activities carried out

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

* Does not include Complementary Diagnostic Arrangements

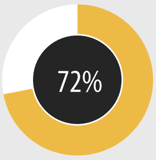
ITER JAPAN (JA-DA)

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

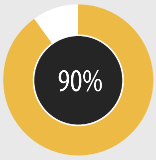


PROCUREMENT ARRANGEMENTS*

Thirteen PAs signed since 2007 representing…



in number



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

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

Japanese procurement highlights in 2019 — **% of ITER system procured by Japan**

MAGNET SYSTEMS

Toroidal Field Conductor — **25%**
- All conductor unit lengths delivered

Toroidal Field Magnet Windings (9 out of 19) — **47%**
- First toroidal field coil (#12): vertical insertion into case, closure welding, gap filling between winding pack and case completed **(IC milestone)**
- Second winding pack successfully inserted into case

Toroidal Field Magnet Structures — **100%**
- Three further sets of toroidal field coil structures (TFCS) delivered to Europe; another shipped
- Two TFCS sets for Japan under assembly with winding packs

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%**
- High-voltage test installation for power supply components completed
- Integrated output test (1 MV, 60 A) underway

Electron Cyclotron Radio Frequency Power Sources (8 gyrotrons out of 24) — **33%**
- FAT completed on second gyrotron
- Gyrotrons #3, #4, #5 manufactured; gyrotron #3 in testing
- Fabrication and tests of #1-#4 anode/body power supply completed
- #5-#8 anode/body power supply and control cubicles in fabrication

Electron Cyclotron Equatorial Launcher — **71%**
- Prototypes of launcher components in preparation
- Final design of equatorial launcher in progress

REMOTE HANDLING

Blanket Remote Handling System (BRHS) — **100%**
- Project Team: new procurement strategy developed, enabling the system to be in operation for Pre-Fusion Power Operation I
- Progress made on many technical issues (consolidation of interfaces with blanket, finalization of seismic design)

DIVERTOR

Outer Target — **100%**
- Prototype material procurement completed (tungsten monoblocks, XM-19 stainless steel forgings, CuCrZr-IG tubes, NiAl-bronze bar)
- Launched material procurement for outer vertical target tungsten monoblocks

TRITIUM PLANT

Atmosphere Detritiation System — **50%**
- Progress on qualification activities: manufacture of integration system test rig launched
- Joint JA-DA/IO procurement activities proceeding

DIAGNOSTICS

Diagnostics — **14.2%**
- FDR for micro fission chamber in-vessel components held
- Neutron and gamma ray irradiation test for edge Thomson scattering system is advancing
- Prototyping and tests for retroreflector made of tungsten completed for poloidal polarimeter
- Development of viewing field alignment system for divertor impurity monitor, spectroscopic system for divertor IR thermography

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

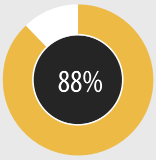
* Includes Complementary Diagnostic Arrangements

ITER KOREA (KO-DA)

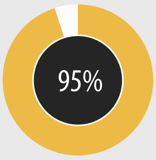
www.iterkorea.org

PROCUREMENT ARRANGEMENTS*

Eight PAs signed since 2007 representing...

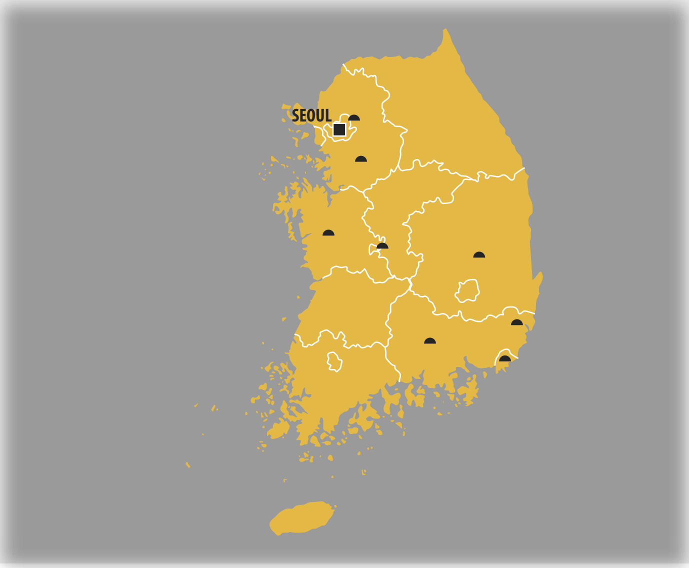


in number



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

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



Korean procurement highlights in 2019	% of ITER system procured by Korea
VACUUM VESSEL	
Main Vessel (2 of 9 segments)**	21.26%
■ KO procurement: Final-stage manufacturing activities underway on Sector #6 (97.5% complete); activities progressing well on Sector #7 (89.9% complete)	
■ Delegation agreement: Sectors #8 and #1 over 70% complete	
■ FAT planned in March on first-completed sector	
Equatorial Ports	100%
■ Manufacturing of in-wall shielding and ex-wall shielding for neutral beam port completed	
■ Manufacturing of neutral beam port and regular ports in progress	
Lower Ports	100%
■ Local penetration completed and delivered	
■ Lower port stub extension manufacturing in final stage (3 delivered)	
■ Manufacturing progressing on lower port extensions	
BLANKET	
Blanket Shield Block	49.82%
■ Process qualification completed; series production launched	
POWER SYSTEMS	
AC/DC Converters	37.17%
■ FAT completed for AC/DC converters VS1-2, 2 CCS, 1 CS	
■ Delivery of AC/DC converters VS1-1, CCS, CCU/L	
■ AC/DC converter (VS1-1) installation completed (except bridge)	
■ Installation and testing of AC/DC converter/transformers (6 CS, 6 CCU/L, 3 CCS, 2 VS1) completed	
MAGNET SYSTEMS	
Toroidal Field Conductor	20.18%
■ All conductor unit lengths delivered	
THERMAL SHIELD	
Vacuum Vessel Thermal Shield and Cryostat Thermal Shield	100%
■ Series production progressing well	
■ Vacuum vessel Sector #6 thermal shield delivered **(IC milestone)**	
■ Lower cryostat thermal shield cylinder delivered	
ASSEMBLY TOOLING	
Machine Assembly Tooling	79%
■ SAT completed on sector sub-assembly tools #1 and #2	
■ Upending tool delivered	
■ In-pit column tool in fabrication; central column completed FAT	
TRITIUM PLANT	
Tritium Storage & Delivery	94.25%
■ Full-scale experimental getter bed manufacturability reviewed; performance test ongoing	
■ Storage and delivery system process HAZOP study performed	
■ Process gas analytical system prepared and helium-3 collection process validation ongoing	
DIAGNOSTICS	
Diagnostics	2%
■ Preliminary design of upper port #18 integration completed	
■ Final design of equatorial port #11 (components of neutron activation system and vacuum ultra violet spectrometers)	

*** Plus two sectors manufactured on behalf of the ITER Organization through a delegation agreement*

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

* Does not include Complementary Diagnostic Arrangements

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

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

Russian procurement highlights in 2019 — **% of ITER system procured by Russia**

POWER SYSTEMS

Switching Network, Fast Discharge Units, DC Busbar and Instrumentation — 100%
- FDR-2.3 meeting held at ITER
- Five batches of equipment for coil power supply systems manufactured, tested and delivered
- Ongoing manufacturing of busbars, copper links, supports and other components
- A number of manufacturing and inspection plans for series production approved

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%
- Manufacturing of all 8 double pancakes completed; stacking underway

BLANKET

Blanket First Wall — 40%
- Verification of design and technical solutions through the fabrication and testing of first wall components and mockups
- First wall panel full-scale prototype: optimization of technological process for CuCrZr/316L HIP joint for bimetallic cover; beryllium armour manufactured

Blanket Module Connectors — 100%
- First batch of 10 electrical strap pedestals and inserts manufactured following MRR

DIVERTOR

Dome — 100%
- Full-scale prototype: removal of solder traces from brazed plasma-facing units; welding and machining of stainless steel support structure; welding of cooling pipes between plasma-facing units and manifolds

Plasma-Facing Component Tests — 100%
- A number of hydraulic and high heat flux tests carried out on plasma-facing components; data processed and reports prepared

VACUUM VESSEL

Upper Ports — 100%
- Port stub extensions #16, #14, #03, #05, #09, #11 completed
- Fabrication of upper port extension #12 launched
- Central upper port stub extensions #04, #06, #08, #18 shipped to EU-DA

Port Plug Test Facility (PPTF) — 100%
- A number of MRR documents on test tank, heating system, vacuum system, handling system (non-nuclear stands) designed and approved
- CDR preparation for nuclear stands: documents designed and approved

DIAGNOSTICS

Diagnostics — 17%

Port Plug Integration Engineering
- PDRs held for upper ports #02, #07, #08; FDR held for equatorial port #11
- Conceptual design of diagnostic racks and in-vessel neutron shield blocks developed for lower port #08

Diagnostics
- A number of mockups and components for CXRS (Charge eXchange Recombination Spectroscopy) manufactured
- PDRs held for CXRS, upper ports #08, #09, #17, and high field side reflectometry (atmosphere)
- Design developed for relocated divertor neutron flux monitor
- Neutral particle analysis: FDR-1 held and mockups manufactured and tested

HEATING & CURRENT DRIVE SYSTEMS

Electron Cyclotron Radio Frequency Power Sources (8 gyrotrons out of 24) — 33%
- FAT carried out successfully on gyrotron set #3; manufacturing completed on set #4
- Test of control system of gyrotron pair #1/#2

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

* Does not include Complementary Diagnostic Arrangements

US ITER (US-DA)

www.usiter.org

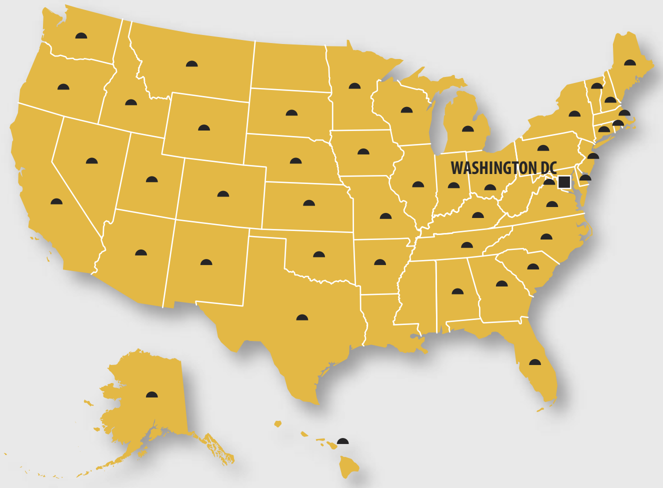
PROCUREMENT ARRANGEMENTS*

Seventeen PAs signed since 2007 representing…

in number

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

The US has awarded more than 600 design or fabrication contracts to US industry, universities, and national laboratories in 47 states plus the District of Columbia since 2007.



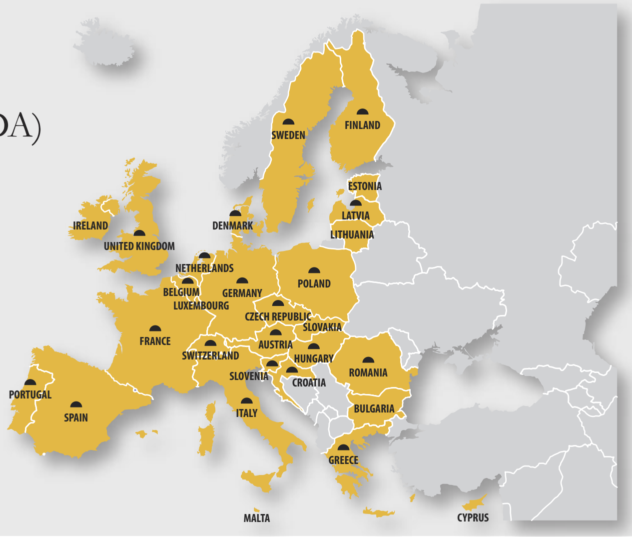
US procurement highlights in 2019	% of ITER system procured by US
COOLING WATER SYSTEM	
Tokamak Cooling Water System	100%
Post-First Plasma FDR completed	
Piping deliveries and fabrication continue	
First components installed in Tokamak Complex	
Procurement underway for pumps, heat exchangers, storage tank	
MAGNET SYSTEMS	
Central Solenoid (CS) Modules, Structure and Assembly Tooling	100%
First module completed fabrication and prepared for testing	
Six remaining modules are in fabrication	
Tie plate, lower component and upper component fabrication is underway	
Lower key block fabrication and delivery is complete	
Lifting fixture fabrication is complete and testing is underway	
Toroidal Field Conductor	8%
All conductor unit lengths delivered	
DIAGNOSTICS	
Port-Based Diagnostic Systems	14%
HEATING & CURRENT DRIVE SYSTEMS	
Ion Cyclotron Transmission Lines	88%
Electron Cyclotron Transmission Lines	88%
FUEL CYCLE	
Vacuum Auxiliary and Roughing Pump Stations	100%
Piping deliveries and fabrication continue	
Fabrication of vacuum manifold stubs complete and manifold fabrication underway	
Pellet Injection System	100%
Disruption Mitigation System up to a capped value	
Testing performed on JET tokamak	
Two shattered pellet injectors installed on KSTAR tokamak for testing	
TRITIUM PLANT	
Tokamak Exhaust Processing System	88%
Tokamak Exhaust Processing System Procurement Arrangement signed in May	
POWER SYSTEMS	
Steady State Electrical Network	75%
All components delivered	

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

* Includes Complementary Diagnostic Arrangements

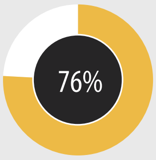
FUSION FOR ENERGY (EU-DA)

www.fusionforenergy.europa.eu

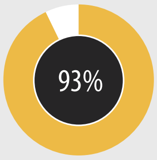


PROCUREMENT ARRANGEMENTS*

Thirty-seven PAs signed since 2007 representing…



in number



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

The EU has awarded 725 design or fabrication contracts related to ITER procurement to universities, laboratories and industry since 2007.

EU procurement highlights in 2019 — **% of ITER system procured by the EU**

BUILDINGS

Building Construction, Tokamak Pit Excavation and Drainage, Ground Support Structure, Seismic Isolation Pads — 100%
- Anti-seismic bearings completed in 2012
- Tokamak Complex critical path civil works completed on time, including erection of crane hall
- Painting completed in Tokamak Complex B2 and B1, Diagnostic Building up to L3
- Assembly Hall: installation of services completed, commissioning underway
- Site infrastructure deep underground works finalized
- Handover of Magnet Power Conversion buildings to IO

Architect Engineer Services — 100%

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%
- Series production advancing; 8 out of 10 winding packs completed. First coil insertion completed. Final machining of first coil ongoing

Pre-Compression Rings — 100%
- Six of nine rings manufactured, five tested and delivered

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

Poloidal Field Magnets No. 2-6 — 100%

PF 2-5 (manufactured at ITER site)
- Series manufacturing progressing; cryogenic chambers installed for PF5 and PF6; PF5 ready for impregnation

PF 6 (manufactured for EU-DA in China)
- Manufacturing and testing completed

HEATING & CURRENT DRIVE SYSTEMS

Power Supply Heating Neutral Beam — 45%
- Ion source and extraction power supplies (ISEPS): installation and commissioning of MITICA unit
- Acceleration grid power supplies (AGPS-CS): handover of MITICA unit to IO
- Kick-off meeting for procurement of ITER ISEPS and AGPS units
- Ground related power supply (GRPS): MITICA unit SAT

Neutral Beam Test Facility (NBTF) Components — 64.7%
- SATs completed for SPIDER caesium oven; MITICA cooling plant; MITICA beam source vessel
- MITICA beam line components manufacturing contract signed
- FATs completed for MITICA beam line vessel; gas and vacuum system
- MITICA SF6 gas handling and storage system handed over to IO

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

Neutral Beam Source and High Voltage Bushing — 41%
- MITICA high voltage deck 1 and high voltage bushing assembly handed over to IO

Neutral Beam Pressure Vessel, Magnetic Shielding — 100%

Electron Cyclotron High Voltage Power Supply (8 units out of 12) — 67%
- First high voltage power supply unit delivered
- Conceptual design of grounding system completed

Electron Cyclotron Radio Frequency Power Sources (6 gyrotrons out of 24) — 25%
- Assessment completed on industrial prototype; improvements underway

Ion Cyclotron Antenna — 60%

Electron Cyclotron Control System — 100%
- PA for Upper Launchers and Ex-Vessel Waveguides signed in March
- Contract signed for the series production of 60 diamond disks

Electron Cyclotron Upper Launchers — 76%
- Upper launcher port plug FDR successfully held
- Fabrication route for upper launcher blanket shield module established with industry

VACUUM VESSEL

Main Vessel (5 of 9 segments) — 56%
- Outer shell welding started on Sectors #5 and #4
- Final assembly stage for poloidal segments PS1 and PS2 (Sector #5)
- Schedule acceleration plan launched

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

* Does not include Complementary Diagnostic Arrangements

EU procurement highlights in 2019	% of ITER system procured by the EU
DIVERTOR	
Inner Vertical Targets	100%
Progress in the manufacturing of four full-scale prototypes	
Cassette Body and Assembly	100%
Cassette bodies: completion of design qualification Stage I	
Start of material procurement	
In-Vessel Divertor Remote Handling Equipment	100%
Divertor Rail	100%
BLANKET	
Blanket First Wall	47.4%
Three first wall full-scale prototypes completed	
Call for tender launched for first wall series production	
Call for tender launched for beryllium material procurement	
Blanket Cooling Manifolds	100%
Validation of pipe bundle and pipe support designs through prototype manufacturing	
REMOTE HANDLING	
In-Vessel Divertor Remote Handling System	100%
Closed PDR phase; qualified hydraulic digital valve technology for inclusion in final design	
Cask and Plug Remote Handling System	100%
Started preliminary design of MA-1 units	
Neutral Beam Remote Handling System	100%
Monorail crane PDR held successfully; other preliminary design tasks ongoing	
In Vessel Viewing System	100%
System PDR held successfully	
Successful R&D on optical system through mockup lab tests	
Common Technologies	100%
Development of radhard digital cameras and multiplexer electronics towards industrialization	
Significant advancements in implementation of GENROBOT framework software	
POWER SYSTEMS	
Steady State Electrical Network (SSEN) and Pulsed Power Electrical Network (PPEN):	
Detailed System Engineering Design	100%
SSEN 400 kV and 22 kV switchyard design approved; PPEN 400 kV switchyard design approved	
Installation and Commissioning	100%
Site power supply now supplied directly from the French grid	
PPEN 400 kV start of energization	
First three load centres and first three medium voltage load centres delivered; start of installation	
Emergency Power Supply	100%
SSEN Components	25%
SSEN 22 kV cables and cable trays: approximately 25% supplied and installed	
FUEL CYCLE	
Front End Cryo-Distribution: Warm Regeneration Lines	100%
Delivery of full scope to IO	
Front End Cryo-Distribution: Front End Cryopump Distribution	100%
Final design started for torus and cryostat cold valve boxes and warm regeneration box	
Final design completed for torus and cryostat johnston couplings, started for cryojumpers	
Cryopumps, Torus (6) and Cryostat (2)	100%
Signature of the contract for the torus and cryostat cryopumping system	
Cryopumps, Neutral Beam	100%
Engineering manufacturing of MITICA cryopump	
Leak Detection	100%
Call for tender launched for leak detection system	
TRITIUM PLANT	
Water Detritiation System	100%
Water holding tanks and emergency tanks completed in 2019	
Hydrogen Isotope Separation System	100%
CRYOPLANT	
Cryoplant: LN2 Plant and Auxiliary Systems	50%
Mechanical installation underway in the cryoplant	
DIAGNOSTICS	
Diagnostics	25%
Eight Complementary Diagnostic Arrangements signed	
270 outer vessel coils delivered to ITER site	
Four contracts signed for inner vessel coils	
Magnetics sensor electrical platforms, low-temperature co-fired ceramic coils, high-frequency coils and diamagnetic coils are in manufacturing	
In-vessel electrical cabling contract signed and started	
PDRs held for EP01, UP01 and UP03 port integration; divertor remote handling connector; equatorial visible/IR wide-angle viewing system (EP12)	
FDR held for the magnetics diagnostic electronics	
RADIOACTIVE MATERIALS	
Waste Treatment and Storage	100%
Radiological Protection	100%
Signature of the PA amendment for procurement of the radiological and environmental monitoring system (REMS) for First Plasma	

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

* Does not include Complementary Diagnostic Arrangements

The European Domestic Agency is working with contractors in Italy and Spain to manufacture the many building blocks required for five ITER vacuum vessel sectors. Pictured, a segment of Sector #5 is delivered to a facility for radiographic tests.

LEGAL AFFAIRS/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
State Nuclear Power Engineering Company (SNPEC)	China
Universities	
Seoul National University	Korea
The National Research Nuclear University (Moscow Engineering Physics Institute- MEPhI)	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 Research TOMSK Polytechnic University (TPU)	Russia
Dalian University of Technology (DLUT)	China
Eindhoven University of Technology	Netherlands
University of Milano-Bicocca	Italy
Åland University of Applied Sciences	Finland
National Schools	
Ecole Centrale de Marseille (ECM)	France
Politecnico di Milano	Italy
Royal Institute of Technology (KTH)	Sweden
Other	
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
Broader Approach Activities (EU/Fusion for Energy + JA/National Institutes for Quantum and Radiological Science and Technology, QST)	Europe/Japan
Consortium RFX (ENEA, the University of Padova, Acciaierie Venete S.p.A., and the Italian National Institute for Nuclear Physics)	Italy

ORGANIZATION CHART

ITER Council

ITER Council Secretariat ICS

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

ITER Organization Executive Project Board EPB

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

Quality Management Division QMD

Legal Affairs LGA

Cabinet CAB

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

Security

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
Experiments and Plasma Operation

Plasma Modelling and Analysis

Controls
Data Connectivity and Software

Facility Control System

Central Control Integration

Operations

Caption cover image: The ITER Assembly Hall, where all machine components will be prepared for handling and in-pit assembly. Several bespoke assembly tools procured by Korea are already in place for the handling of the vacuum vessel sectors and D-shaped toroidal field coils; two sets of powerful bridge cranes are also commissioned and ready (the smaller set is pictured).

LOOKING AHEAD: 2020

- Handover of the Tokamak and Assembly buildings
- Official start of machine assembly
- First-of-a-kind magnet and vacuum vessel components on site
- Giant sector sub-assembly tools enter into action
- Cryostat manufacturing concludes
- New construction-focused organization at ITER
- Staff numbers pass 1,000

In the Assembly Hall, contractors must control humidity and maintain air at a uniform temperature during machine assembly. A powerful heating, ventilation and air conditioning system and anti-dust coating on the floors will contribute to maintaining required air quality.

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

www.iter.org

iter
china eu india japan korea russia usa