THEMATIC WORKSHOP

Machine assembly program

ITER Core Machine Assembly

Progress to date, challenges & solutions ■ Evolution of contractor, collaboration on Machine Assembly Construction Contracts

Jens REICH
ITER Machine Assembly Program Manager

He is specialized in management and coordination of design, construction, and installation of large mechanical - fusion related - components in collaboration with industrial partners.

Mary O'LOUGHLIN
ITER Contract & Cost Management Officer

She oversees Machine Assembly contract cost control, & participates on contract negotiations and business process management.

iter
china eu india japan korea russia usa

Contractor Perspective on collaboration on Machine Assembly works

Peng WANG
CNPE

He possesses extensive expertise in large-scale component handling, assembly, and project coordination,

Arican PAMIR
SIMIC

He is skilled in project engineering, design and construction site management.

Chairperson:

Kattalai Ramachandran SRIRAM
ITER Head of Director-General's Office

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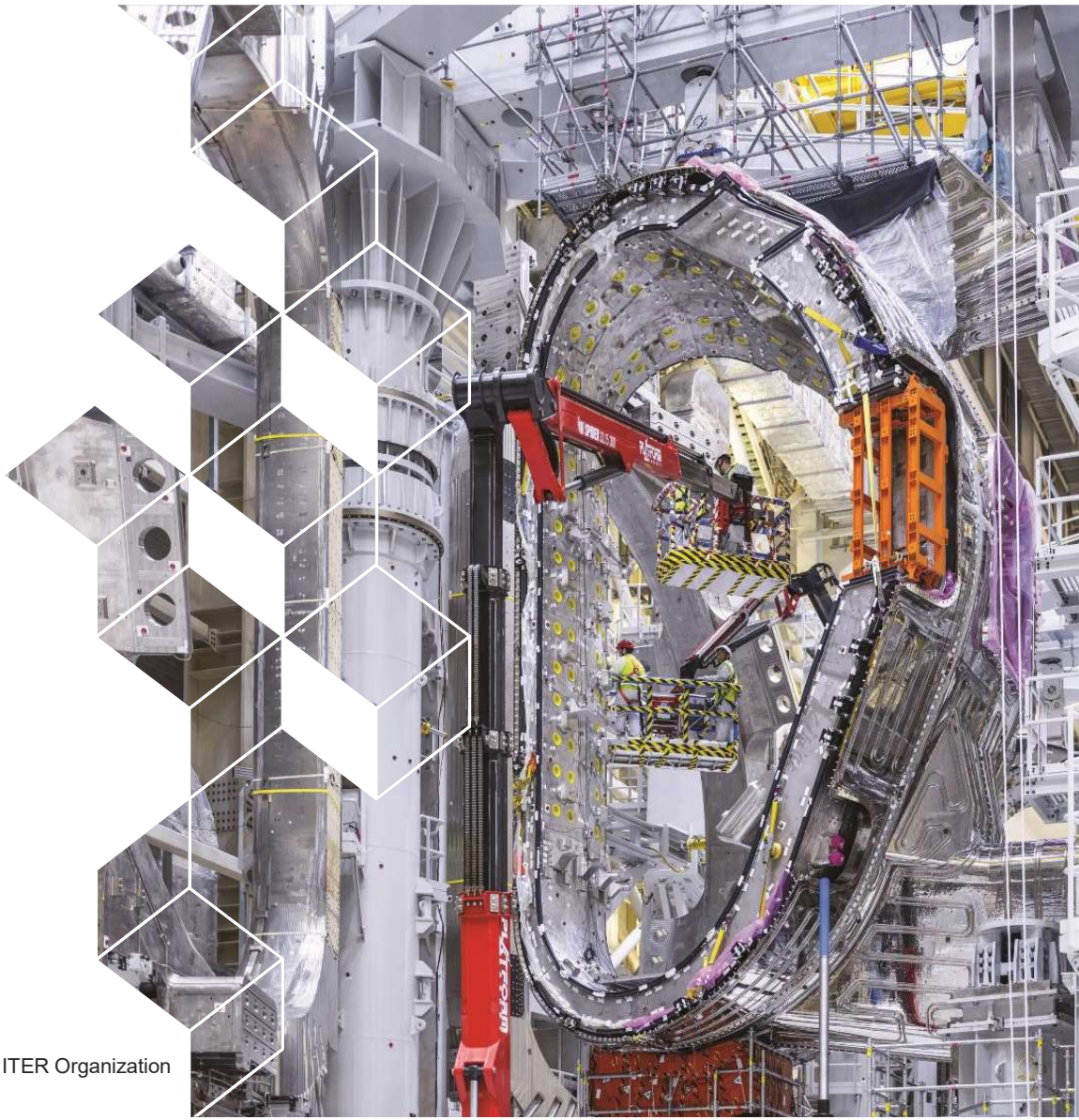
INTERNATIONAL ITER BUSINESS FORUM

ITER Core Machine Assembly

Jens Reich,
Machine Assembly Program Head,
ITER Organization

Mary O'Loughlin
Construction Project Office Lead, Machine Assembly Program.
ITER Organization

THURSDAY 24th April



CONTENTS

1. ITER Machine Assembly –

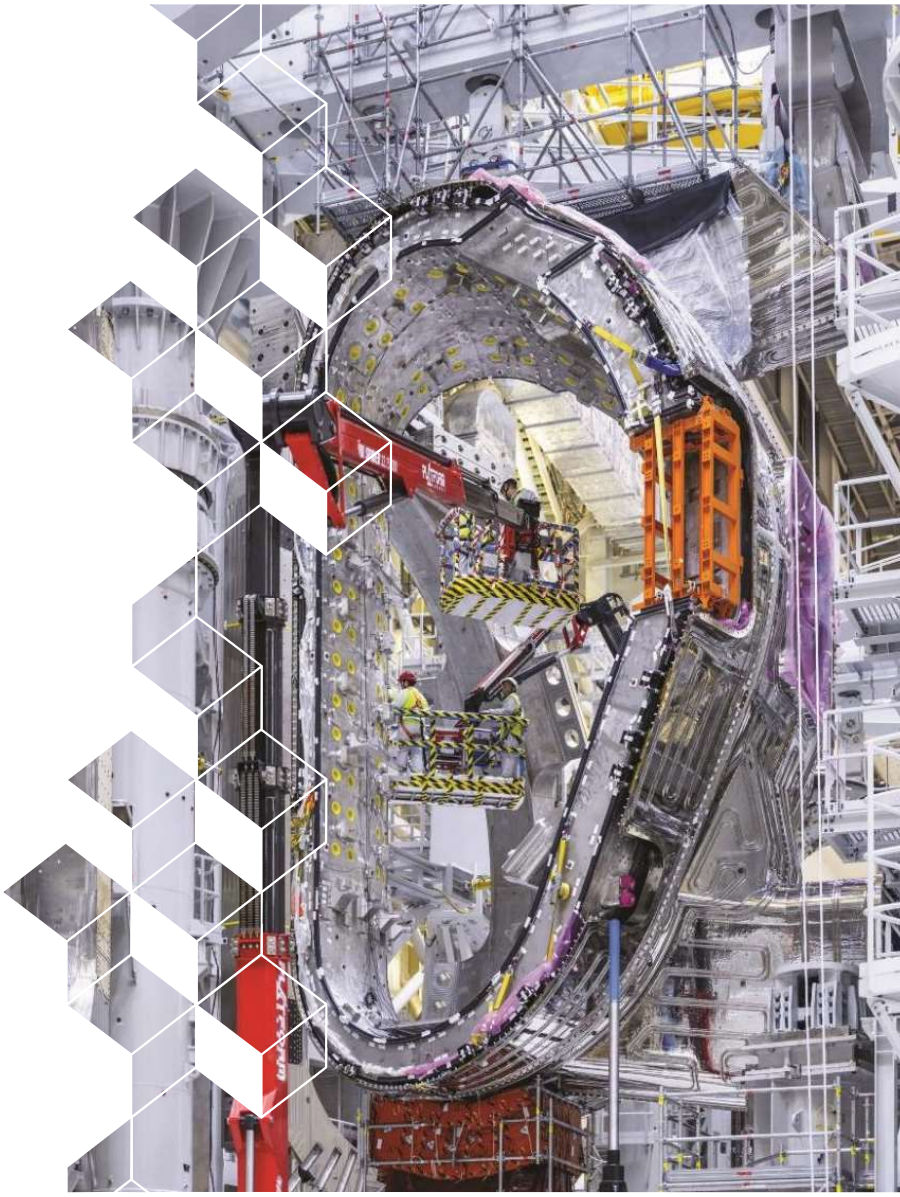
Progress to Date, Challenges & Solutions

Progress To Date

Works started already in 2019 with installation of the Cryostat Base, Poloidal Field Coils, Pre-compression rings, Lower Cryostat Thermal Shield elements, Toroidal Field coils gravity supports, Bottom Correction Coils and many other important and captive components

In parallel Magnet Feeders have been installed in galleries and critical superconducting busbar connections are made.

Valuable experience has been built in relation to work organization in preparation to the movements of components with physical installation works (e.g. heavy lifting, instrumentation)



Progress To Date

ASSEMBLING THE MACHINE

[Tokamak Pit, top-down view]

The Cryostat Base, 30 metres in diameter, was positioned with a final tolerance under 3 mm at all metrology points.

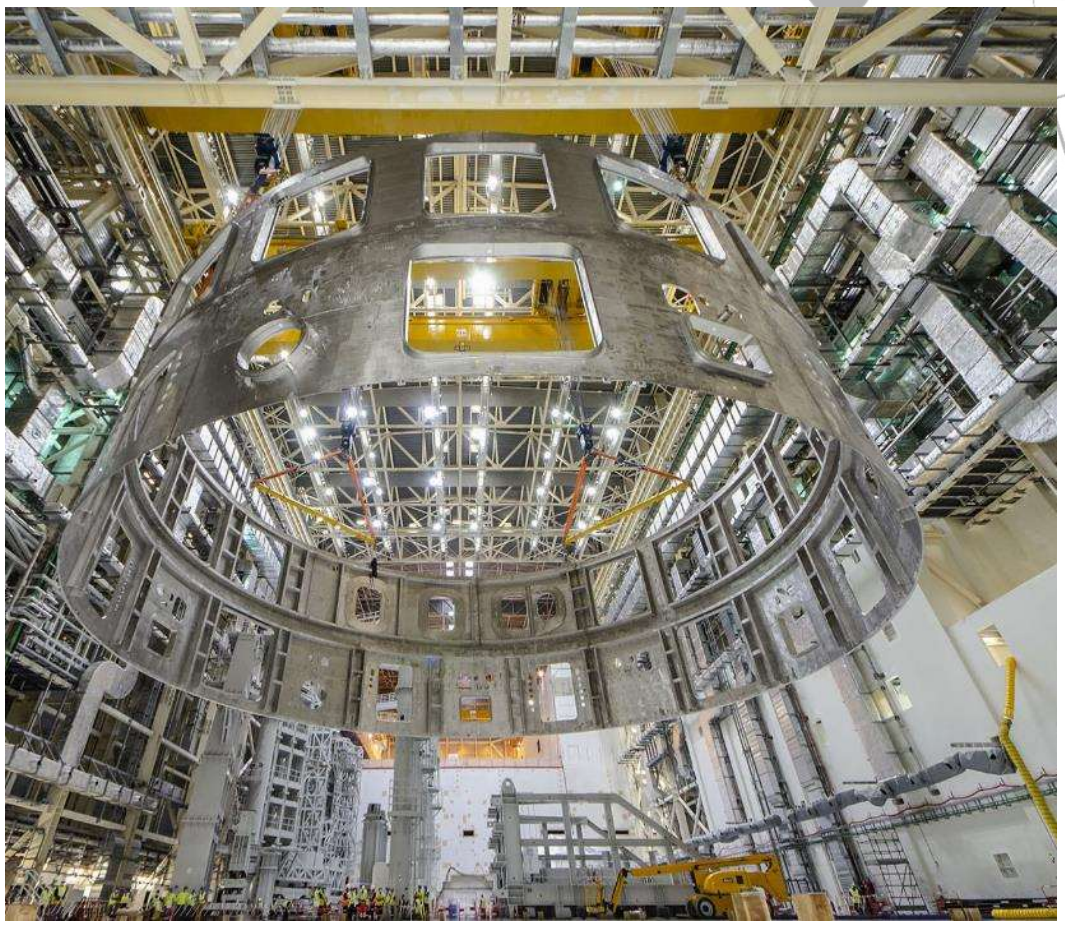
May 2020

Progress To Date

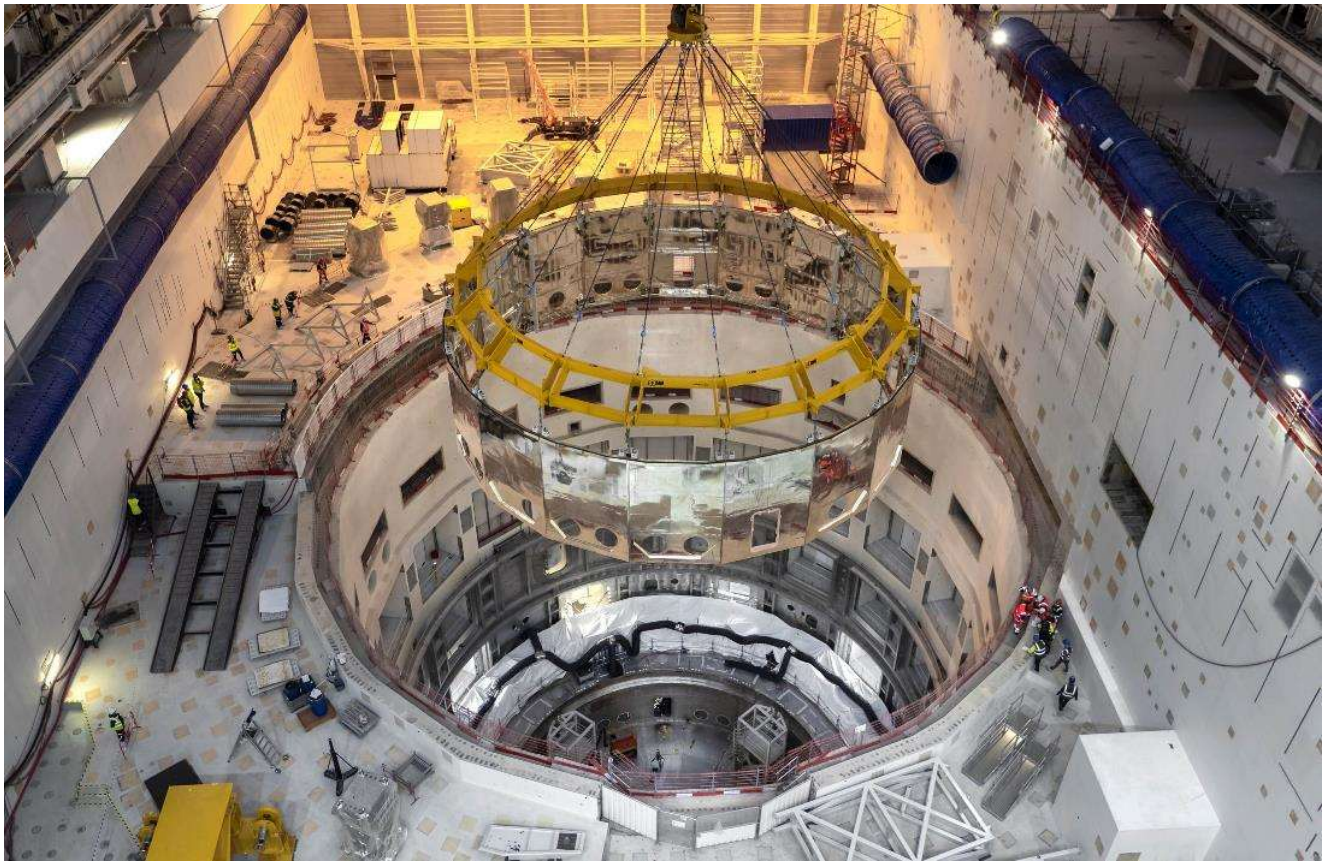
ASSEMBLING THE MACHINE

Cryostat Lower Cylinder installation

August 2020



Progress To Date

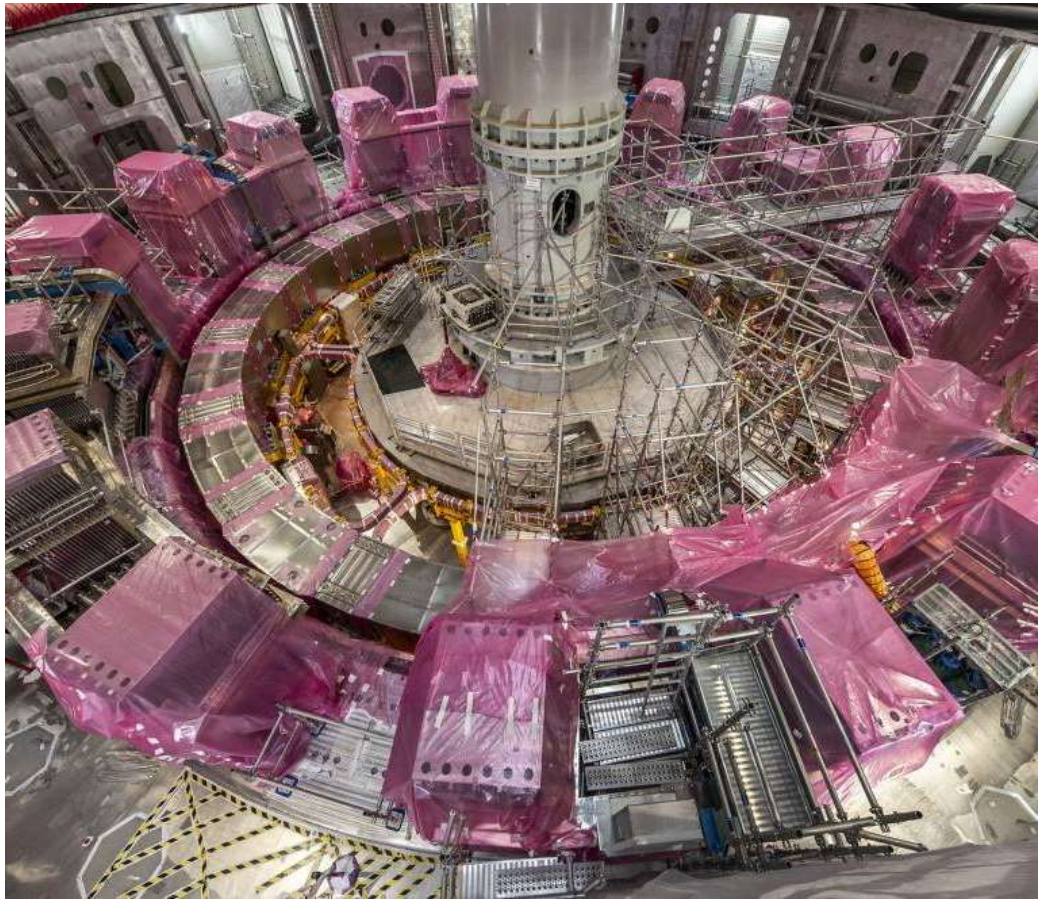


ASSEMBLING THE MACHINE

Lower Cryostat Thermal Shield installation

January 2021

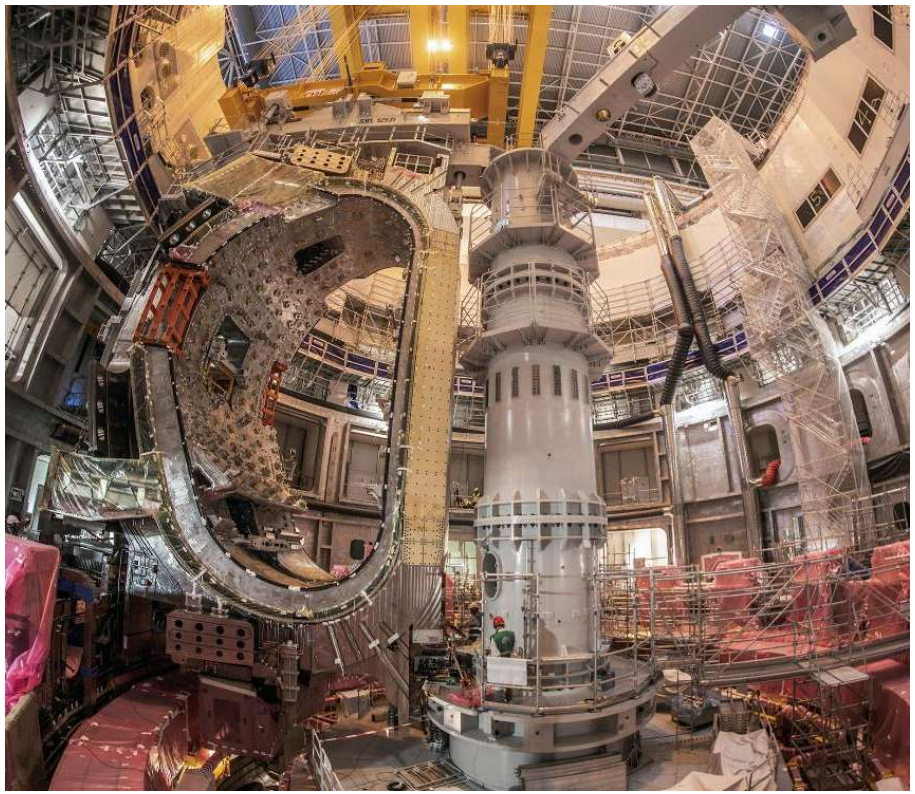
Progress To Date



ASSEMBLING THE MACHINE

Preparation of Pit prior to
Vacuum Vessel Sector Landing

Progress To Date



Sector Module #7: Assembled in Record Time

In just 6 months and 10 days, teams at ITER assembled a massive 440-tonne vacuum vessel, two 330-tonne toroidal field coils, and thermal shields into Sector Module #7—a key “building block” of the ITER machine.

Thanks to lessons learned, better tools, and outstanding teamwork, the process was completed 3x faster than the first module.

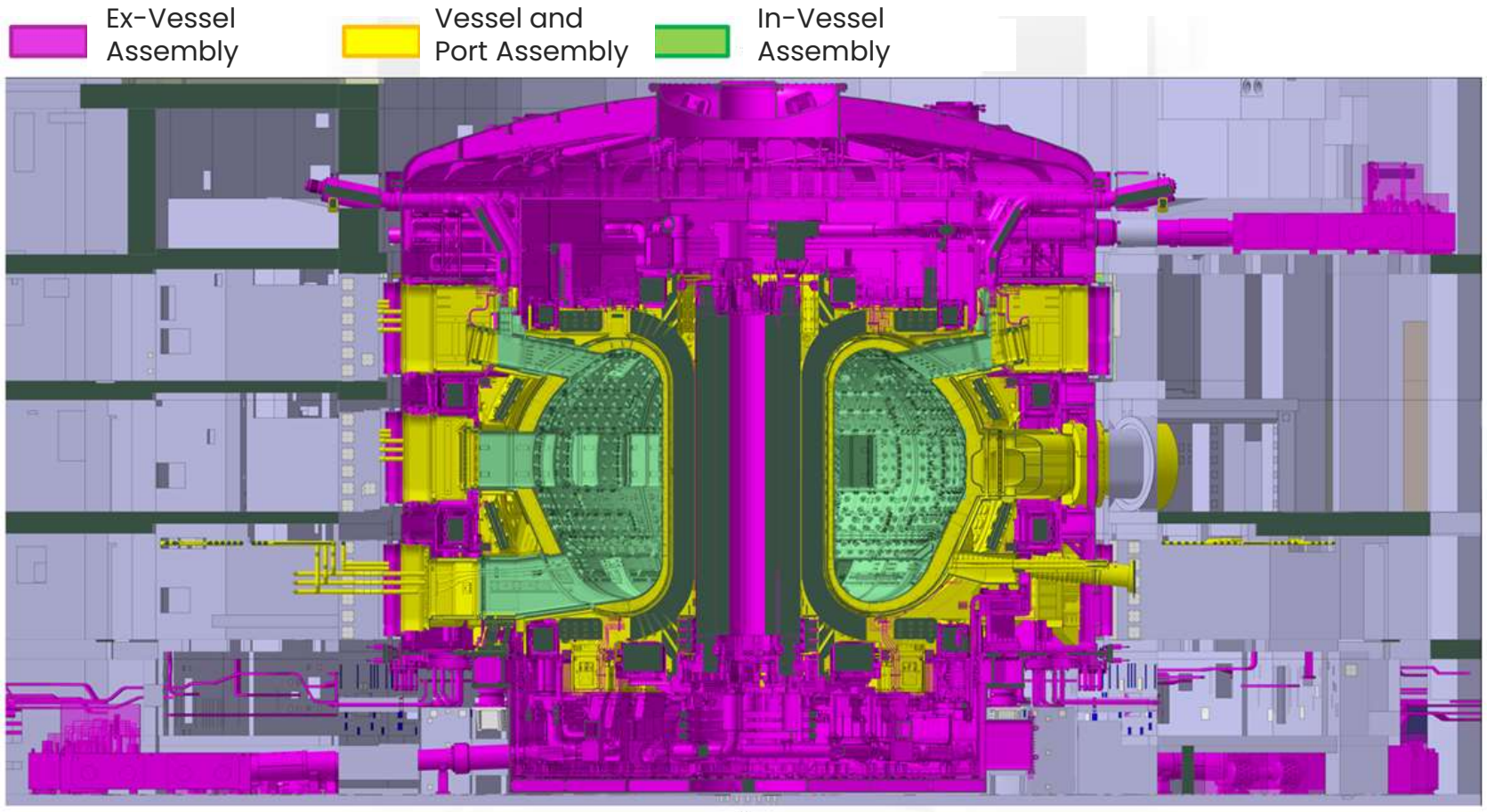
Progress to Date

Currently works in relation to the Vacuum Vessel Module Assembly

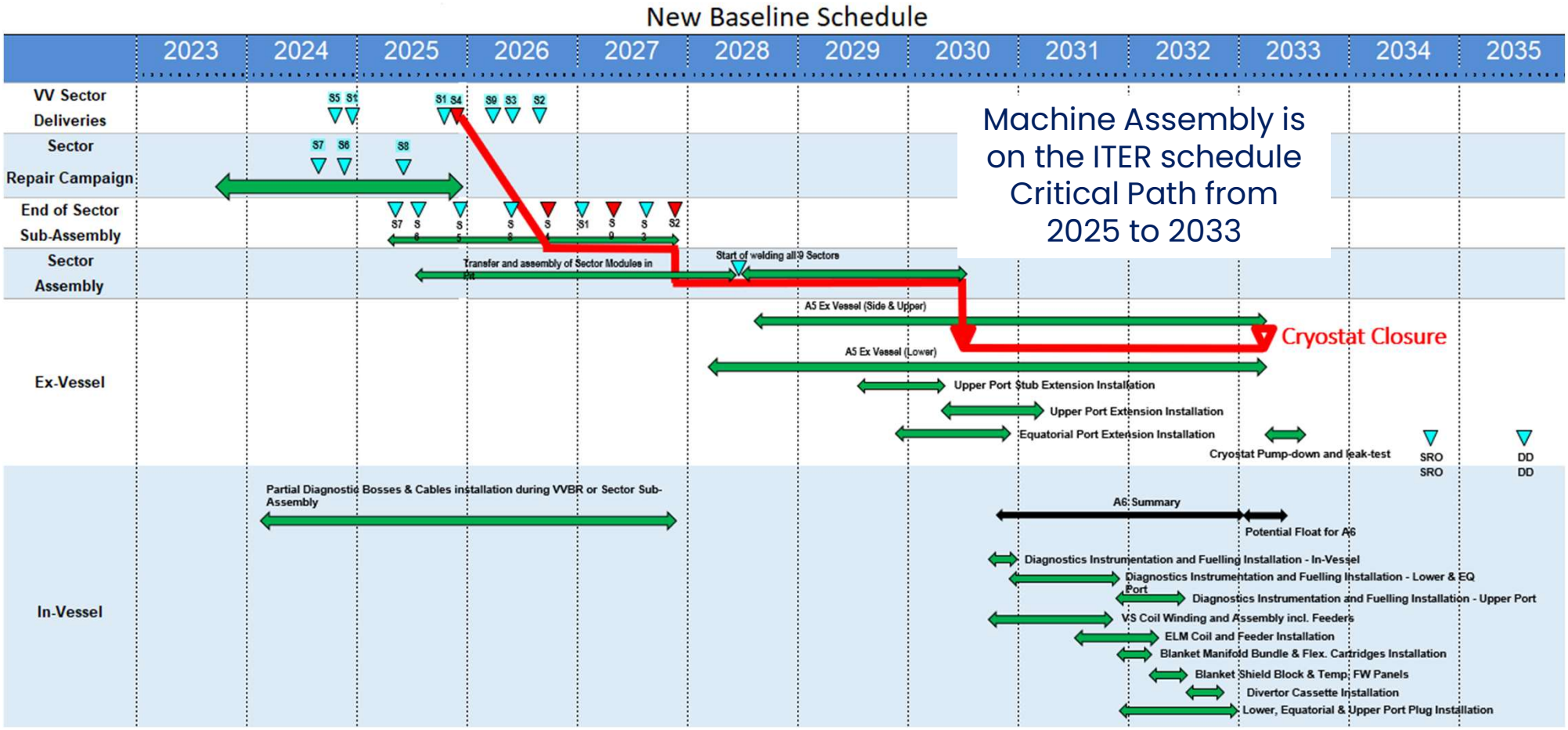
- With preparation of VV with welding of bosses, clips attachment points to fix diagnostics systems
- Upending of TF coils and Vacuum Vessel in the Sector Sub-Assembly Tools
- Pre-installation of Vacuum Vessel Thermal Shield components
- Welding of pipes, NDT
- Customization of intercoil structures and installations
- Lifting of all modules into the pit by latest end 2027

- In parallel pit work with landing of the VV on their gravity supports
- Intercoil connections between pre-assembled modules
- VVTS splice plate installation and many more items before the welding of the VV could start

Challenges – Scope Density

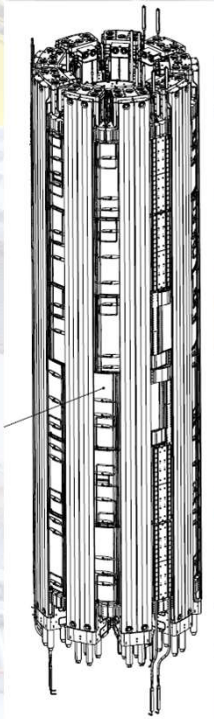


Challenges – Schedule

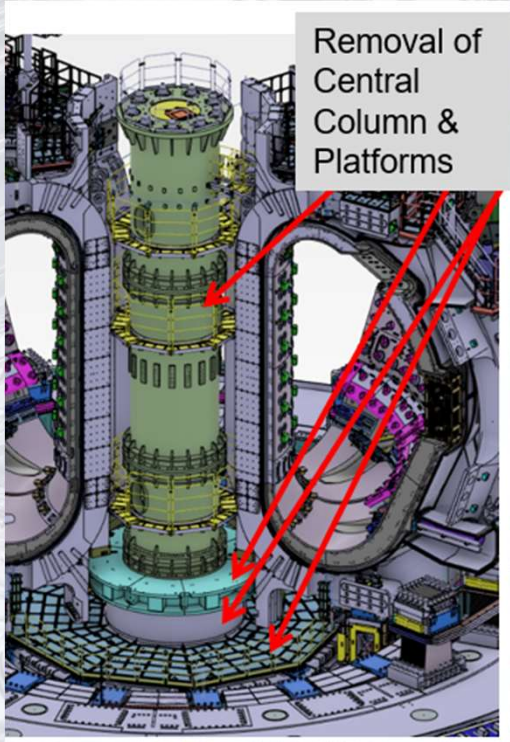


Technical Challenges during the Execution

- Extremely limited clearance between components few millimeters left while handling major components (e.g on CS coil: ~12m height and 18 mm gap in radius)

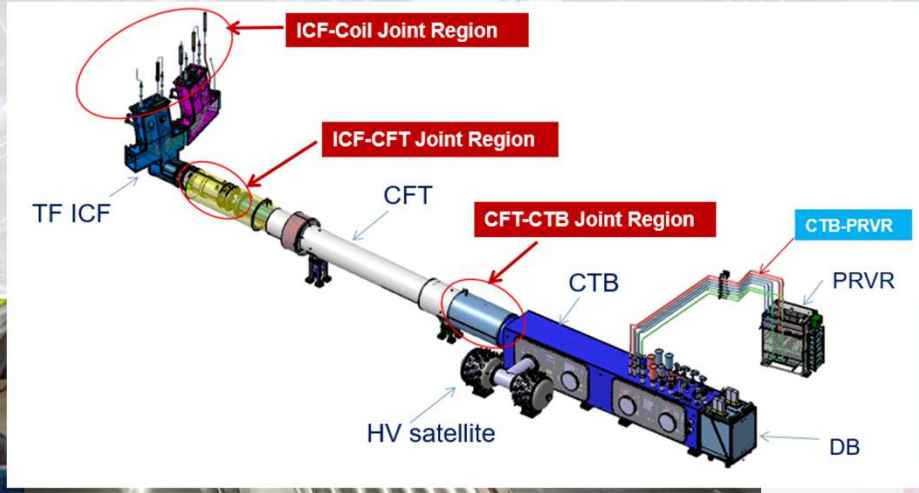


Central Solenoid Stacking & Connections



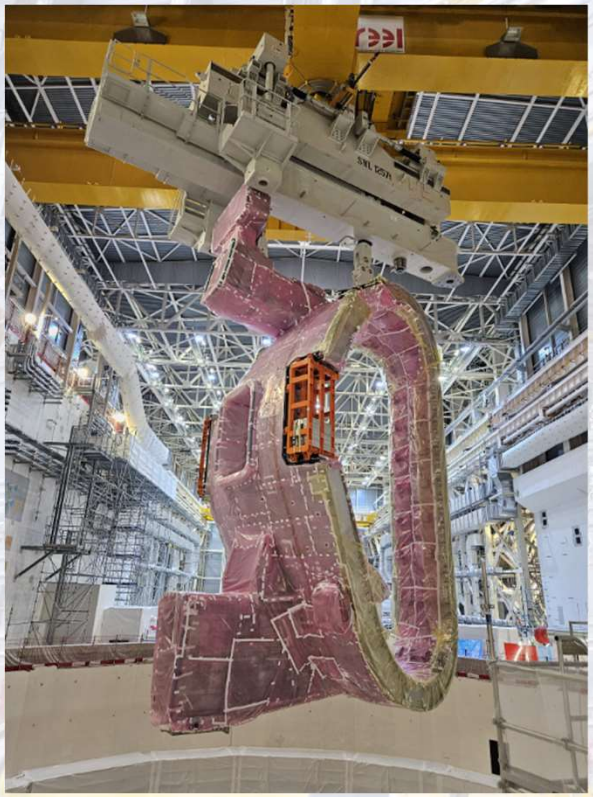
Technical Challenges during the Execution

- Superconducting Connection Joints between Magnet Feeders and Coils as a specific process with insulation, and high voltage instrumentation, HV and cryogenic testing



Technical Challenges during the Execution

- Continuation of VV repair works onsite e.g. VV rotation (~420 t with the given geometry and center of gravity to be determined)
- Cryostat Thermal Shield still to be repaired



Technical Challenges during the Execution

Logistics inside the assembly hall and adjacent buildings

- Delivery of special convoys from port to IO site in line with French regulations
- Preservation/Maintenance of stored components
- Availability of major crane in assembly hall

Solutions

Use Opportunities

- 2 Upending Tools (UTs) to accelerate and to give opportunities to prepare items in parallel

Solutions

- Strong coordination of onsite activities with multiple stakeholders aligned
- Rapid turnaround to address field issues
- Process improvement, especially when repetitive with minimized paperwork
- mplementation of 3 shift scheme
- Investment in mockups & tools to qualify assembly processes & carry out trails
- SQEP – definition of required training on IO tools (lifting, rigging, welding, NDT, logistic, machining, instrumentation installation)

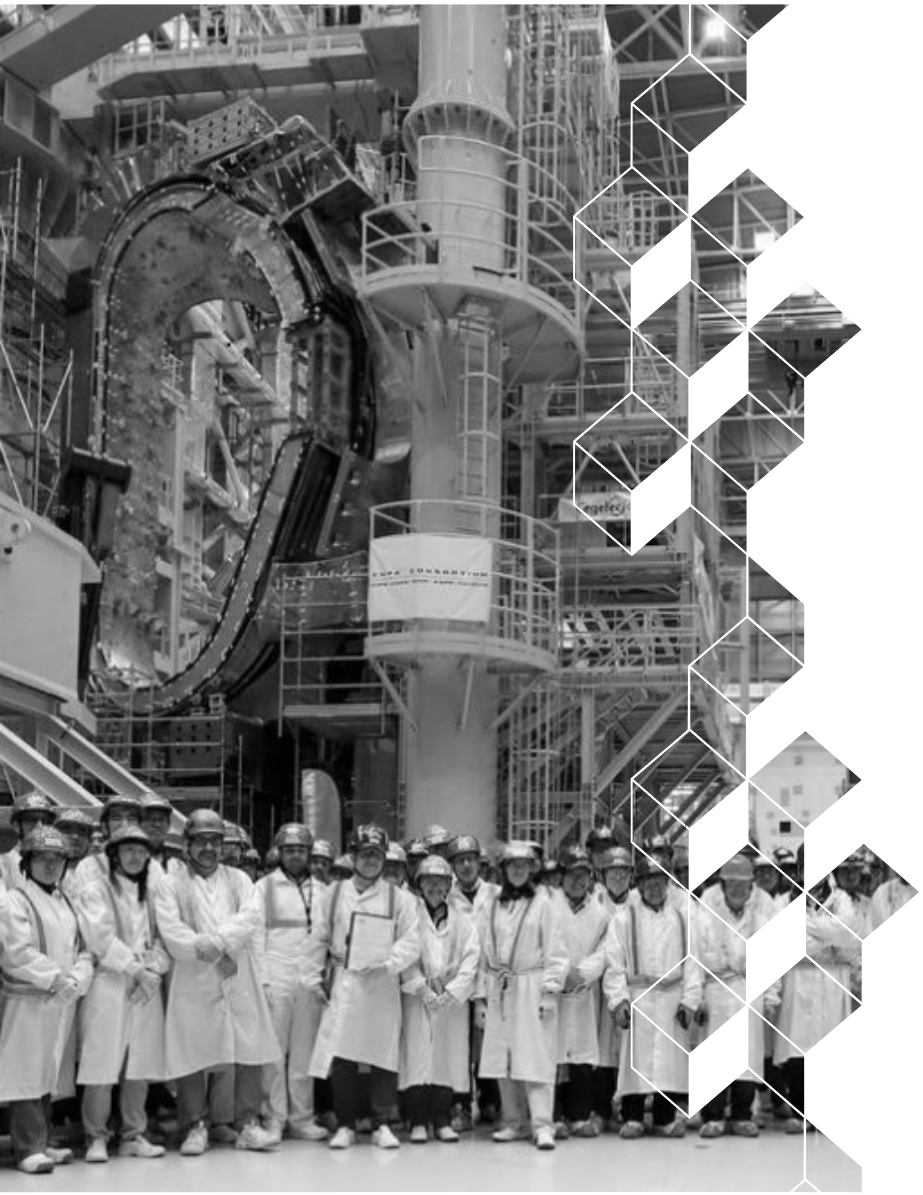
Partnership

- Put problems on the table, find together solutions
- Coordinate with the contractor on daily/weekly basis
- Upfront agreement on target dates with short and long term look ahead approach

2. ITER Machine Assembly –

Evolution of Contractor / IO collaboration;

Business Opportunities



Evolution of IO Contractor Collaboration

- Relationship with main contractors has evolved from stiff, prescriptive and formal, to a partnership approach where incentives are aligned with common targets

- The IO, as an organization, has matured, with now smoother flows of materials, works execution, information, and documentation

Evolution of IO Co ractor Collaboration

Contracting predicament:

- Sign early, risk of technical change, difficult to set lump sum
- Sign late, risk of insufficient time to develop & trial assembly processes & build float to manage risks

Consideration of above, together with lessons learned on early Machine Assembly works led to changes:

- **Deeper engagement of IO & Contractor senior management** (strengthened credibility & commitment)
- **Change of Project culture,** increased agility; general awareness of schedule criticality; collaborative solution focused; risk anticipation
- **Consideration of maturity of technical inputs & future roadmap, to arrive at a fair financial partnership**
- **Award of contract as lump sum only when technical inputs are mature**

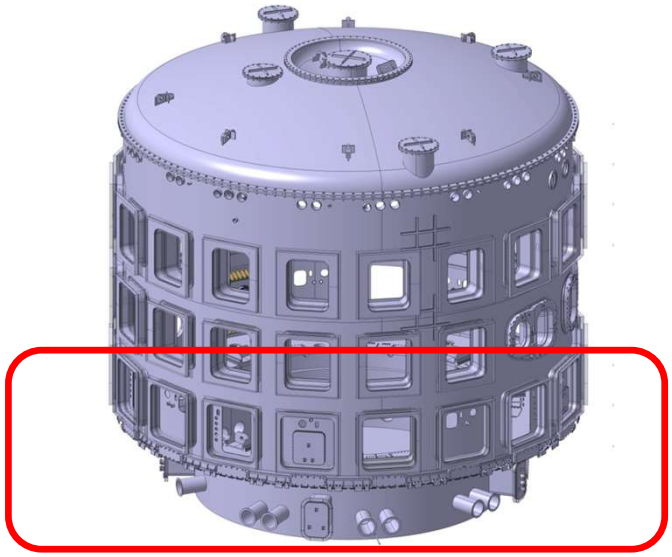
Evolution of IO Contractor Collaboration

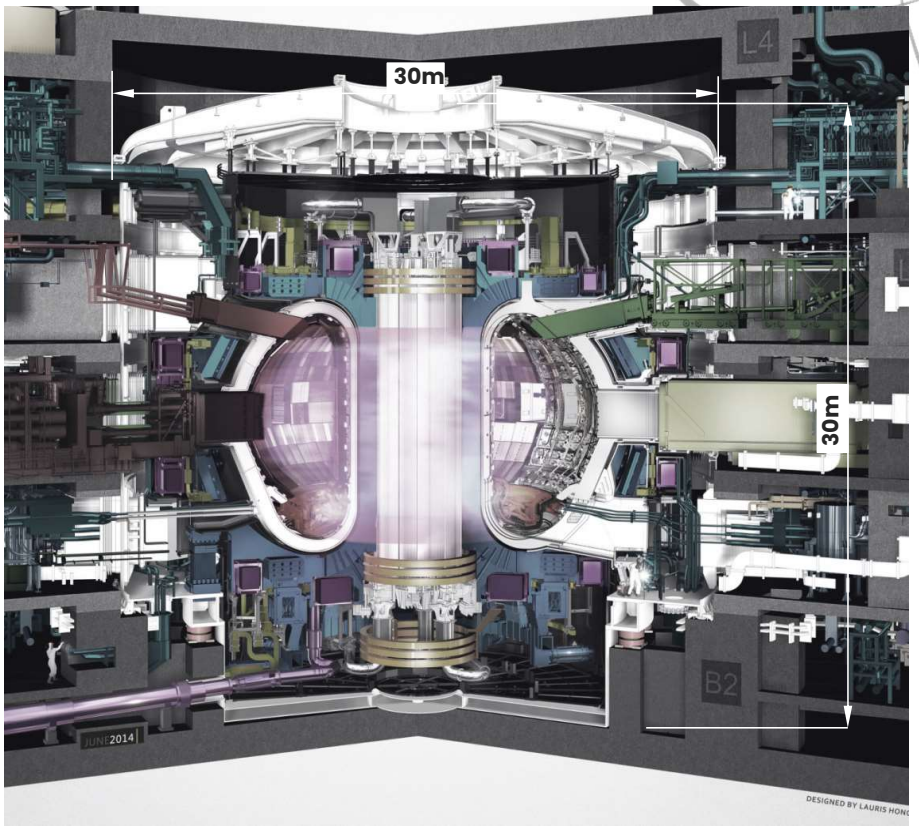
- **Involvement of installing contractor earlier in the process** -> at assembly methods & means development
- **Pooling contractor & IO resources** (save time, cost, co-own result avoiding conflict)
- **Rebalancing of IO / Contractor risk & liabilities** (Assignment of risks to party best placed to control the risk)
- **Reduction of penalties & set acceleration incentives on ad-hoc short-term basis** e.g. to recover IO delay of component hand-over
- **Monitor contract objectively on physical milestone achievement** with shared monitoring & payment files
- **Removal of third party (FIDIC Engineer)** in the contract -> Employer & Contractor only

ITER Machine Assembly: Contracts to date

Machine Assembly works commenced in 2019 with installation of the Cryostat base in the Tokamak pit, followed by…

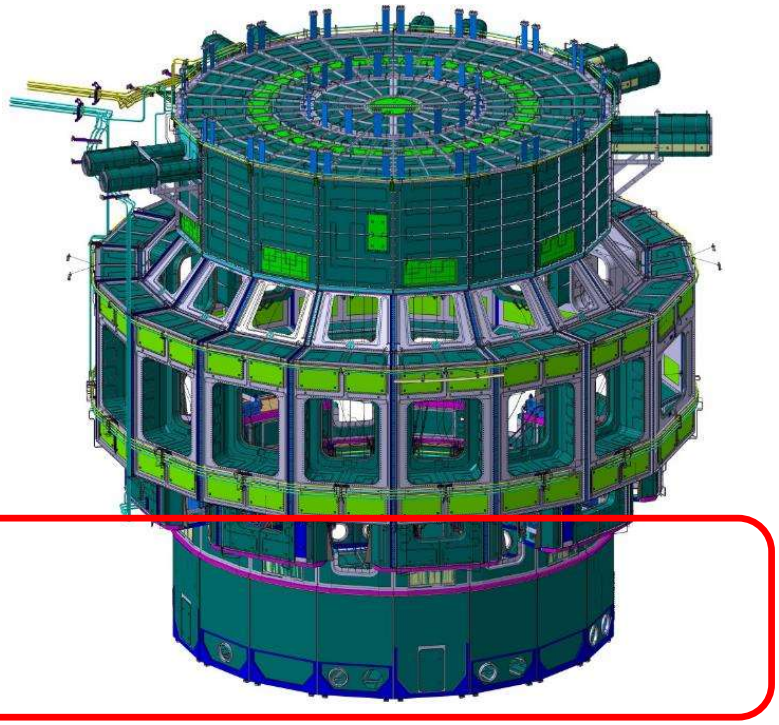
(Cryostat= Stainless steel, 4 sections: Base (1200t), lower cylinder, upper cylinder, lid)

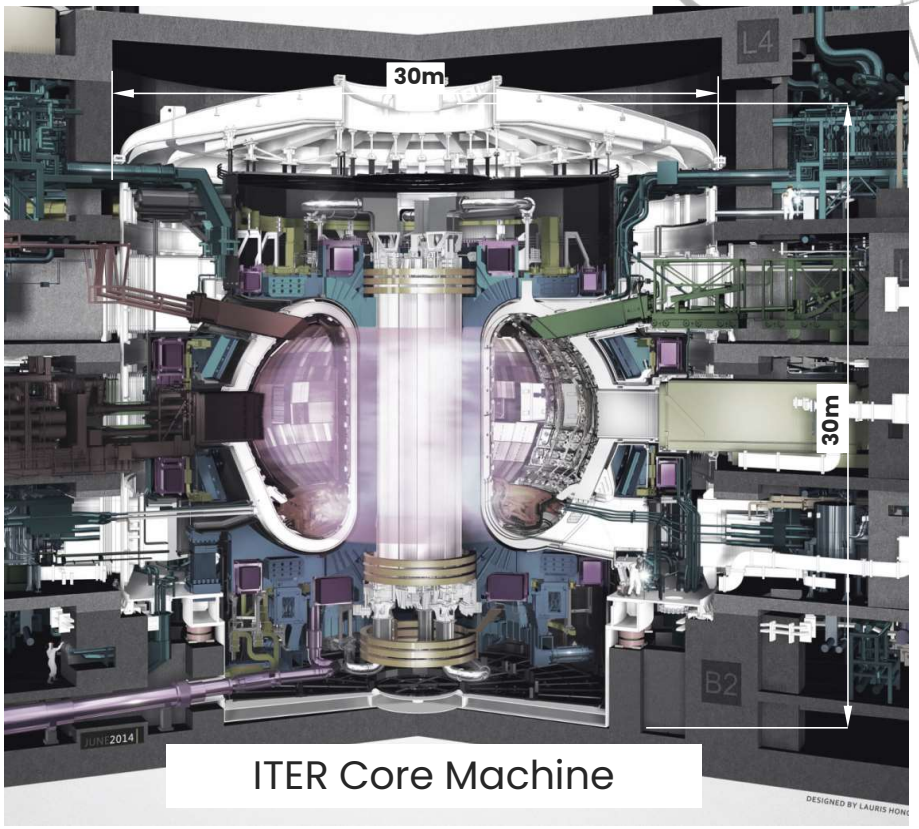




ITER Machine Assembly: Contracts to date

…Lower Cryostat Thermal Shields…



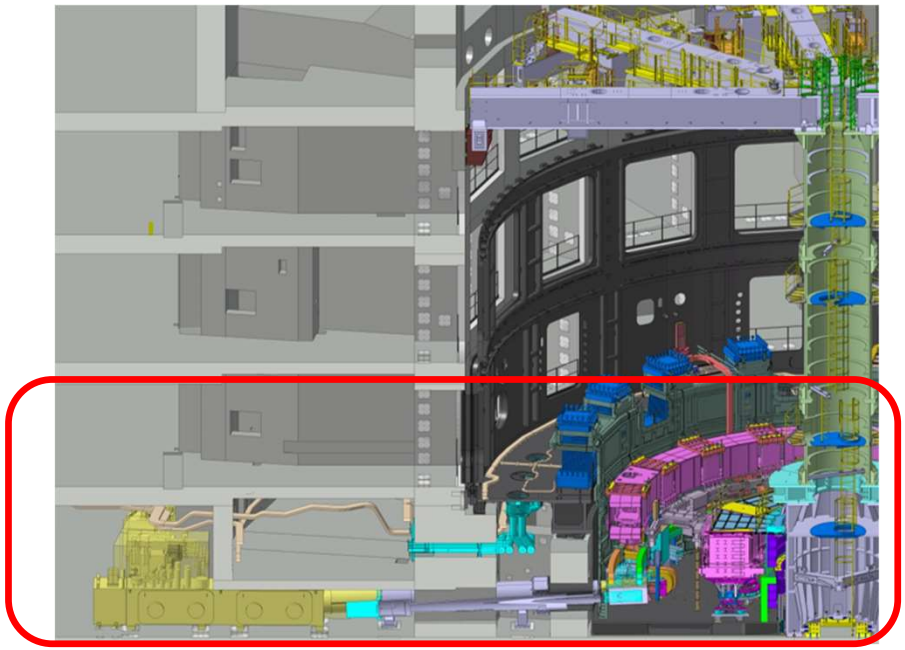


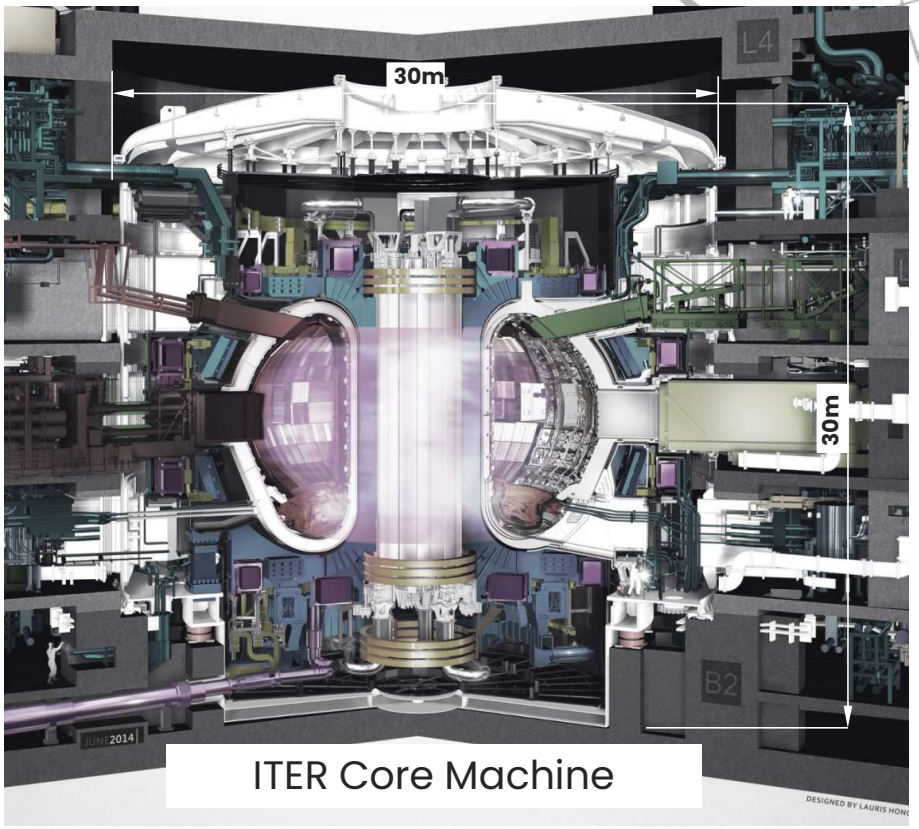
ITER Core Machine

ITER Machine Assembly: Contracts to date

…PF Super-Conducting Magnet Coils

& Feeders…

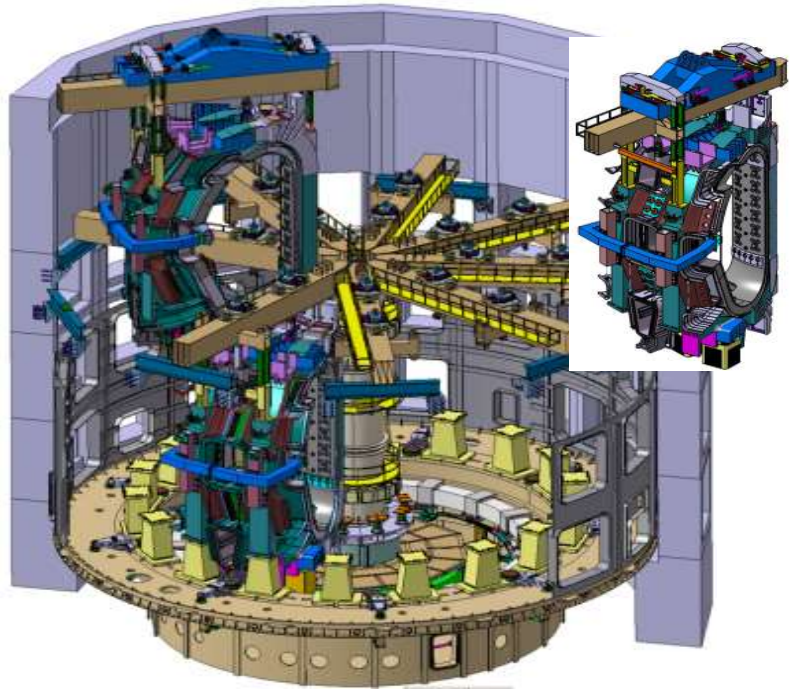


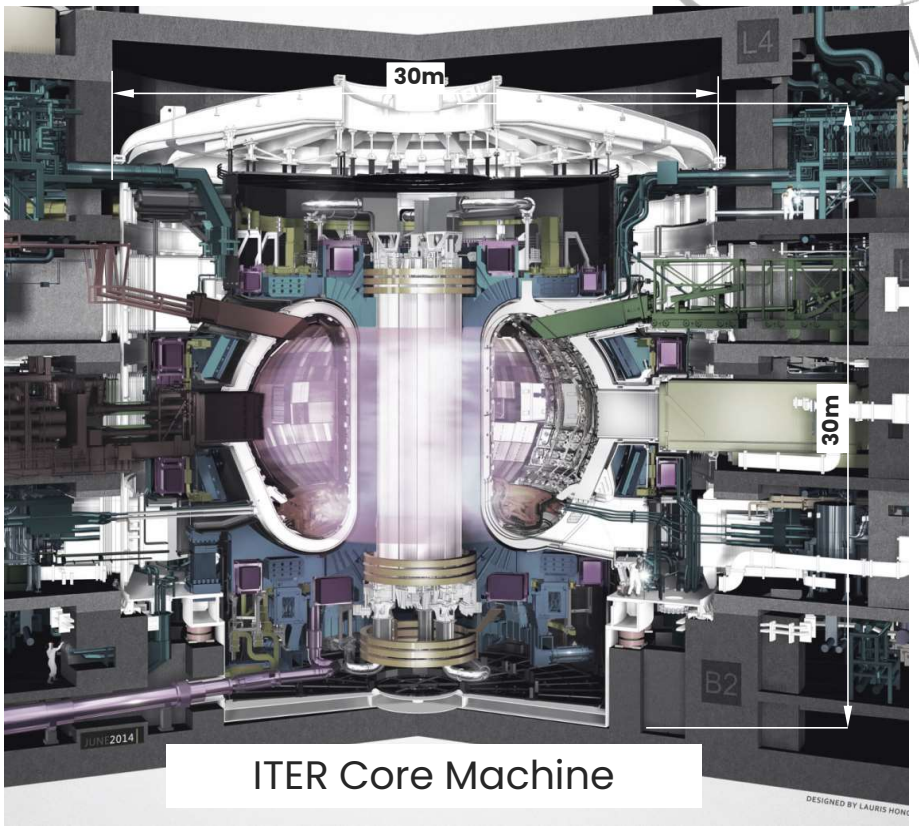


ITER Core Machine

ITER Machine Assembly: Contracts to date

…Sector sub-assembly & landing in Tokamak Pit



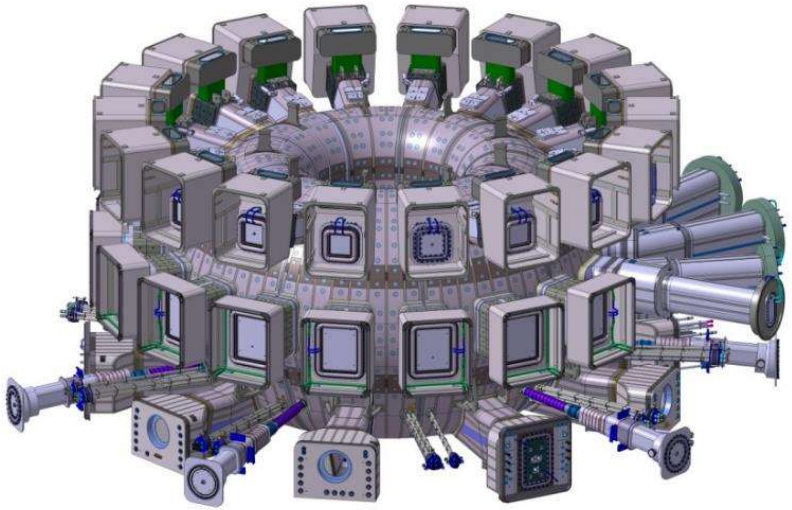


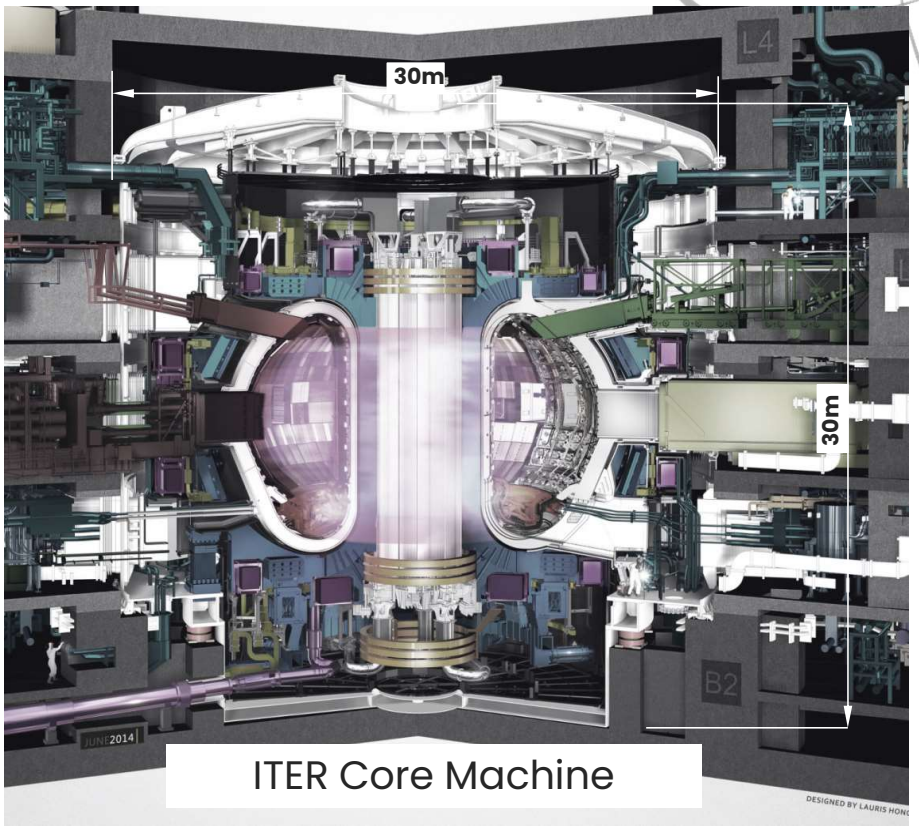
ITER Core Machine

ITER Machine Assembly: Contracts to date

Vacuum Vessel (torus) welding works under preparation

Ports & bellows welding works under preparation





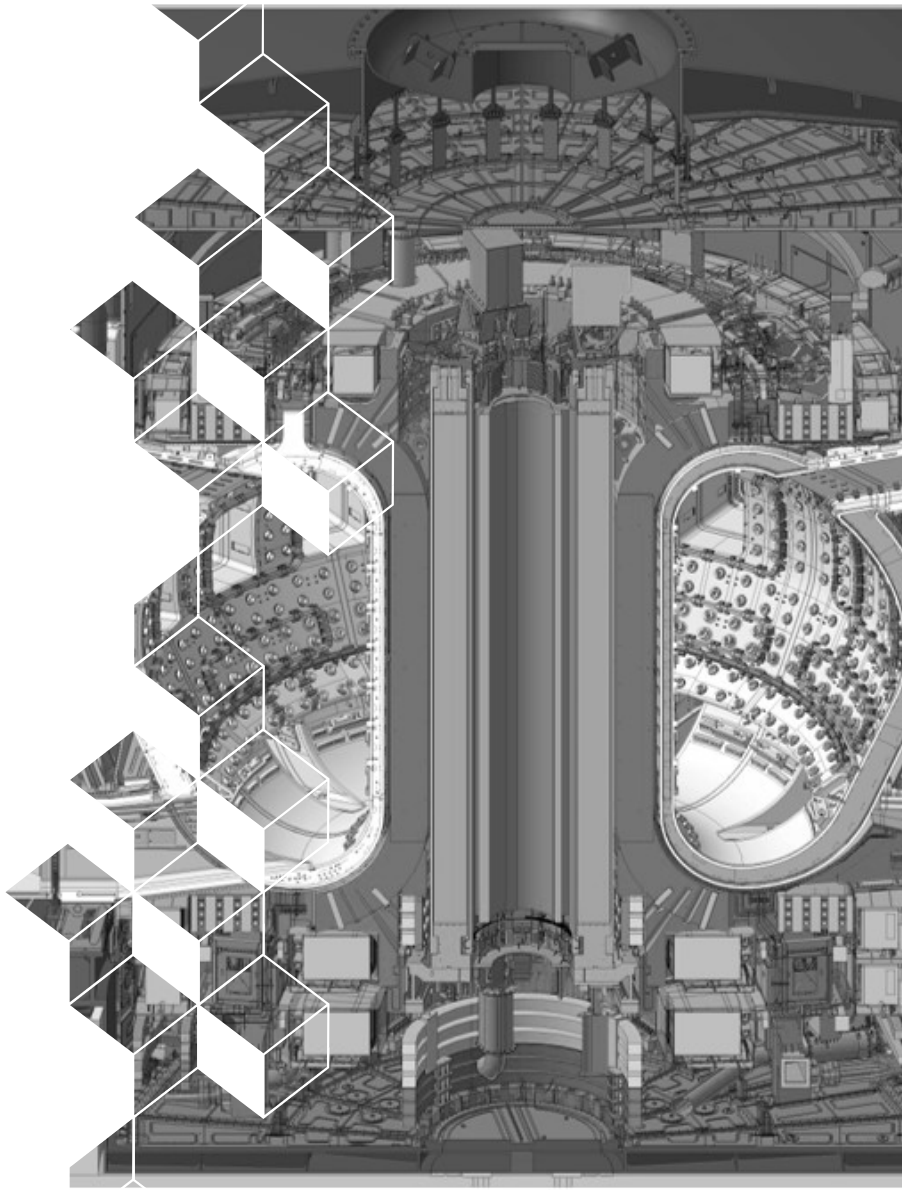
ITER Core Machine

Business Opportunities

Contracts for Machine Assembly Works & tools:

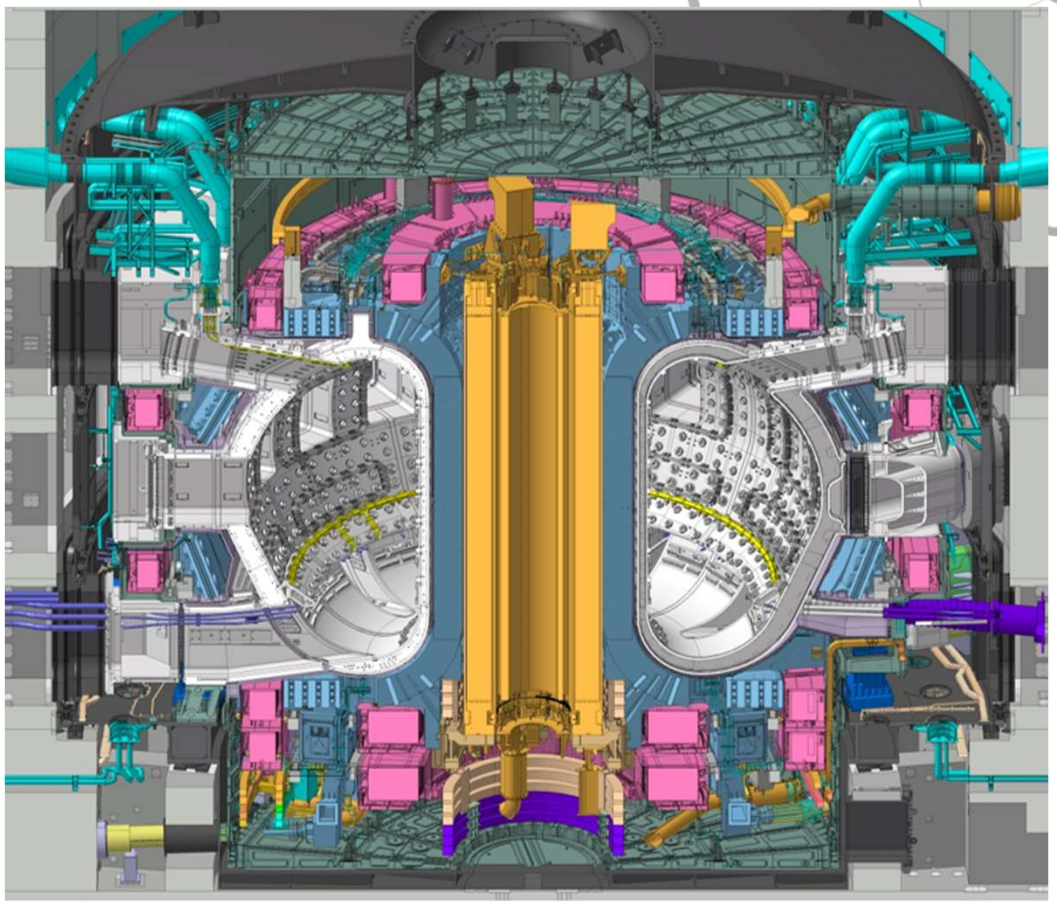
In-Vessel & Ex-Vessel through to Cryostat closure yet to be awarded.

Tenders through 2025-2027



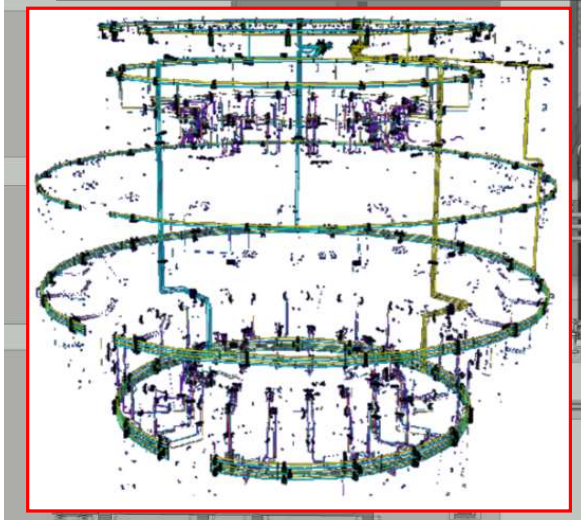
ITER Machine Assembly: Contracts to come Ex-Vessel

- **Super-Conducting Magnets**
  - All In-Cryostat Feeders (21+10)
  - PF Coils (6)
  - Central Solenoid (CS)
  - Correction Coils (18)
  - Magnet Structures cooling pipes and instrumentation
- **Cryostat**
  - (Upper Cylinder, Top Lid, Closures, NB liners/shielding, Instrumentation)
- **TCWS** (IBED, PHTS, Divertor Pipes) – under tender
- **Thermal Shields** (TS & TS Manifolds and connecting pipes)
- **Vacuum Pumping** (6+2 Cryo pumps),
- **Cable trays**
- **Diagnostics** – all penetrations between VV and Cryostat



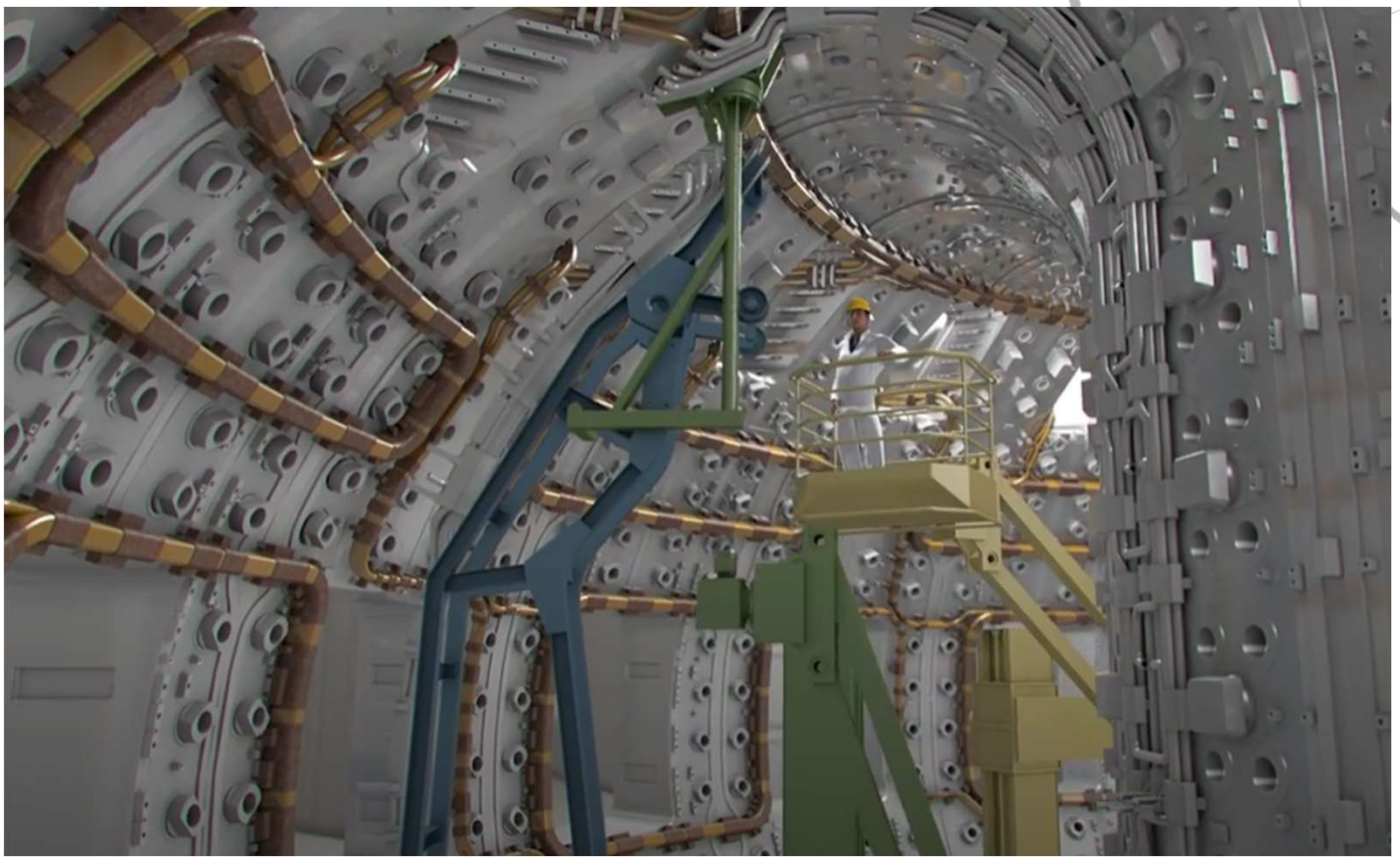
Thermal Shields, TS Manifolds and Connecting Pipes

TS Manifolds and Connecting Pipes

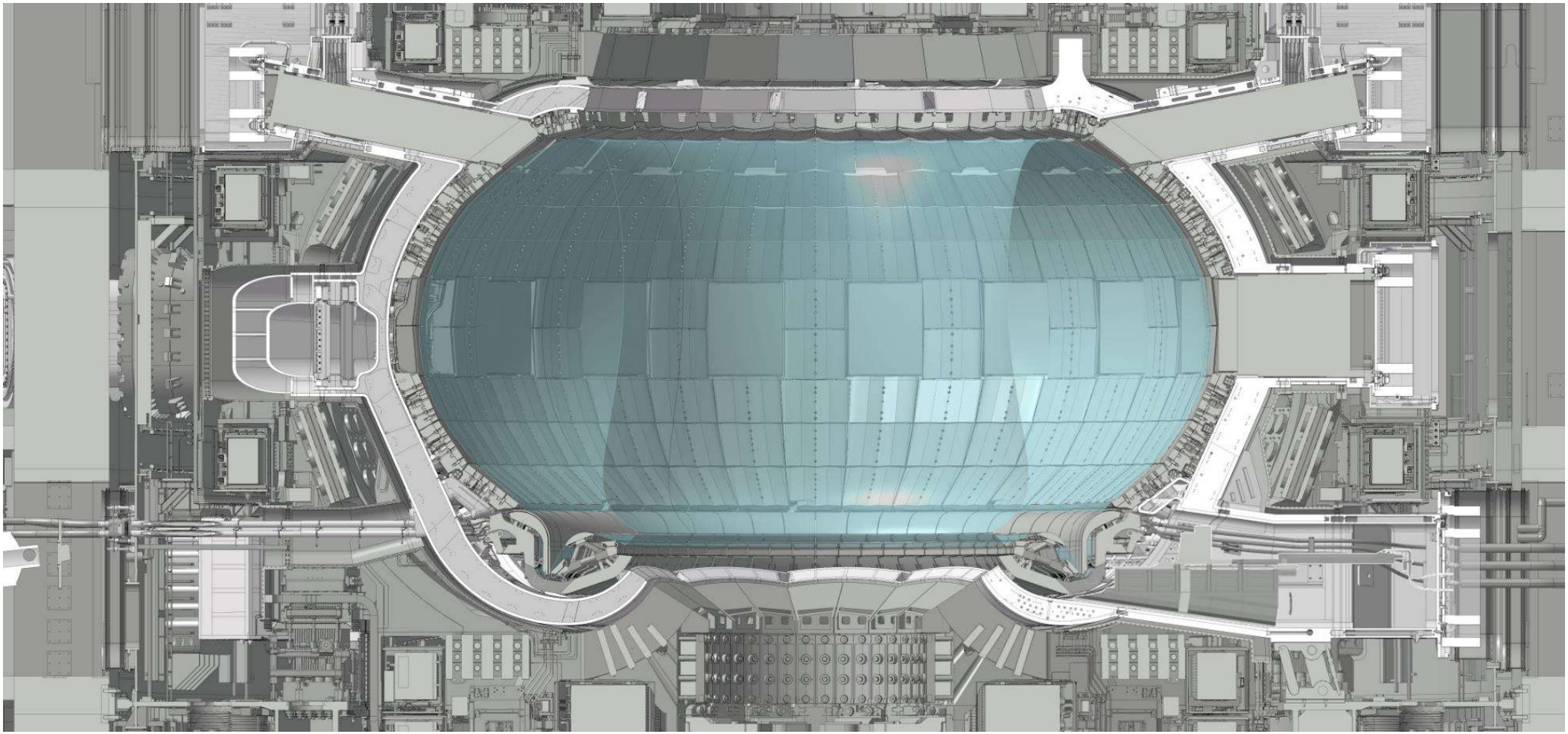


ITER Machine Assembly: Contracts to come In-Vessel

- In-Vessel Diagnostics
- In-Vessel Coils
- Lower port shielding
- Blanket Manifolds System
- Blanket & Shield Blocks
- Divertor
- Port Plugs



In-Vessel Assembly & Cryostat Closure



Business Opportunities

In addition to involvement as a main installing Contractor, many other opportunities exist

We encourage those present to make these connections through the IBF

The IO is also happy to facilitate this contact

Other services: compliance; supply chain & logistics; inspections, labs & testing; cleaning support services (air-locks, clean rooms etc.); minor machining, tooling; repair & maintenance eservices; engineering services; planning services; Metrology services; Reverse Engineering; Radiographic Testing. Specialized manpower (technical manpower) & non-technical (area cleaning; basis preservation, tool handling etc.). Scrappage opportunities (materials no longer needed), Lifting supplies, etc.

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THANKS

TO BE PART OF THE WORLDWIDE **FUSION** NETWORK

PLATINIUM SPONSOR SILVER SPONSOR SILVER SPONSOR BRONZE SPONSOR

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ITER Core Machine Assembly – Contractor Perspective

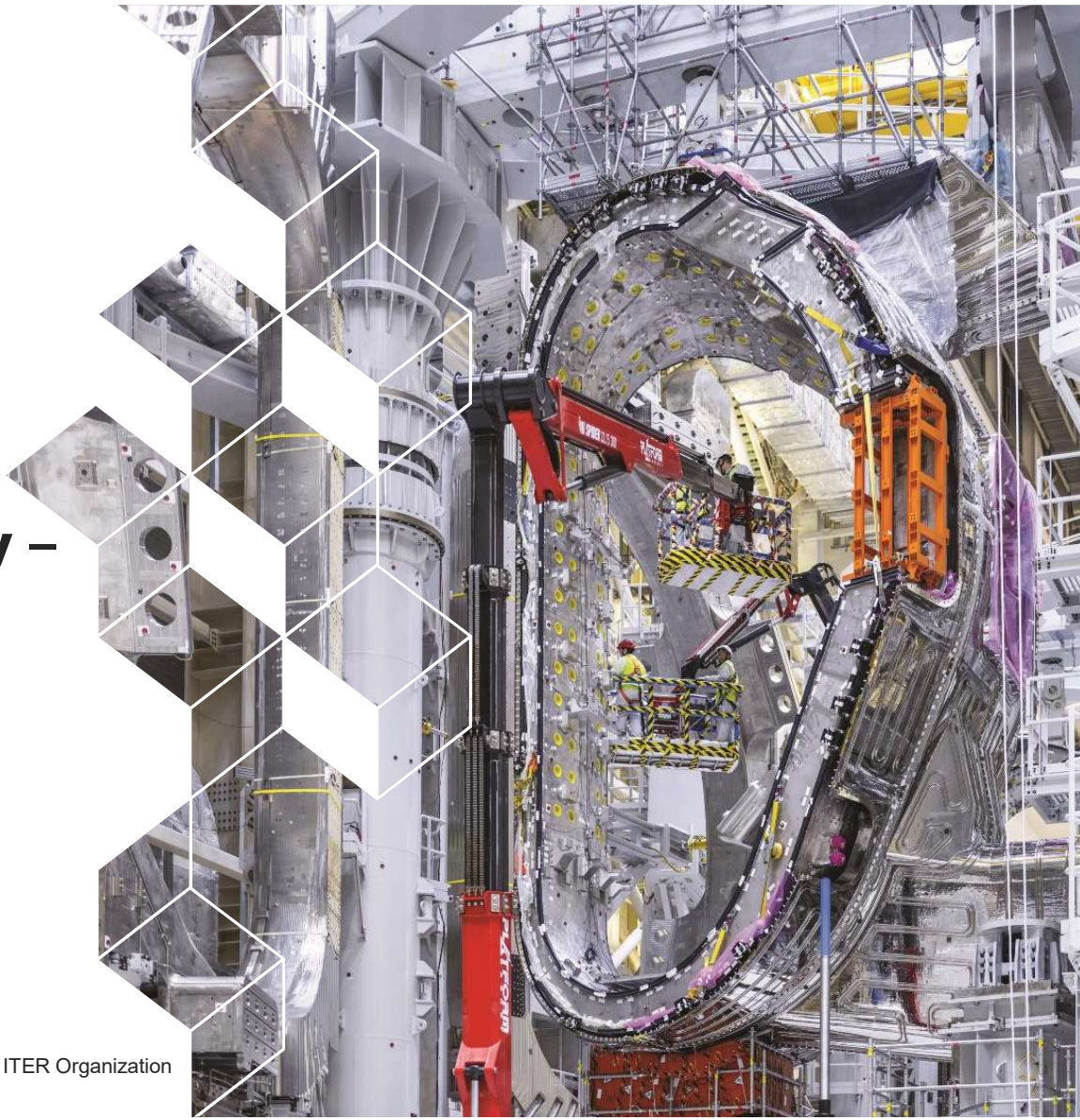
Peng WANG,

CNPE, Project Manager

Pamir Arican,

SIMIC, Project Manager

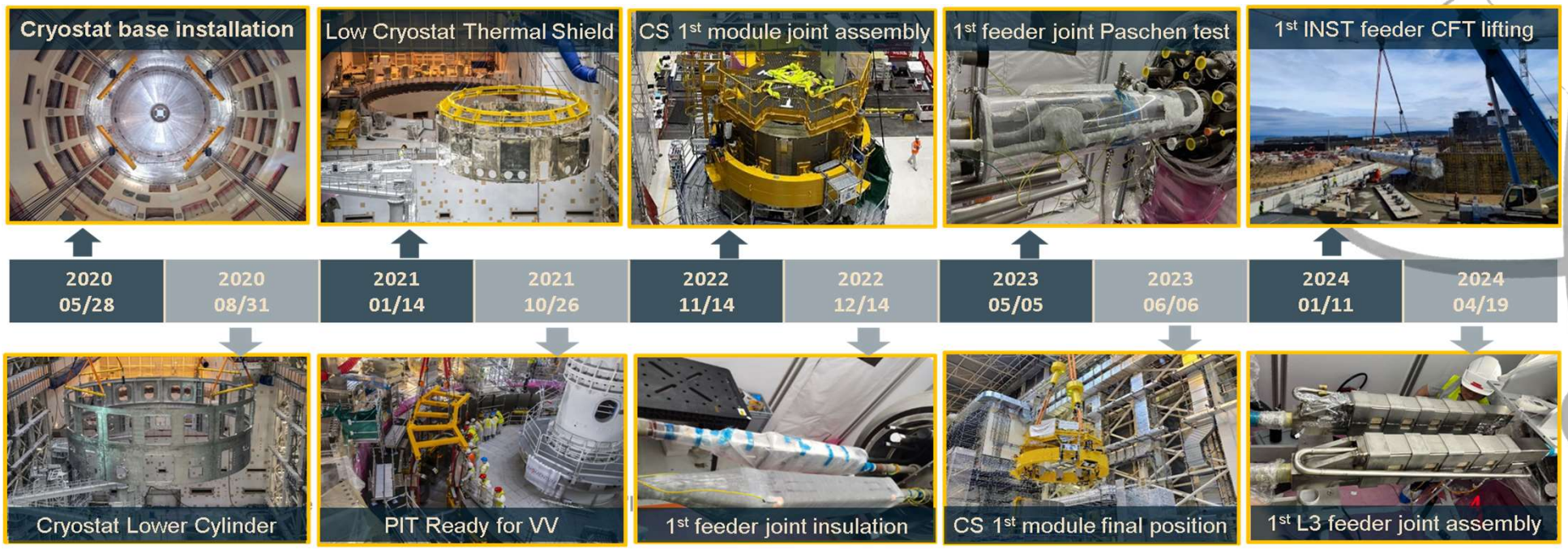
WEDNESDAY APRIL 23rd



ITER – TAC-1 Contract

CNPE CONSORTIUM
CNPE · CNI23 · SWIP · ASIPP · framatome

- As a **major contractor** for Machine Assembly activities at ITER, CNPE Consortium recognizes that collaboration is **fundamental** to achieve the stringent technical, safety, and scheduling requirements of this **first-of-a-kind** international nuclear project.
- Through close collaboration with the IO, the CNPE Consortium has successfully achieved **a series of critical milestones with outstanding precision and quality**. Notably, the project has **surpassed 1,800 days without a Lost Time Injury** — a remarkable accomplishment. From our perspective, collaboration is not merely an option — **it is mission-critical to achieving success**.
- This partnership approach characterized by **open communication, technical knowledge sharing, and operational integration**, which continues to be a **key enabler** for the success of the ITER Machine Assembly works.



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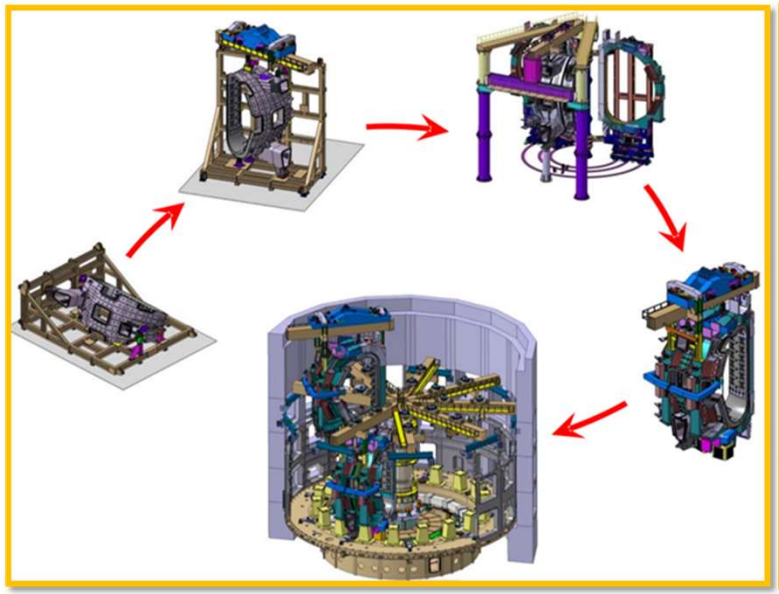
ITER - SMSA Contract

CNPE CONSORTIUM
CNPE · CNI23 · SWIP · ASIPP · framatome

- One of the most significant challenges was the ambitious **seven-month schedule** to assemble the first **Sector Module (SM7)**. Thanks to **effective collaboration**, **CNPE with his industrial partners Framatome and SIMIC,** successfully completed the **SSAT work for SM7 on March 28th**.
- CNPE and IO implemented a **quick decision system** and maintained a **dedicated field engineering team** capable of resolving minor issues rapidly on site.
- A **jointly developed Integrated Planning and Scheduling (IPS) system** between IO and CNPE allowed transparent tracking of activities, timely adjustment to priorities, and stronger coordination, helping to push forward the project's critical path.
- **Collaboration at ITER is built on trust, transparency, and shared responsibility**. We are committed to working hand-in-hand with the IO and all partners to deliver the Machine Assembly works **safely, efficiently, and to the highest standards of excellence**.



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Simic's Role in Critical Assembly Phases

SCOPE: Assembly of the Intercoil Structures

- Simic is leading the precision installation of intercoil structures—critical components that ensure the stability and performance of TF Coils in the Machine Assembly Programme. This includes precise metrology surveys and custom machining to fit tight tolerances.
- Under the SMSA contract, Simic prepares Sector Modules before installation in the PIT. SMPA continues the assembly inside the PIT between adjacent modules. Both scopes are critical to the Machine Assembly Programme.

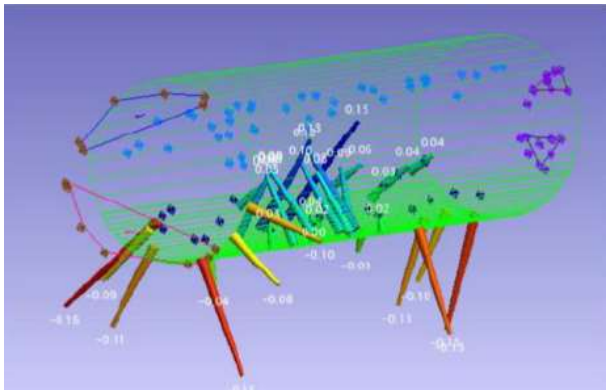
KEY OBJECTIVES:

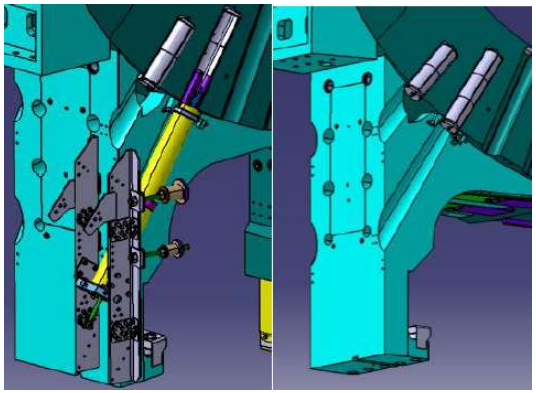
Schedule:

- SMSA Timeline: 2024 –2027 to complete the work for 9 Sector Modules on SSAT
- SMPA Timeline: 2025 –2028 to complete the work for 9 Sector Modules in PIT

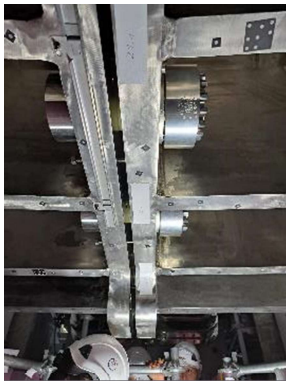
Objectives:

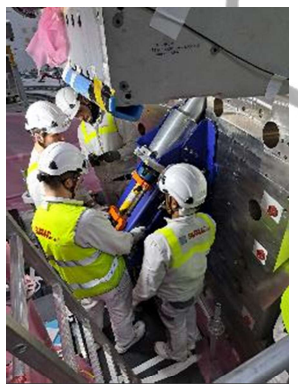
- Hit the schedule milestones to secure Machine Assembly Programme critical path
- Deliver high quality components meeting the needs of tight tolerances for a smoot execution on site

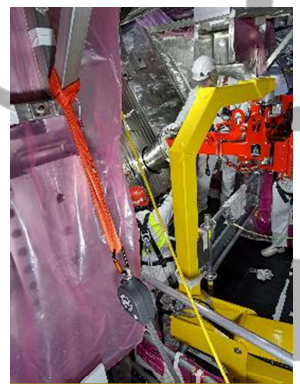




From Engineering







To Execution

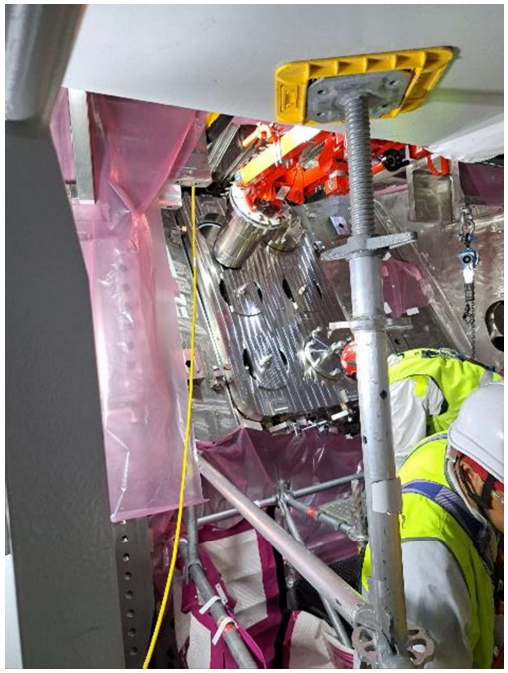
Achievements on the first Sector

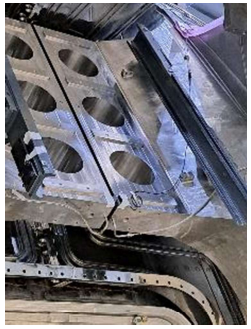
ACHIEVED MILESTONES:

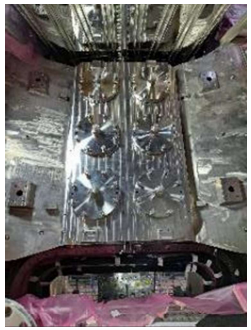
- First Sector Module started late December 2024
- Achieved the first intermediate milestone of TF Coils load transfer by first week of February 2025**, 4 weeks ahead of schedule**
- Completed the full intercoils assembly of by mid March 2025, **with zero critical issues on quality and safety, 6 weeks ahead of schedule**

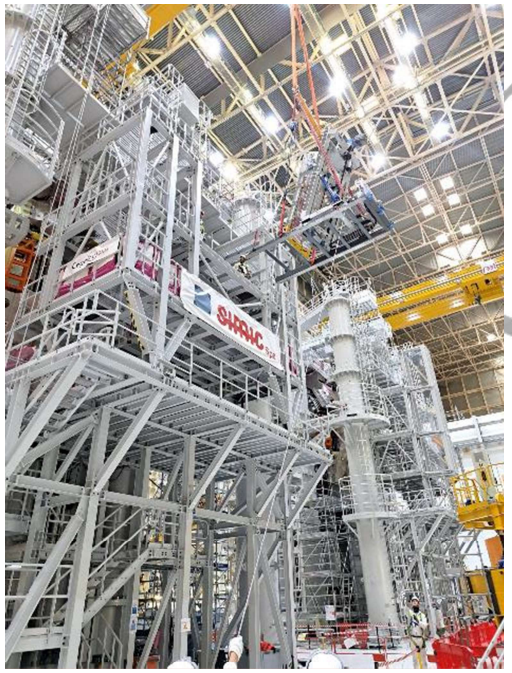
RESULTS:

- Baseline schedule for the first sector reduced by **more than 10 %**
- Achieved full compliance with the technical and quality requirements









Collaboration: How We Worked Together

COLLABORATION & KEY ENABLERS OF SUCCESS :

- Regular alignment meetings and open communication.
- “No Blame Culture”: Encouraging a transparent way of problem identification and solution
- Shared commitment to quality and delivery of all parties: Iter Organization, Momentum, CNPE, Framatome, Simic resources, focused on the same objectives of delivery, moving forward together.
- Clear roles and shared responsibilities. All parties were aware of their roles and duties, while acknowledging that the responsibility of meeting deadlines were shared

The successful completion of the first Sector Module was made possible thanks to the collaboration between CNPE, Framatome and SIMIC with the support of the Iter Organization. We remain committed to the next phases.