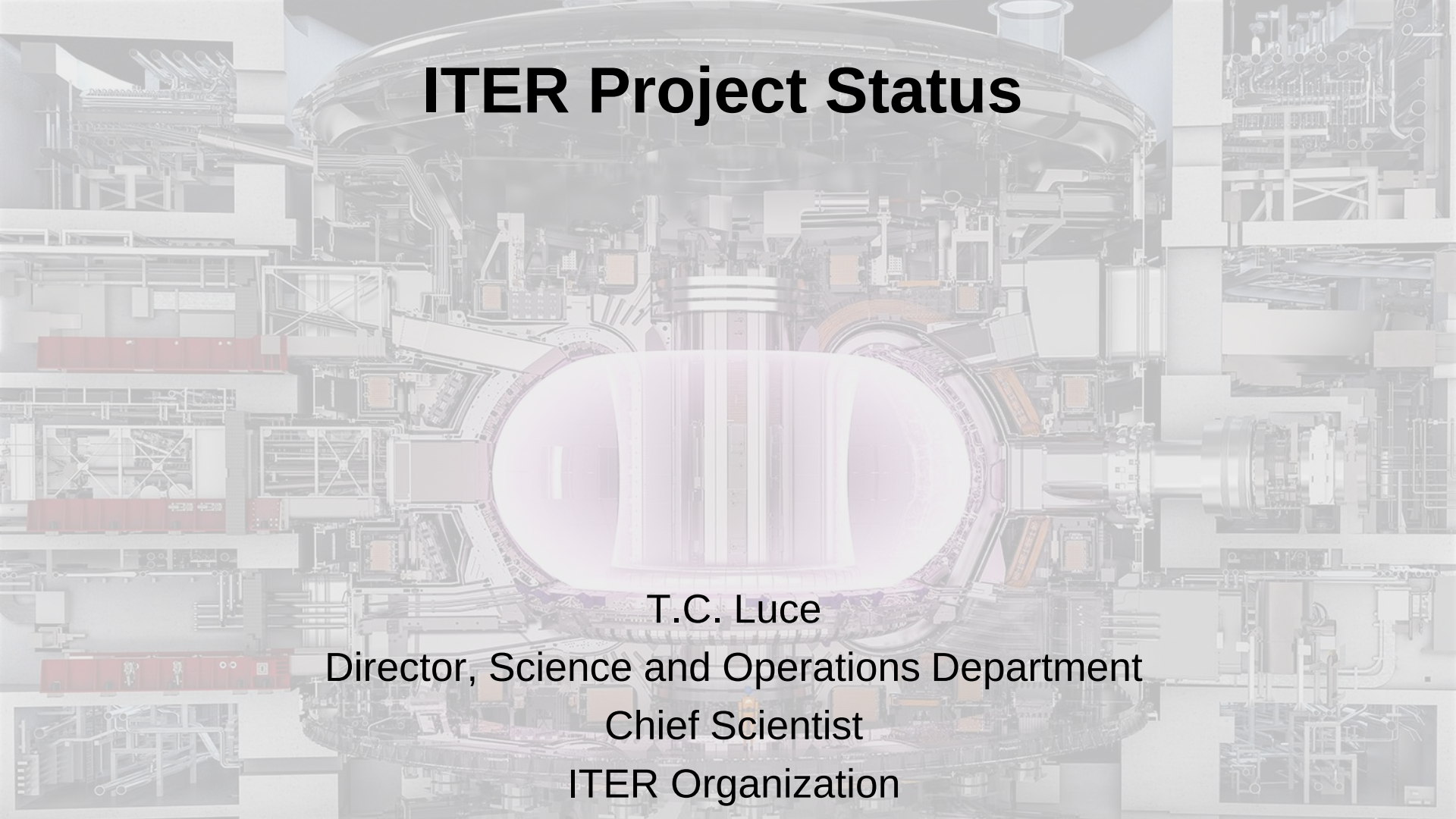
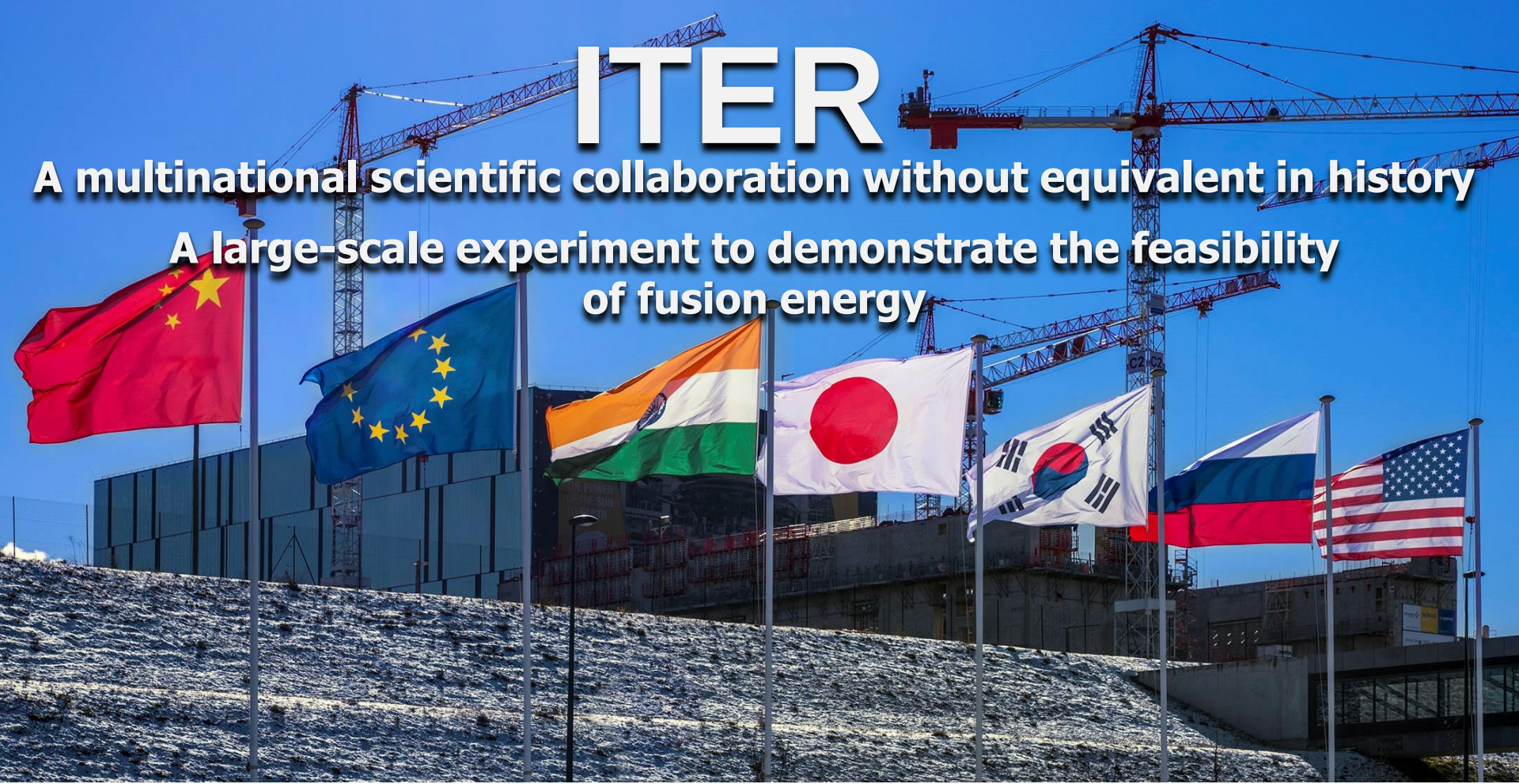
# ITER Project Status



T.C. Luce
Director, Science and Operations Department
Chief Scientist
ITER Organization





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# Fusion in the Universe

- **Fusion powers the Sun and stars.**
- **In a fusion reaction, two light atomic nuclei combine, form a heavier nucleus and release energy.**
- **The Big Challenge: to reproduce in a fusion machine (Tokamak*) a similar reaction on Earth.**

** Tokamak: a Russian acronym for « Toroidal Chamber, Magnetic Coils »*

$$\Delta E = \Delta m c^2$$

**A tiny loss of mass**
**A huge liberation of energy**


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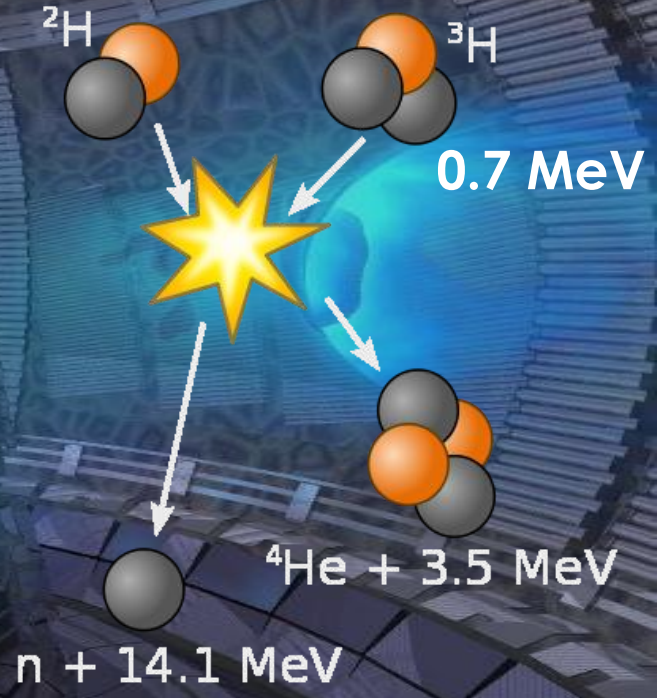
# Fusion on Earth

## 1 gram of fusion fuels = 8 tons of oil

- A plasma of Deuterium + Tritium (hydrogen isotopes) is heated to more than 150 million °C.
- The hot plasma is shaped and confined by strong magnetic fields.
- Helium nuclei sustain burning plasma.
- Neutrons transfer their energy to the Blanket.
- In a fusion power plant, conventional steam generator, turbine and alternator will transform the heat into electricity.





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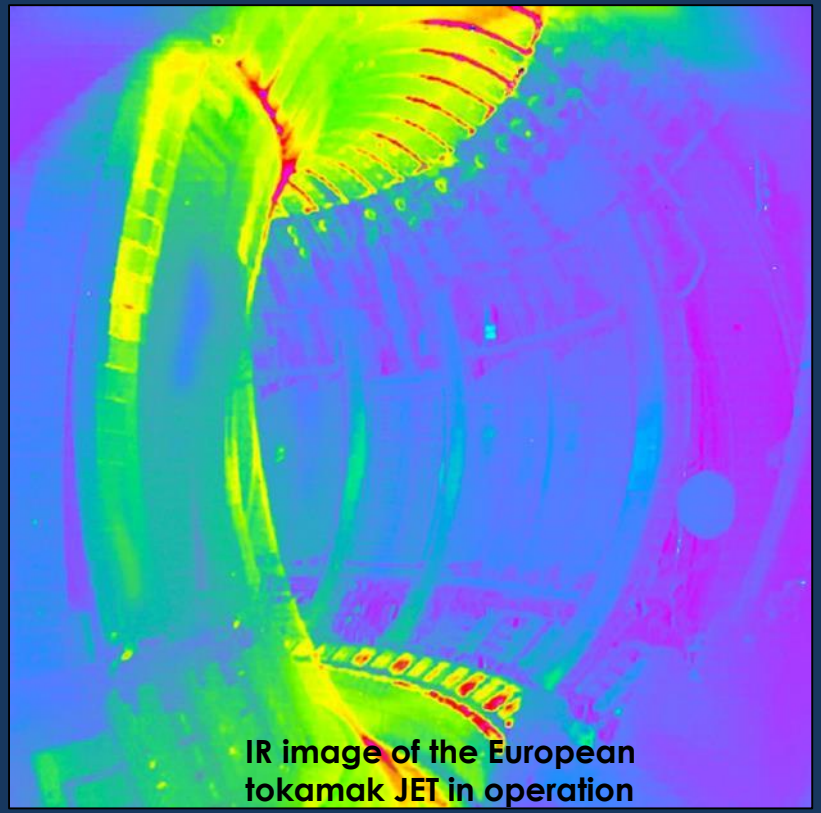
# Fusion's advantages



IR image of the European tokamak JET in operation

- A new source of energy for predictable and potentially continuous or variable power complementary to renewable energies
- Safe, environmentally responsible
- Almost limitless supply of fuel for millions of years, widely distributed around the globe
- No $CO^2$ or other greenhouse gas emission
- No production of long-lasting high-activity radioactive waste



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# ITER: from paper project to steel-and-concrete reality

**November 1985**
At the Geneva Summit President Reagan and General Secretary Gorbachev give a decisive political push to an international collaboration on fusion *"for the benefit of all mankind"…*

**August 2010**
Construction works begin in earnest.

**January 2007**
Preparation works by France (clearing, levelling, etc.) begins on the 42-hectare ITER Platform.

**Today**
Construction on the ITER site and components manufacturing by the ITER Members are progressing in accordance with the 2016 baseline.



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# An integrated project:

## Central Team & Seven Domestic Agencies

- The 7 ITER Members make cash and in-kind contributions (90%) to the ITER Project. They have established Domestic Agencies to handle the contracts to industry.
- The ITER Organization Central Team manages the ITER Project in close collaboration with the 7 Domestic Agencies.
- The ITER Members share all intellectual Property generated by the Project.



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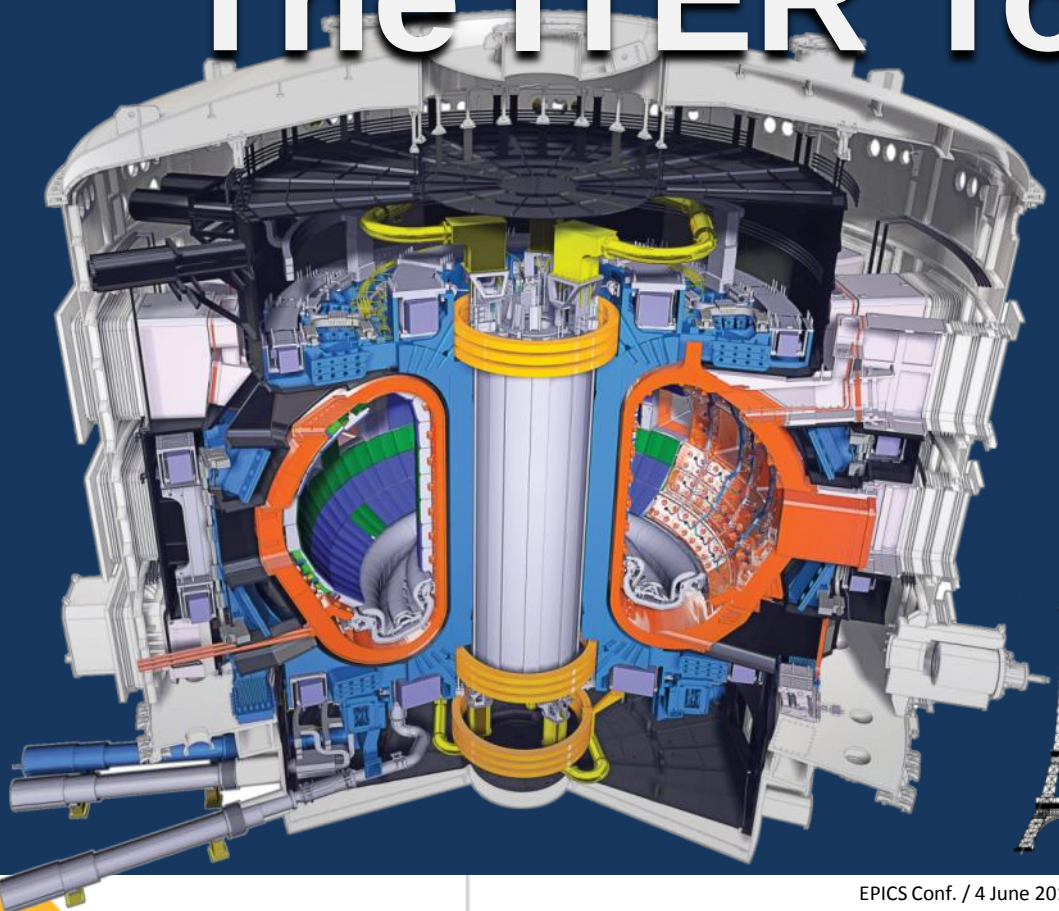
# The ITER Tokamak



**Vacuum Vessel: ~8 000 t.**
**TF Coils: 18 x ~360 t.**
**Central solenoid: ~1 000 t.**
**Total: ~23 000 t.**

**R=6.2 m, a=2.0 m**
**$I_p$=15 MA, $B_T$=5.3 T**

**3,5 times the weight of the Eiffel Tower!**



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# 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 $P_{fus}/P_{in}$ ($\equiv Q$) ≥ 10 for 300-500 s (i.e., stationary conditions)

- Aim at demonstrating steady-state operation with Q ≥ 5

- Capable of advanced operational modes and a wide operating parameter space

- Achieve the minimum cost device that meets **all** the stated requirements


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# Why These Conditions?

- Fusion power of ~500 MW is the minimum for a power plant
- Q ~ 10 is the minimum for a power plant; also dominant self-heating for deuterium-tritium fusion
- Stationary conditions imply duration is not limited by physics, but hardware investment
- Direct comparison of inductive and steady-state scenarios in burning plasmas answers a key design question for the next step
- Wide parameter range requirement avoids a ‘point solution’
- Minimum cost because … why pay more?


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# 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?**


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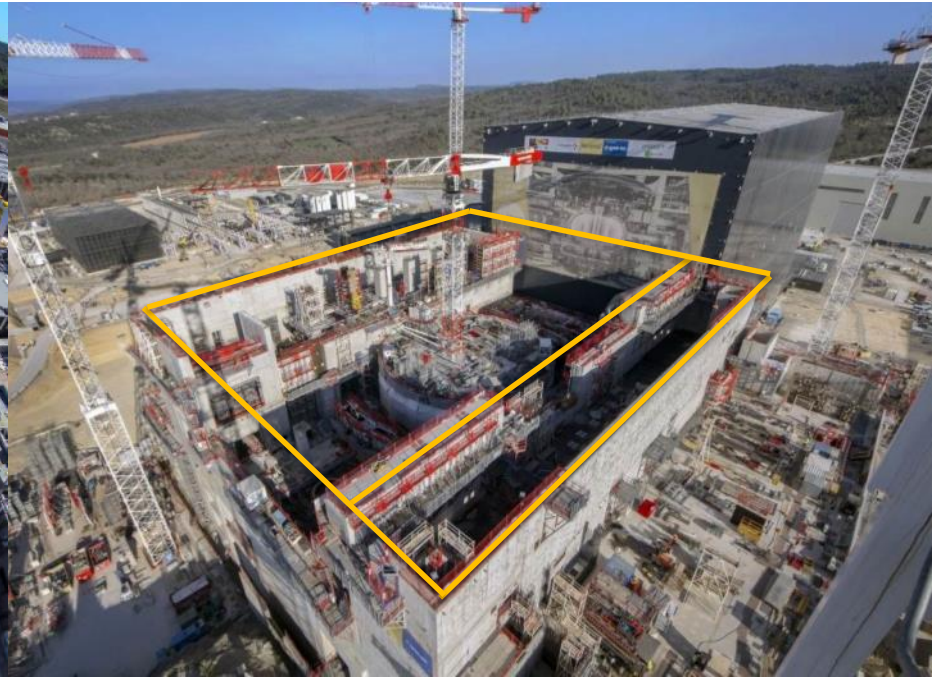
# Tokamak Complex Construction Progressing

April 2018



March 2019



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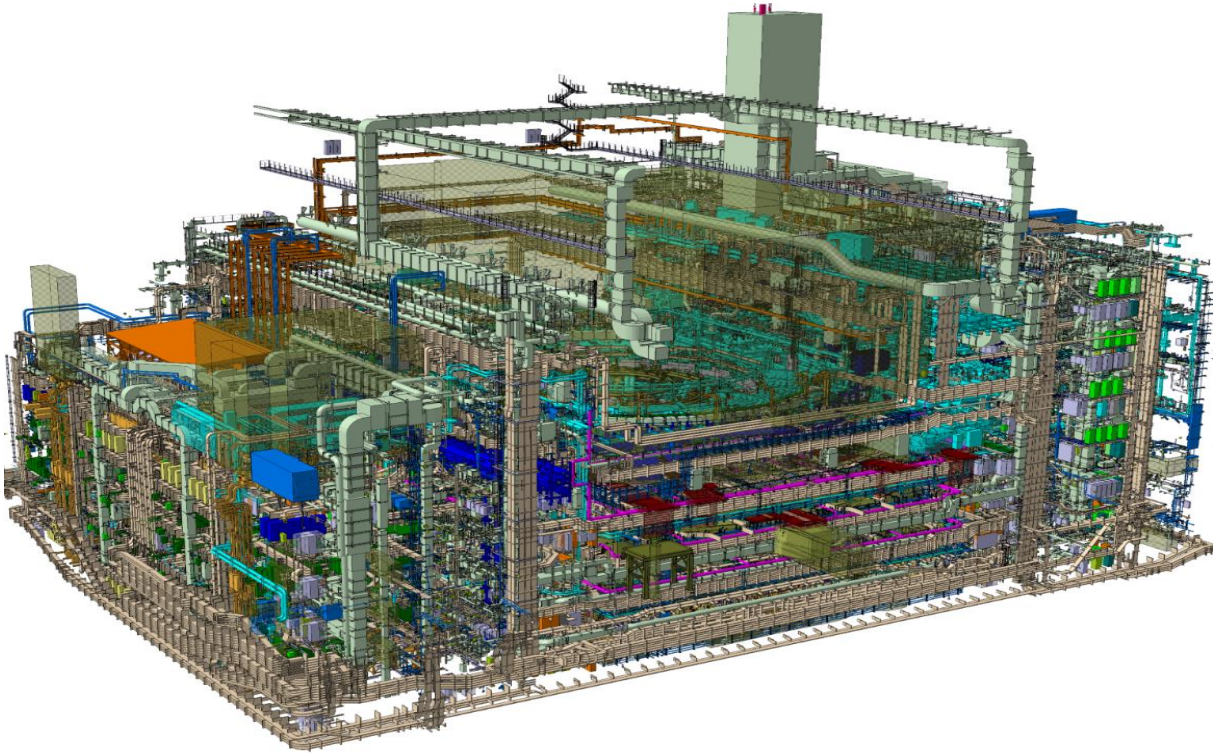
# Challenges of Assembly

- Revised construction strategy endorsed by ITER Council
  - Allows more flexibility to deal with delivery timing
  - Regulatory hold point in 2020
- Significant integration issues for installation of services in the tokamak building

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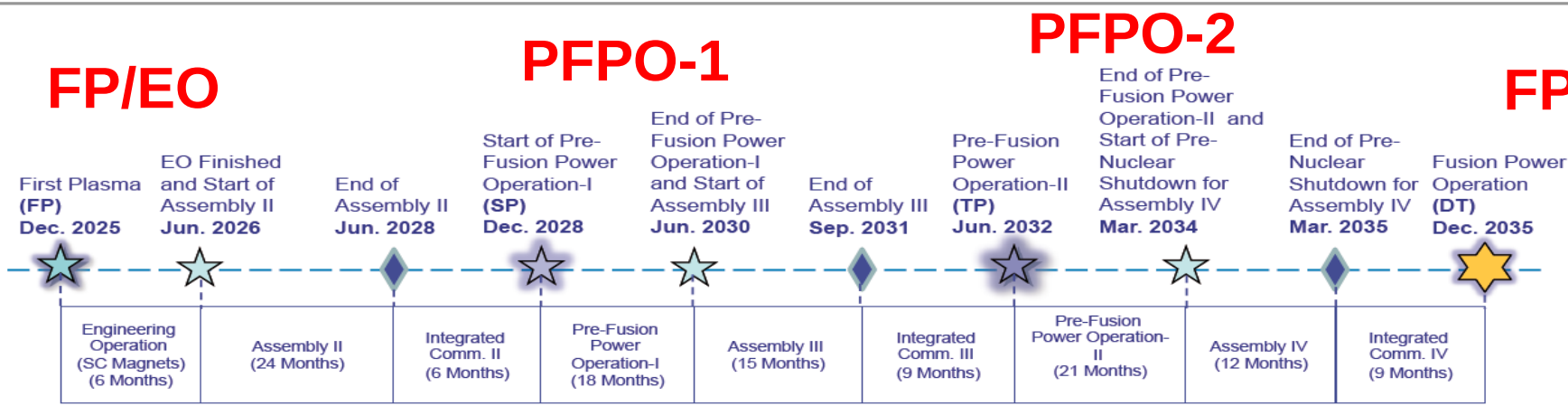
# A “Staged Approach” to Full Operating Capacity




- Extensive interactions among the ITER Organization and Domestic Agencies to finalize revised baseline schedule (2015-6)
  - Schedule estimates through First Plasma (2025) up to DT operation (2035) consistent with Members’ budget and technical constraints
- Required a new ITER Research Plan (completed in 2017)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# Challenges Ahead Until Construction Completion

- ITER Organization, Domestic Agencies and suppliers working as a team with a **strong project culture**
- Strict respect by suppliers for **quality and safety requirements**
- Strict respect by all stakeholders for the **schedule requirements**, in particular for the **required delivery dates** for materials and equipment on the ITER site
- Reliable and fully **integrated assembly/construction sequences** on ITER site
- Contracting with high-performing and experienced companies for the **assembly activities** in the Tokamak Complex
- Setting in place a well-suited organization in charge of **commissioning**
- Setting in place a well-suited organization to conceive and execute the **progressive take-over of the machine**, ultimately for its operation and maintenance
- **Timely, reliable availability of the planned and committed resources from the seven ITER Members**


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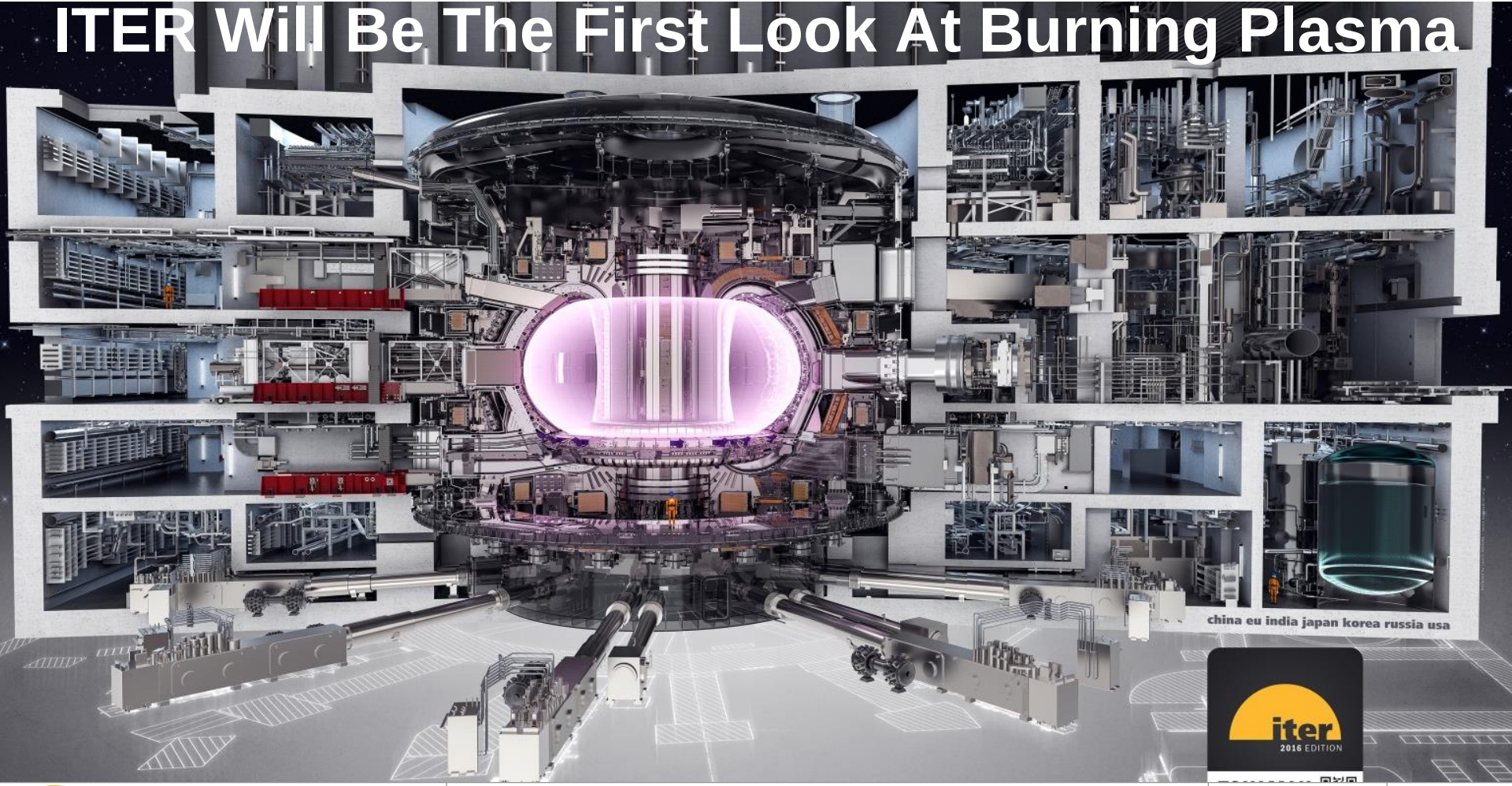
# ITER Will Be The First Look At Burning Plasma





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