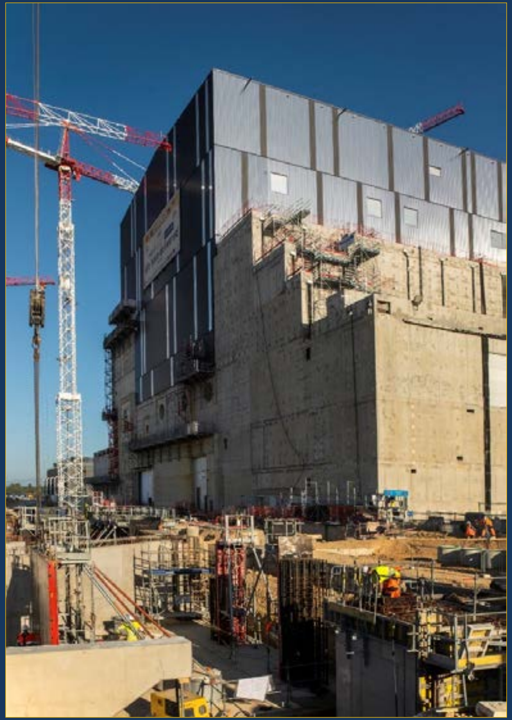
ITER:
An Essential Step toward Fusion Energy

T.C. Luce
Head of Science and Operation Domain
Chief Scientist
ITER Organization

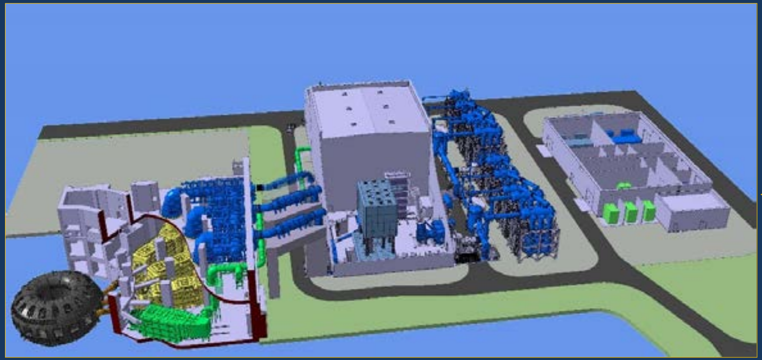
Work scope towards First Plasma
> 75% complete

Worksite progress

Under construction

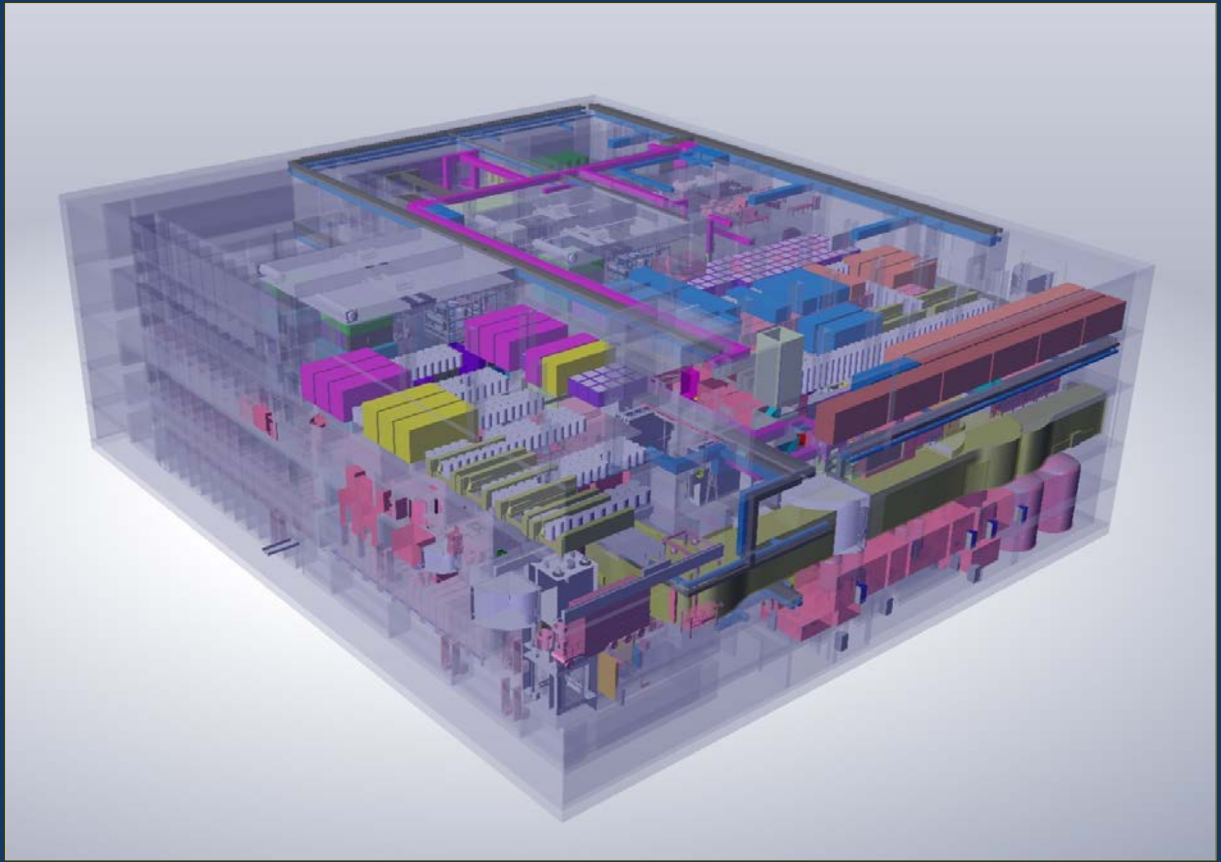


Control Building



Neutral beam building for 1 MV power supplies for the injectors

Conceptual design phase



Hot Cell Complex

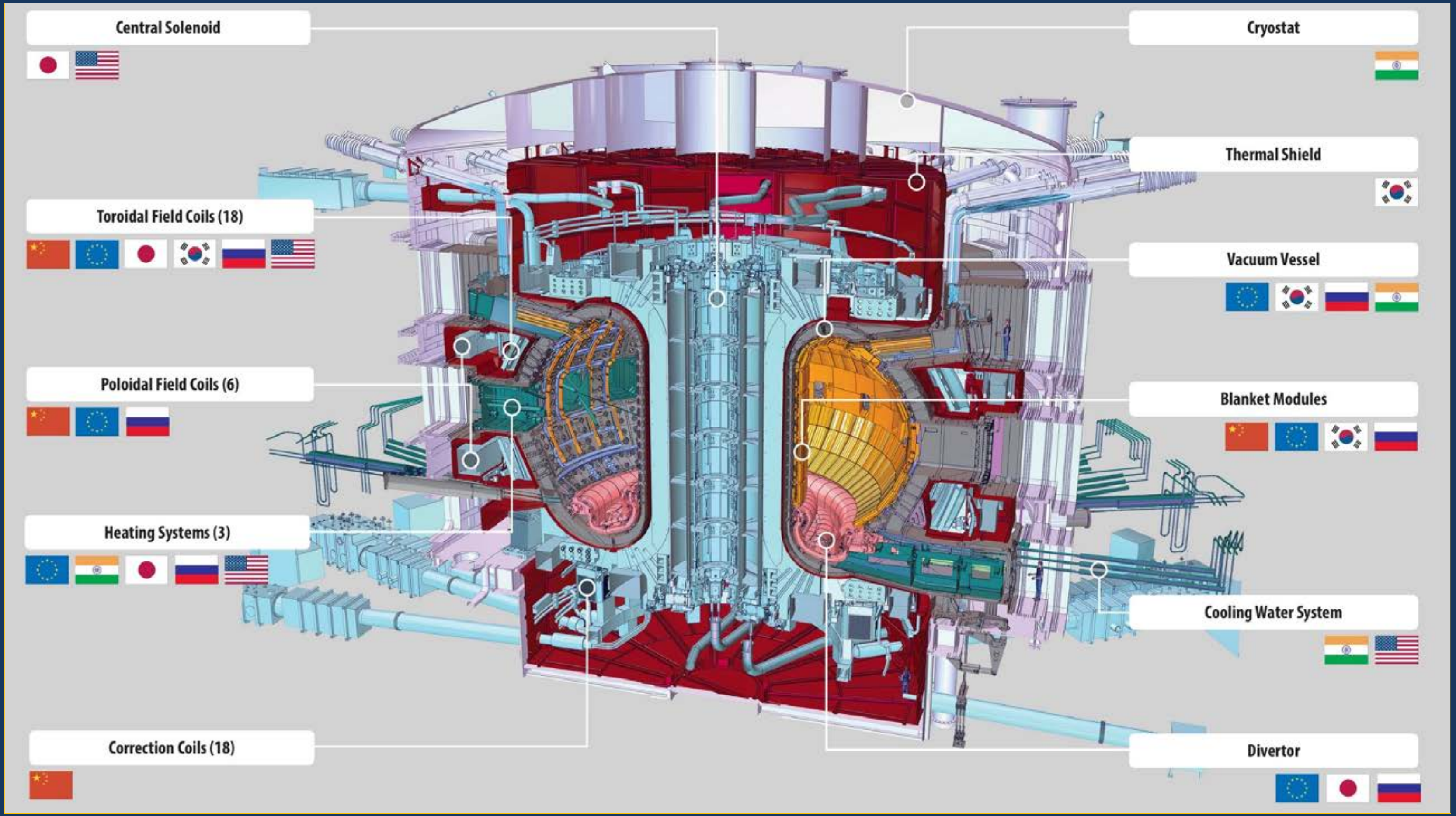
Repair, refurbishment, testing, and decommissioning of components that have become activated or beryllium contaminated will take place in the ITER Hot Cell Complex

Seven years of steady progress

2014 –2021

The civil works are now >80% complete

Who manufactures what?



>85% of the ITER facility is supplied by in-kind contributions of the Members

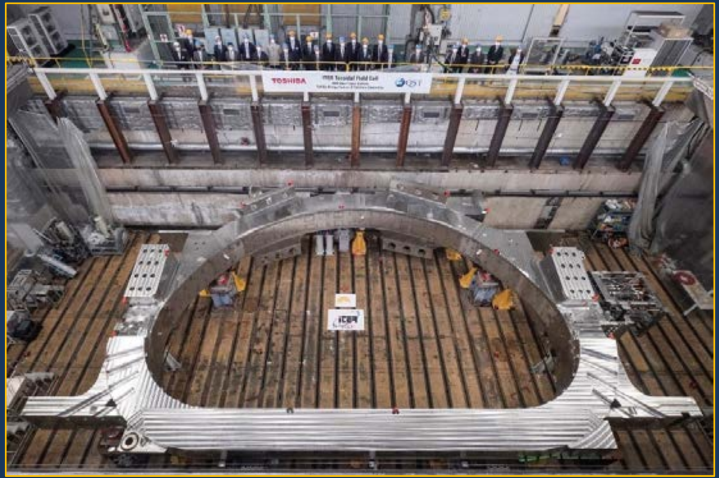
The ITER Members share all intellectual property

85% of total manufacturing finalized

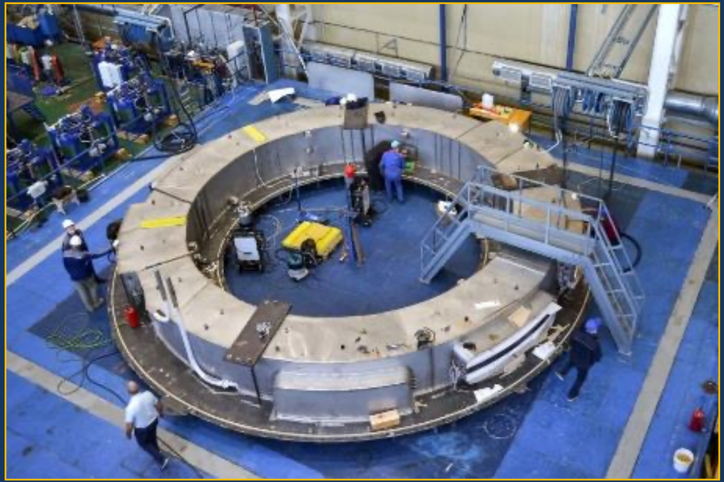
Five vacuum vessel sectors are under fabrication in Italy;
Completion ranges from 76% to 96%
Five Toroidal Field coils delivered; next one expected tomorrow

Two vacuum vessel sectors delivered - completion of the remaining two: 99% and 92%
Most magnet power supplies delivered

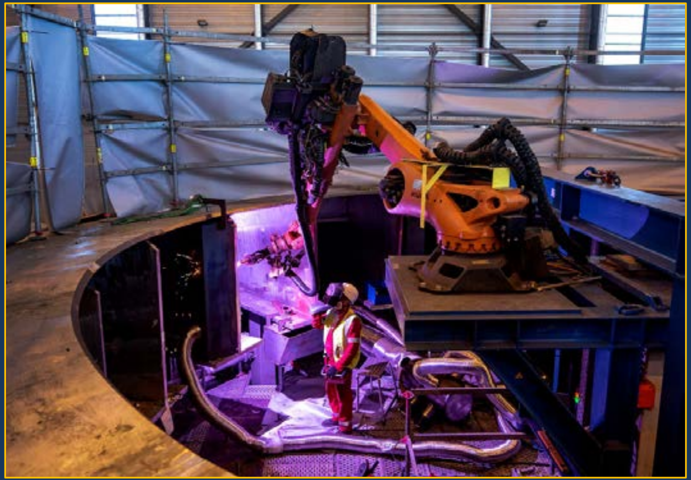
85% of total manufacturing finalized



5 TF coils delivered; 1 en route



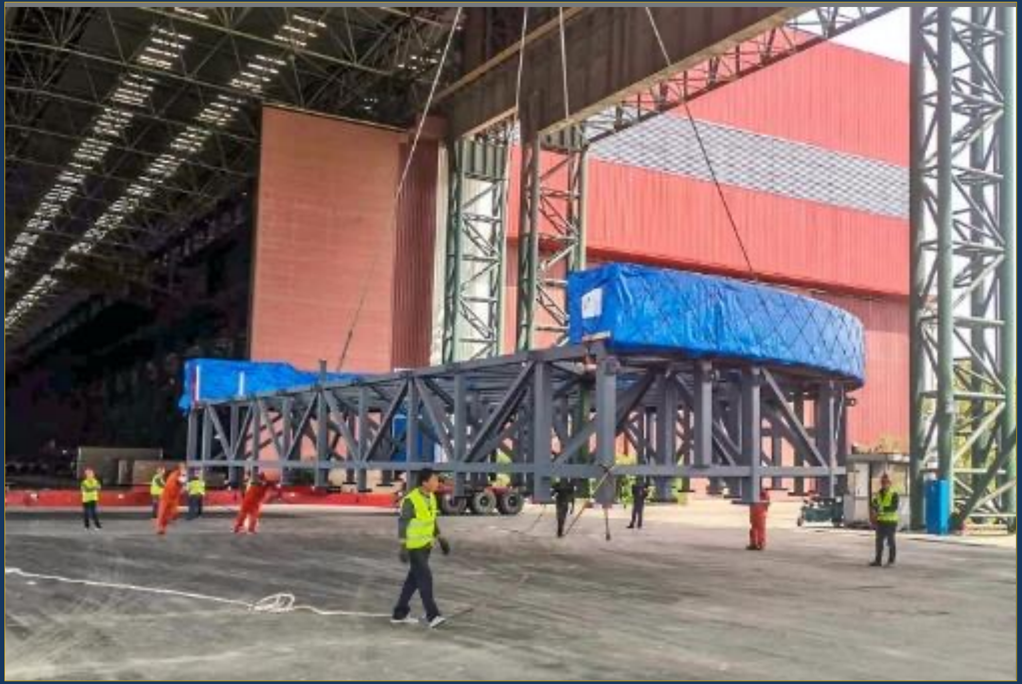
Poloidal field coil #1 is entering the final stages of fabrication in Saint Petersburg; FAT expected next month



3 out of 4 sections of the Cryostat finalized, 2 installed. Top lid at final welding phase

85% of total manufacturing finalized

Two central solenoid modules delivered – 5 others (including 1 spare) nearing end of fabrication

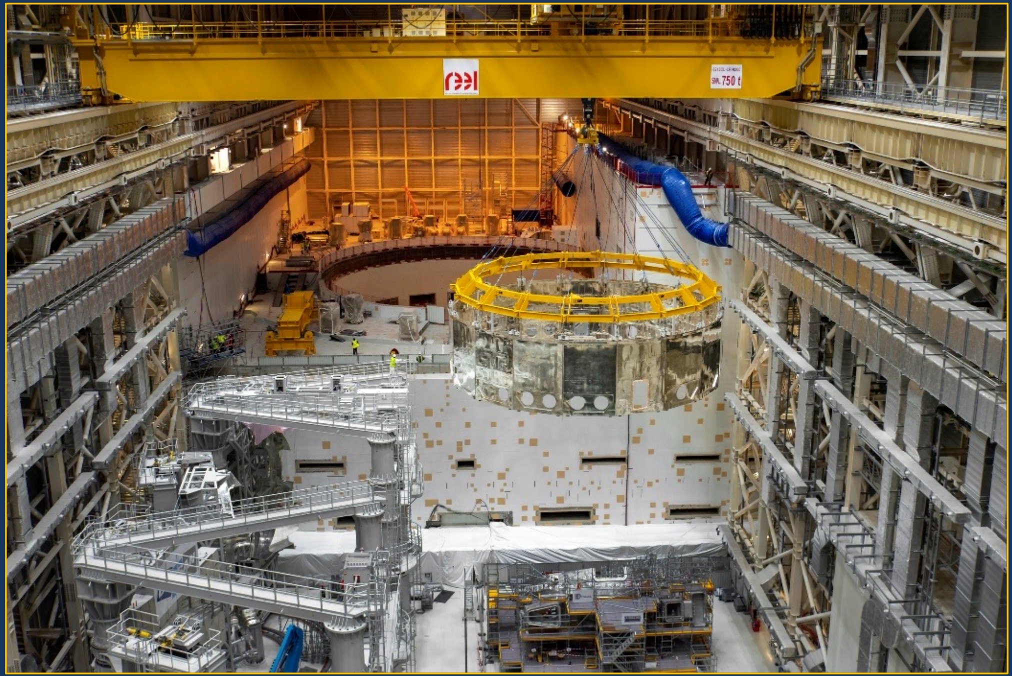


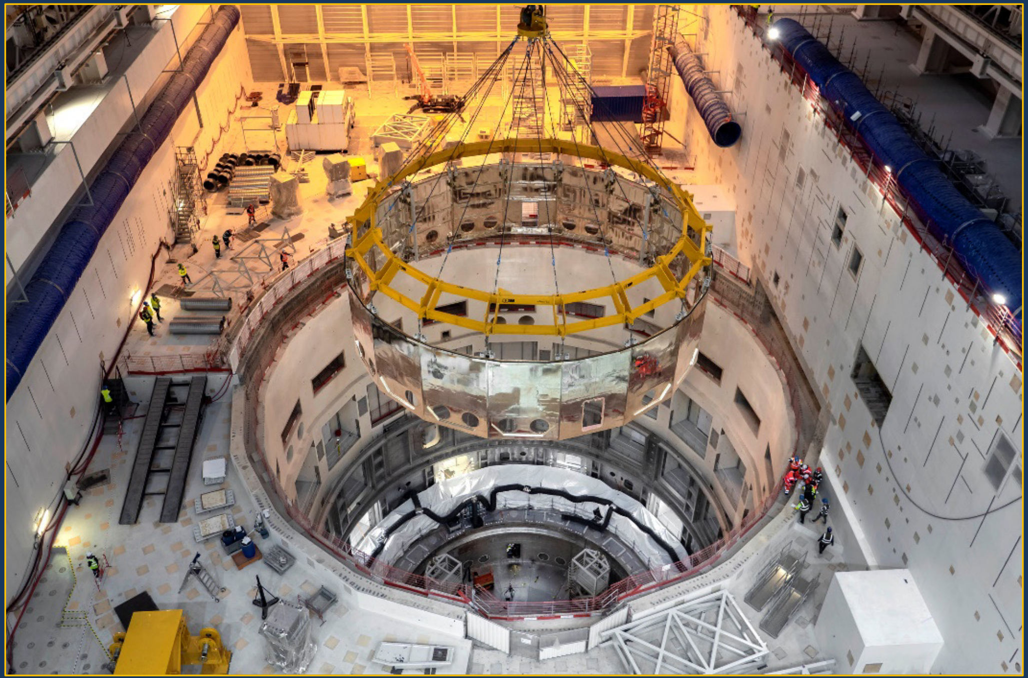
Ongoing delivery of more than 1,600 tonnes of equipment for the magnet feeders and correction coils
Most magnet power supplies delivered

Component deliveries

Main components delivered in 2020-2021:
- 10 TF coils (out of 18+1); 1 more expected
- 2 PF coils (out of 6); 1 more expected
- 2 vacuum vessel sectors (out of 9)
- 2 Central solenoid modules (out of 6+1)

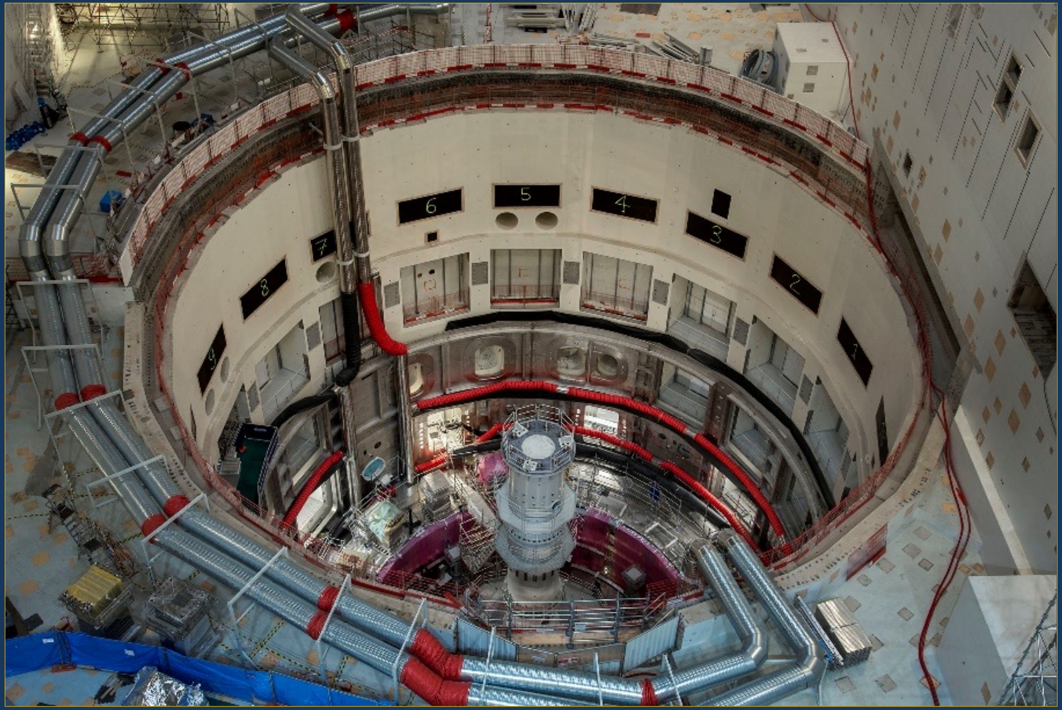
Assembly progress: Thermal shield insertion





The lower cryostat thermal shield (LCTS) was installed on 14 January 2021. A silver-plated component, the LCTS stands between the lower section of the Cryostat and the machine to act as an obstacle to thermal radiation.

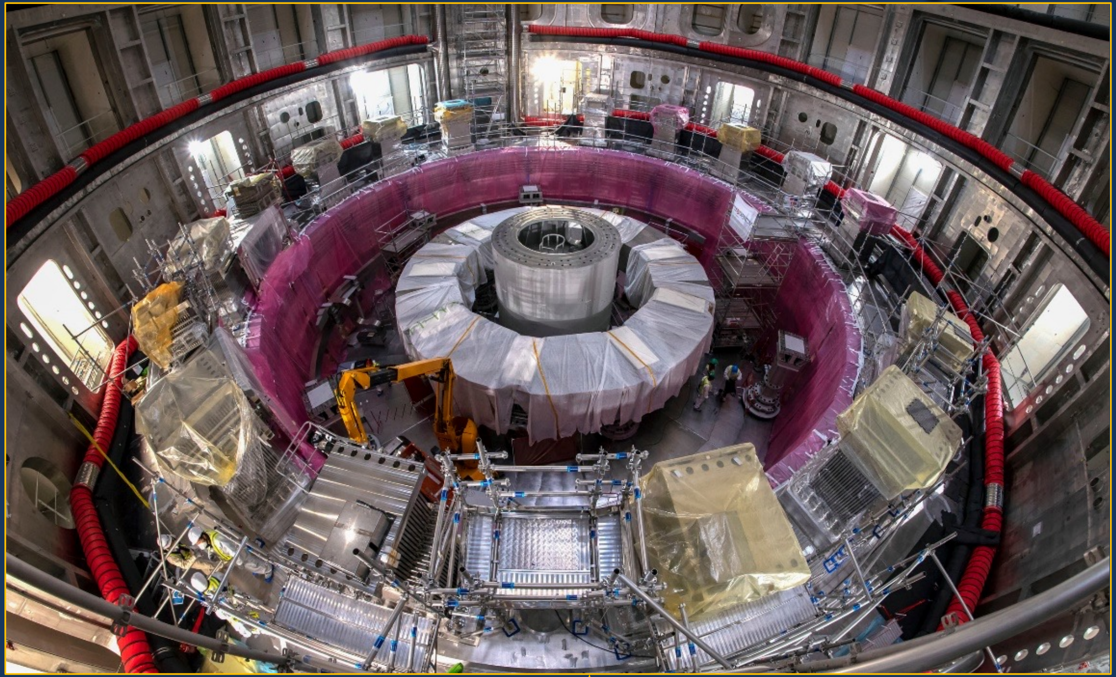
Assembly progress: tooling



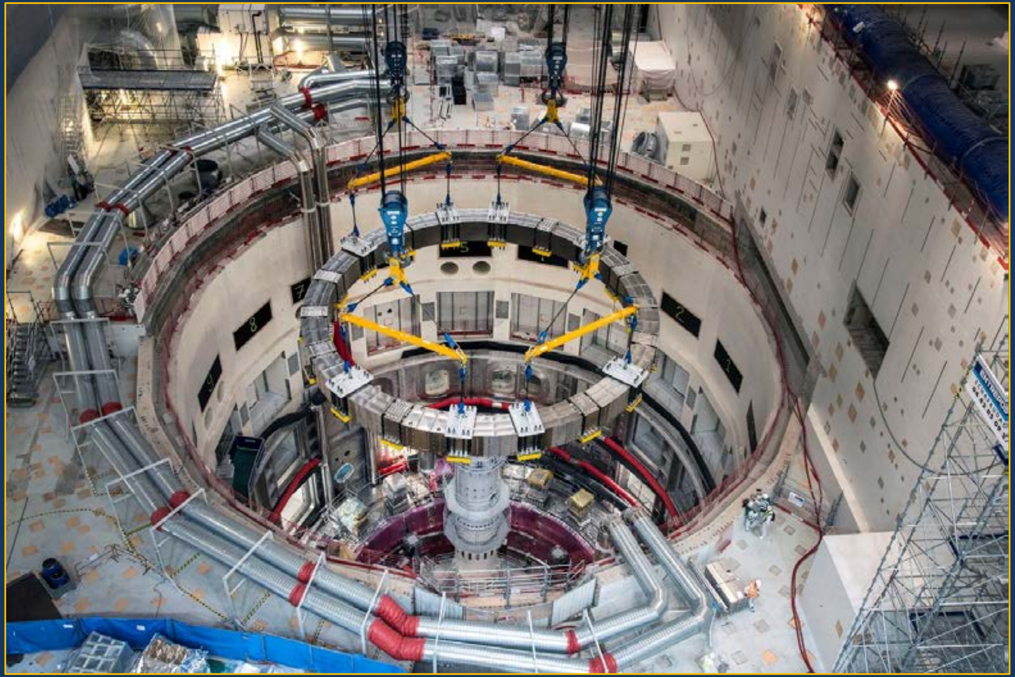
20 August 2021 – Central column (an in-pit assembly tool)

7-8 September 2021 – Test positioning of first radial beam (9 supports for the 9 sector modules – each 1000+ tonnes)

Assembly progress: 2 PF coils (out of 6) in pit



21 April 2021 – Poloidal field coil # 6



16 September 2021 – Poloidal field coil # 5

Toward the first Sector Module sub-assembly

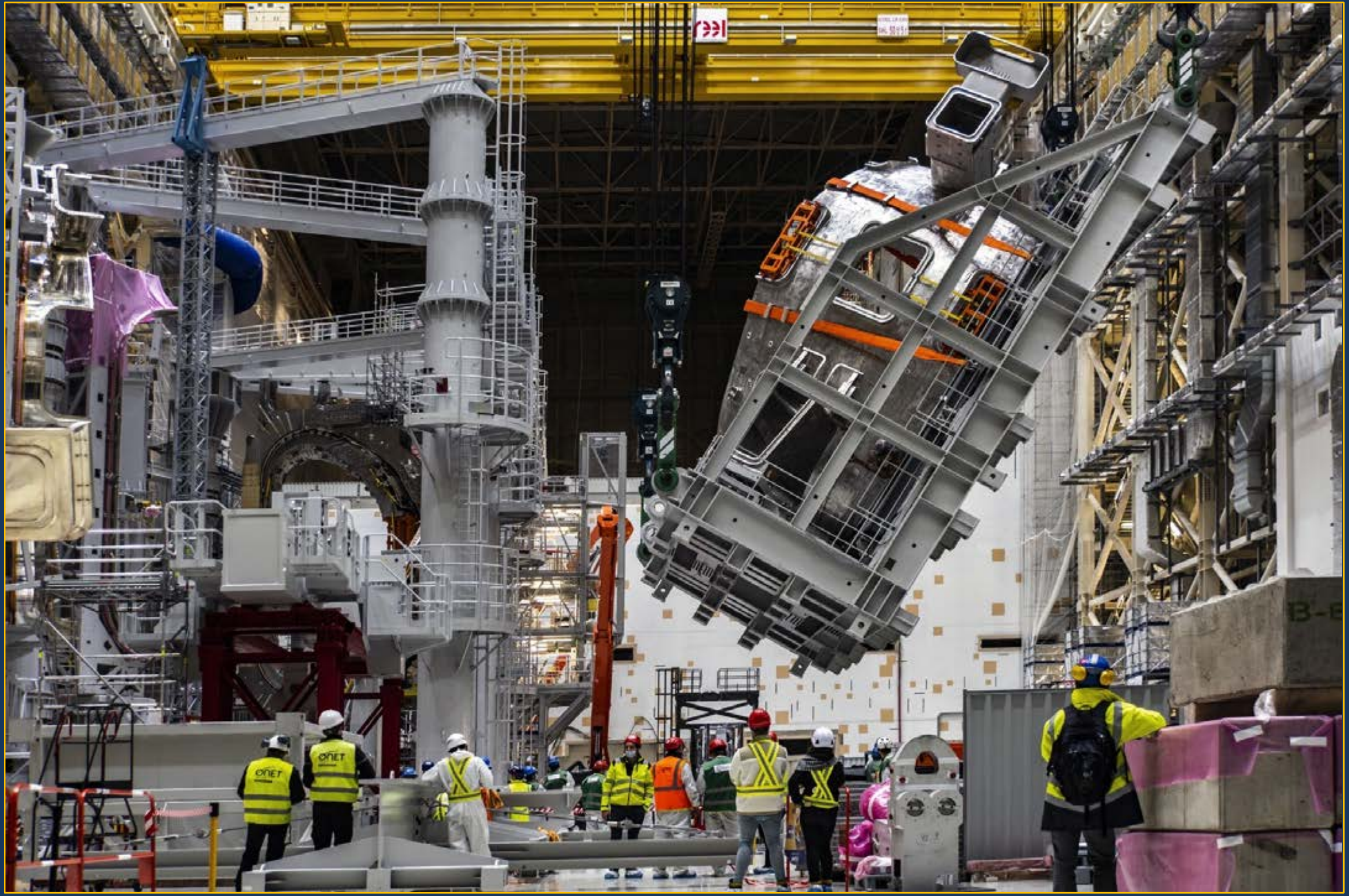
Sector modules are the building bricks of the Tokamak torus. Each comprises a 40° vacuum vessel sector, two toroidal field coils and the corresponding thermal shield panels, and weigh in excess of 1,000 tonnes.

Nine sector modules are required to close the torus.

Final alignment was performed on 17 September within extremely tight tolerances:

radial direction 0.14 mm; toroidal direction 0.25 mm; vertical direction 0.58 mm.

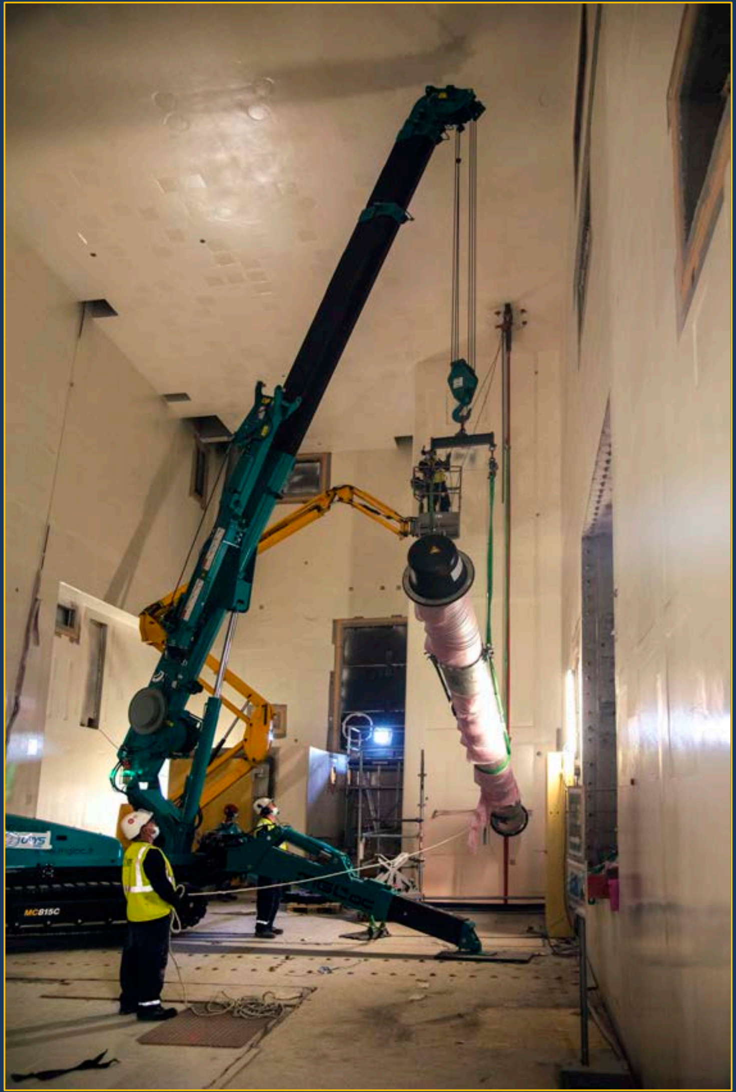
Beginning second sub-assembly



The 650-tonne load of the second vacuum vessel sector is lifted into place: Thursday 9 December 2021

Balance of plant

Towards commissioning



Cryoline installation

Heat Rejection System

Balance of plant

Towards commissioning

10,000 km of electric cables

AC/DC conversion (8 km of busbar)

Towards Integrated Commissioning

15 sub-systems are in various stages of preparation, commissioning, or temporary operation:

- Temporary operation: steady-state electrical supply (99.99% reliability in 2021), demineralized water, compressed air, breathable air
- Commissioning: chilled water, secondary cooling water (2D loop), heat rejection system, test and release basins, reactive power compensation, cryoplant gas supply
- Countdown to commissioning: liquid nitrogen plant, liquid helium plant, electron cyclotron heating, secondary cooling water (2C loop), high-voltage pulsed electrical power

What Is the Mission of ITER?

"To demonstrate the scientific and technological feasibility of fusion energy for peaceful purposes"

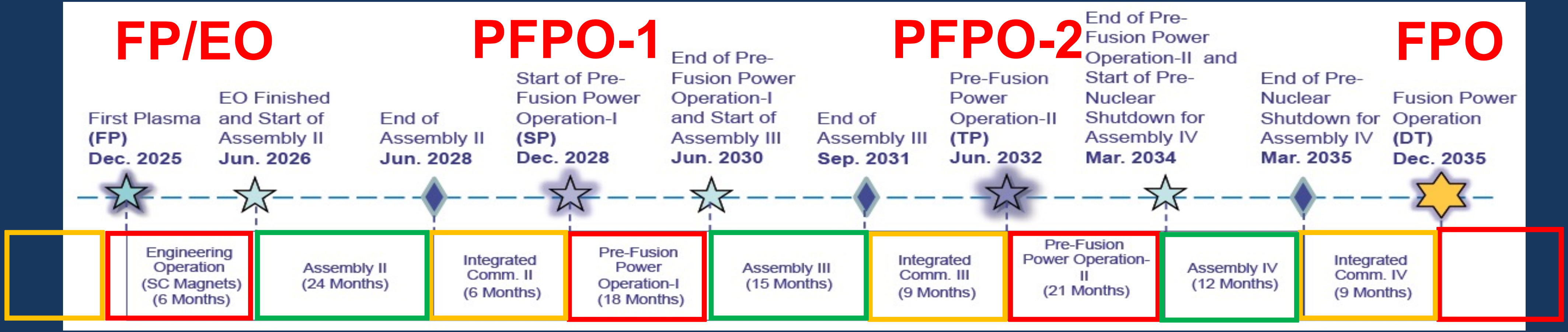
– **How can we claim we have done this?**

- Achieve fusion power of 500 MW with P_{fus}/P_{in} ($\equiv$ Q) $\geq$ 10 for 300-500 s (i.e., stationary conditions)
- Aim at demonstrating steady-state operation with Q $\geq$ 5
- Capable of advanced operational modes and a wide operating parameter space
- Achieve the minimum cost device that meets **all** the stated requirements

What Questions Will ITER Answer?

- **While we are confident in the design basis for ITER, it is still an experiment**
  - This means operation of ITER as envisioned in the design basis will validate (or invalidate) its design basis
  - **Is magnetic fusion reasonable as an energy source?**
- **In the time between now and ITER DT operation, simulation capability will continue to advance**
  - This means operation of ITER will validate (or invalidate) the physics and assumptions in a variety of simulations
  - **Is magnetic fusion predictable?**

A "Staged Approach" to Full Operating Capacity



- Present baseline schedule (2016) foresees First Plasma at the end of 2025 and start of Fusion Power Operation at the end of 2035
  - Required a new ITER Research Plan (completed in 2017)
- Despite the progress shown in manufacturing and assembly, delays due to COVID and FoaK manufacturing make First Plasma in 2025 unlikely
  - ITER Council has asked the IO to evaluate a potential update to the present baseline for discussion in 2022, maintaining start of DT phase in 2035 if possible

ITER Research Plan and Supporting R&D

- ITER Research Plan made publicly available in 2018 (available as Technical Report (ITR-18-003) →now an ITER baseline document
- R&D topics to support effective execution of Research Plan made accessible to fusion community (ITR-20-008) → used to focus R&D programmes (e.g. ITPA)


ITER TECHNICAL REPORT

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REPORT NO.
ITR-18-003

TITLE
ITER Research Plan within the Staged Approach (Level III – Provisional Version)

AUTHOR/AUTHORS
ITER Organisation

AUTHOR EMAIL(S)
ITR.support@iter.org

DATE
17th September 2018

www.iter.org


ITER TECHNICAL REPORT

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REPORT NO.
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TITLE
Required R&D in Existing Fusion Facilities to Support the ITER Research Plan

AUTHOR/AUTHORS
Alberto Loarte

AUTHOR EMAIL(S)
Alberto.Loarte@iter.org

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www.iter.org

ITER Will Be The First Look At Burning Plasma