FUSION FOR ENERGY

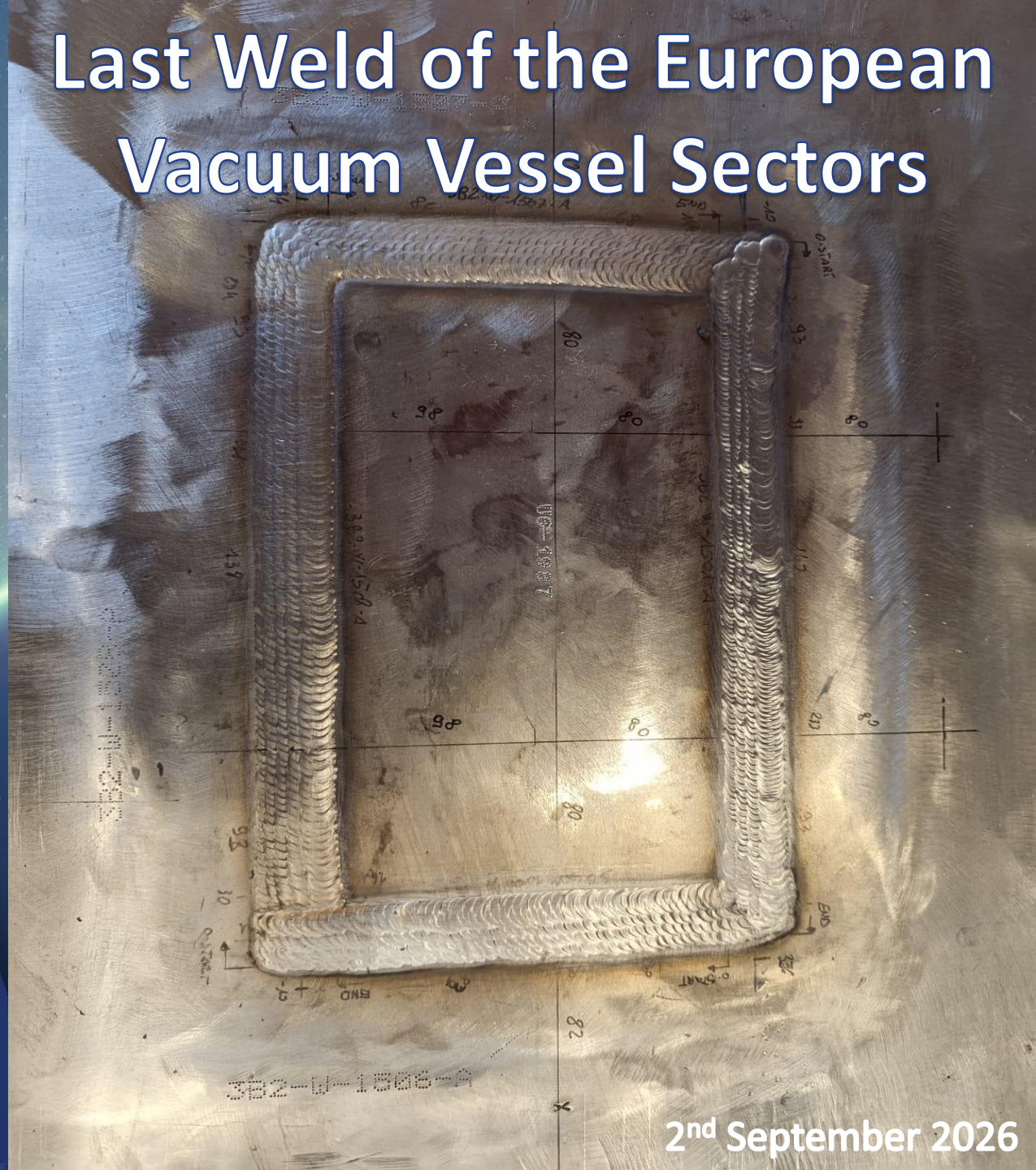
Completion of the European ITER Vacuum Vessel procurement

The VV team: F4E and IO

Ansaldo Nucleare, Westinghouse, Walter Tosto

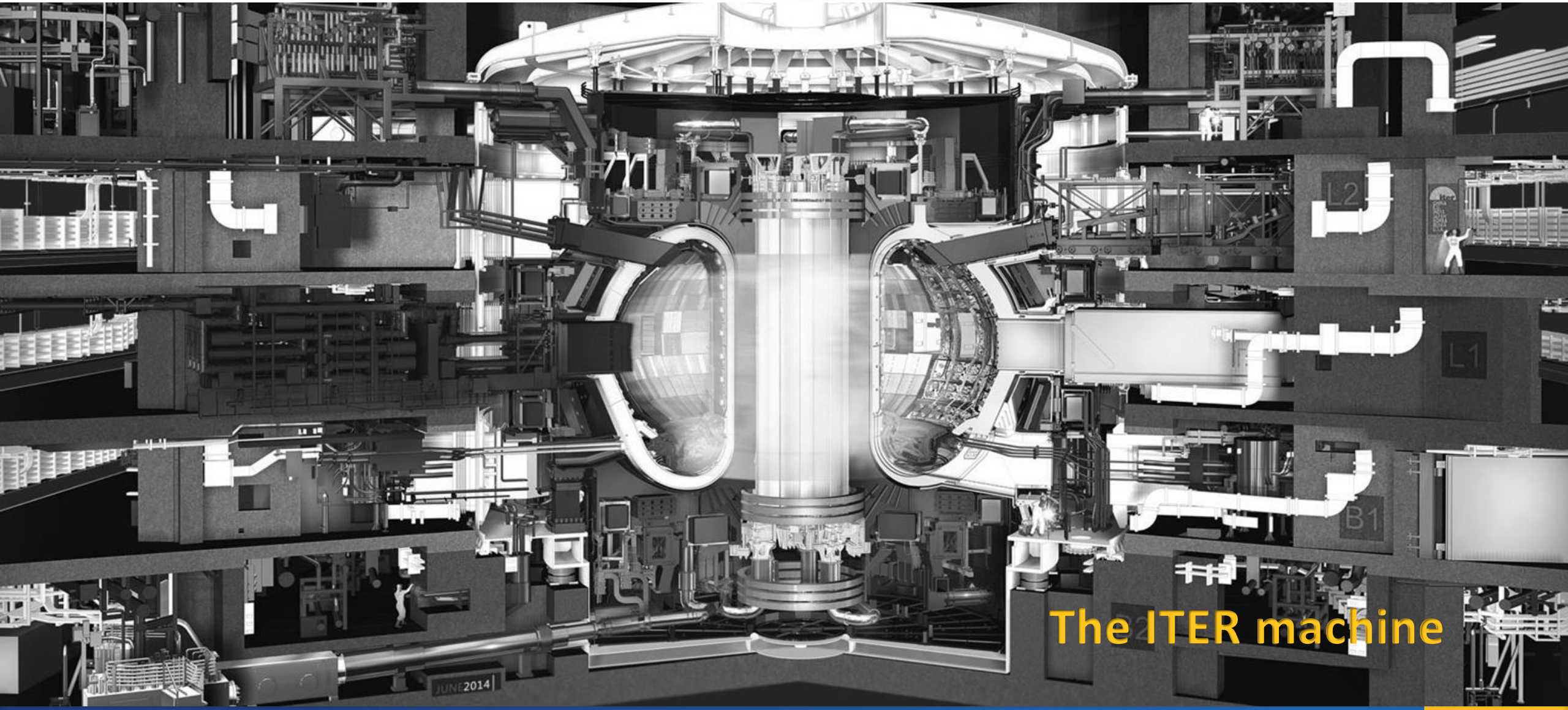
24 Sep 2026

34th SYMPOSIUM ON FUSION TECHNOLOGY
SEPT. 21-25, 2026 AIX-EN-PROVENCE, FRANCE



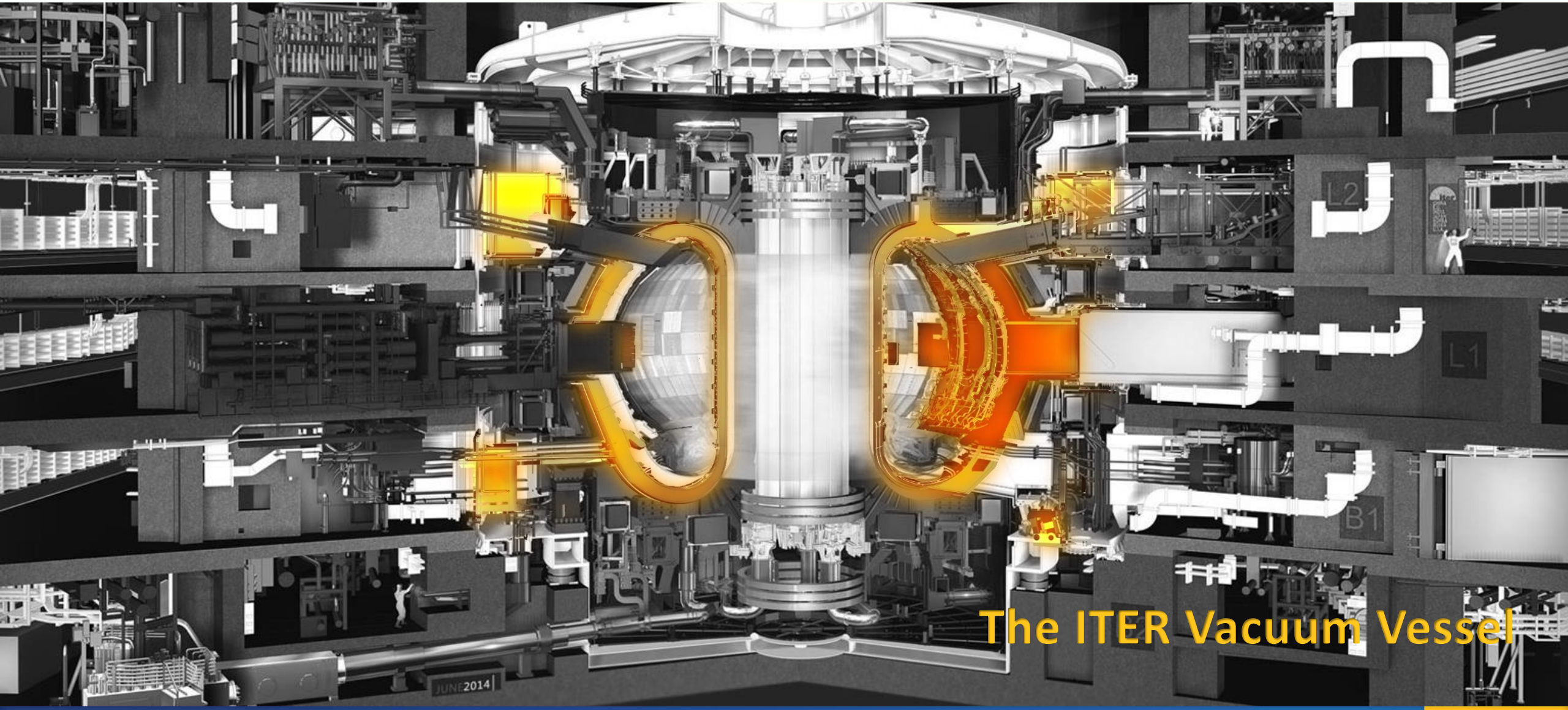
ITER and the Vacuum Vessel

FUSION FOR ENERGY



The ITER machine

ITER and the Vacuum Vessel

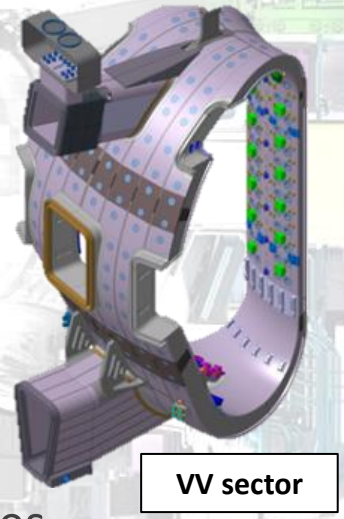


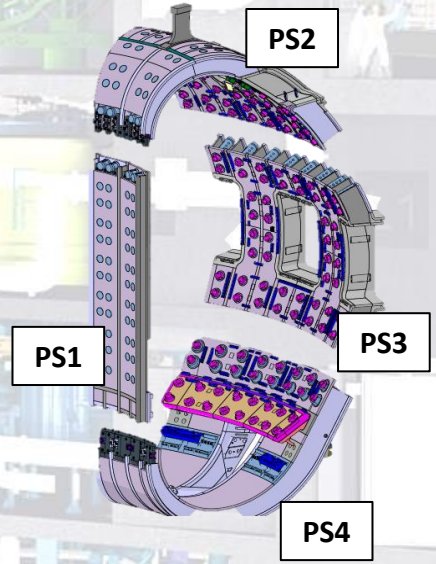
The ITER Vacuum Vessel

ITER and the Vacuum Vessel



- Provide a **high-vacuum** environment for the plasma
- Improves **radiation shielding** and plasma stability,
- 1st **Safety confinement** barrier
- Provide **support** for in-vessel components



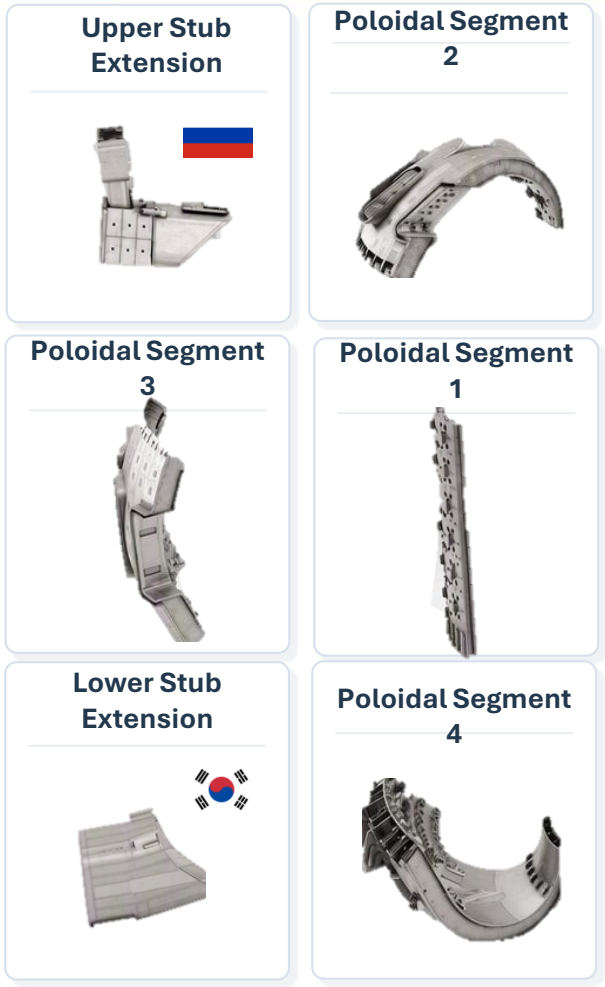


- Toroidal **Double Shell** (60 mm thick each) stainless steel structures
- **9 Sectors** each of them made **by 4 poloidal segments** (PS)
- **19.4 m** in diameter, **12 m** high, volume **1.400 m³,** Weight **5.200 tonnes**

The ITER Vacuum Vessel

Vacuum Vessel Sector







1. Segment manufacturing

2. Sector Assembly

3. Final Machining

EU Suppliers and Manufacturing

- Contract awarded by F4E to AMW consortium* in October 2010
- Main Sub supplier for Segment manufacturing: Ensa (Spain), Belleli (Italy).

	Sector 5	Sector 4	Sector 3	Sector 2	Sector 9
PS1 	Westinghouse	Westinghouse	ensa	ensa	ensa
PS2 	walter tosto	walter tosto	walter tosto	BELLELI	BELLELI
PS3 	walter tosto	walter tosto	walter tosto	walter tosto	walter tosto
PS4 	Westinghouse	Westinghouse	ensa	ensa	ensa
D-S 	Westinghouse	walter tosto	walter tosto	Westinghouse	Westinghouse
F 	Westinghouse	walter tosto	walter tosto	Westinghouse	Westinghouse

Material Procurement & Segment manufacturing

Sector Assembly

Final Machining

AMW consortium Ansaldo Nucleare (AN), Westinghouse Italy (WGI) (ex Mangiarotti), Walter Tosto (WTO)

Vacuum Vessel Sector

5 Sectors delivered in 2 years!

Vacuum Vessel Sector 5



25 Oct 24

Vacuum Vessel Sector 4



09 May 25

Vacuum Vessel Sector 9



06 March 26

Vacuum Vessel Sector 3



7th May 2026

Vacuum Vessel Sector 2

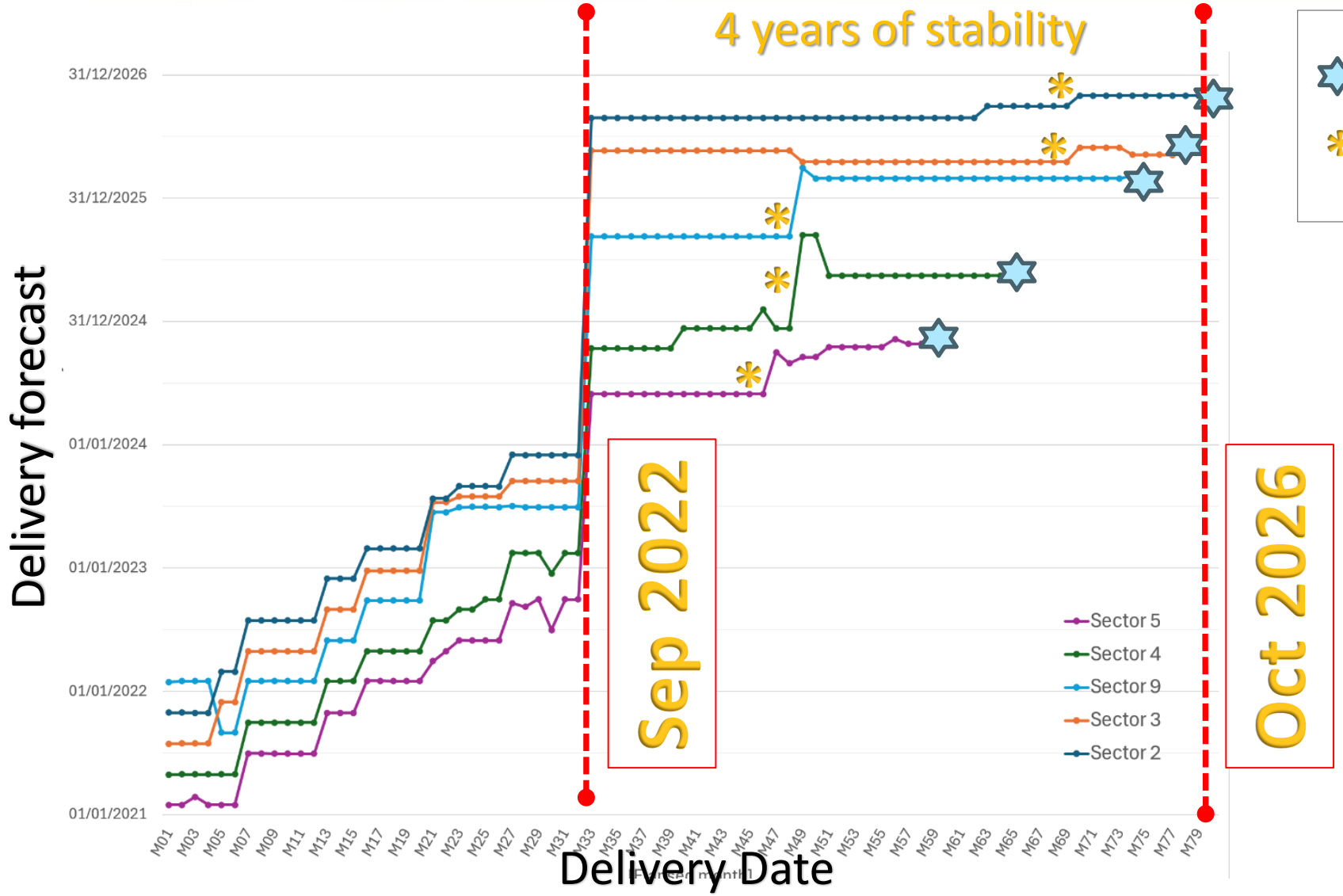


2nd Oct 2026*

* Expected date.

S2 loaded on ship 15th Sep

Schedule stability



Accomplished delivery

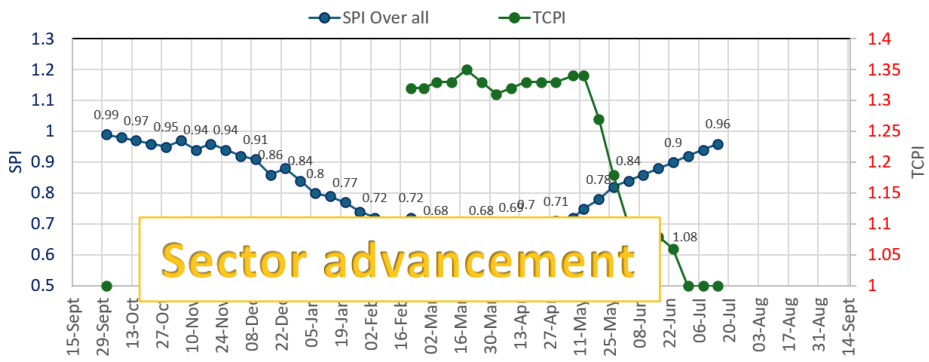
Extra scope not in the schedule: Filed Joint repair

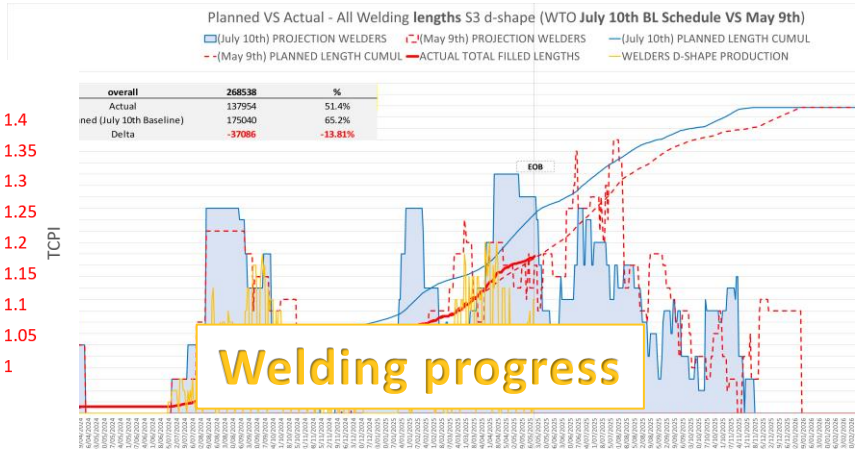
Production Follow-Up

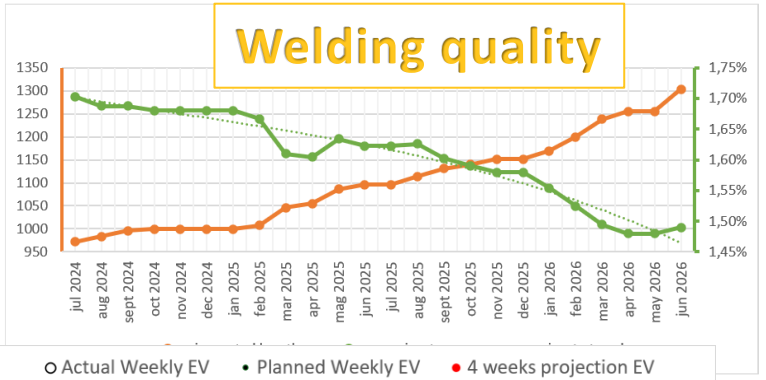
- Treat each sector as a stand-alone project
- Use of dedicated KPIs* adapted to project moment and need
- Weekly measurement of each KPI to fast react to rising issues
- Engage Companies' management (CEOs and Owners)
- 3rd party Inspectors (BV, ISQ)
- F4E Residents

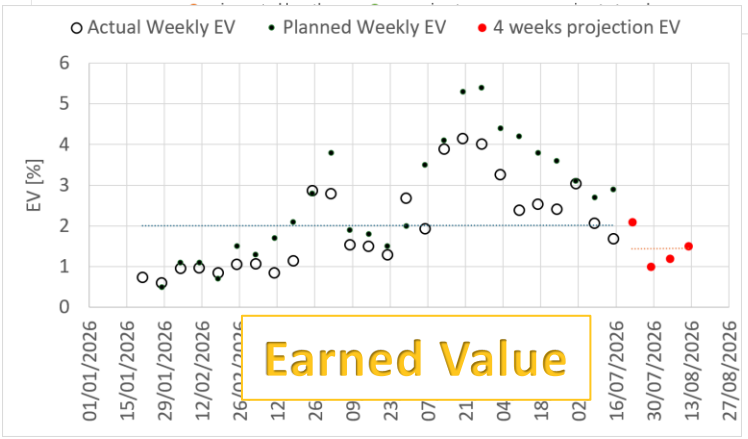
*SPI, TCPI, EV, NCR closure index, milestones trend analysis, Welding/NDE progress, workforce verification, Machining performance, Welding quality…

Some Examples









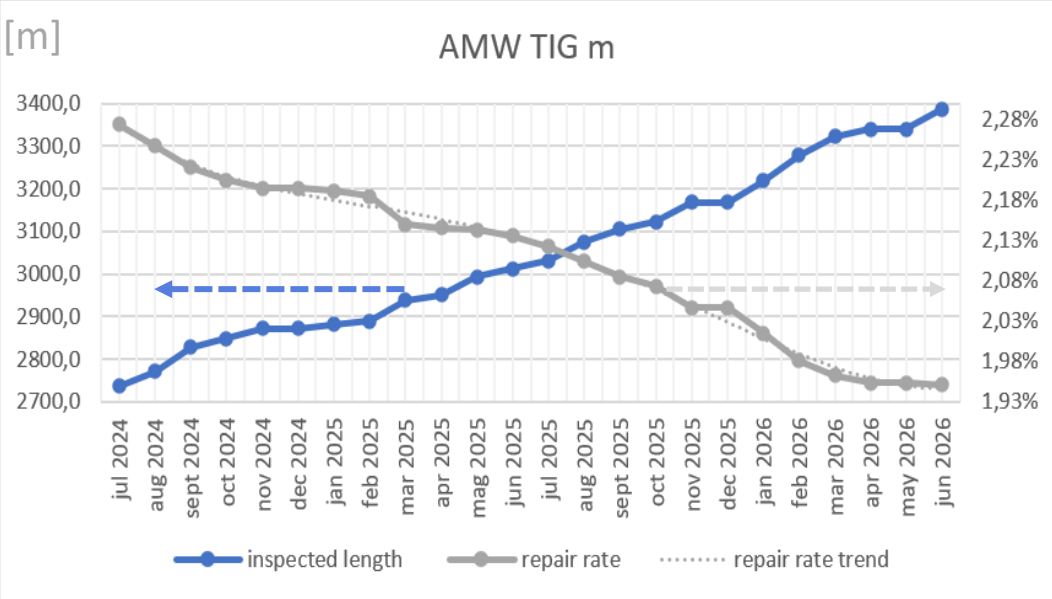
During the path we faced quite a number challenges and overcame them!

…Hereafter we will give a non exhaustive list…

Events and Lesson Learnt

Weld quality

- In 2023, the results of the welding quality triggered implementation of dedicated corrective action based on welders' performance monitoring and redefinition/optimization of welding techniques and NDE procedures.



PAUT defect length rate [sum of defect legnth/tot welding legnth]	S5	S4	S9	S3	S2
welds inspected by RT	0.8%	1.5%	0.6%	0.3%	0.3%
welds inspected by UT	1.0%	0.5%	1.1%	0.1%	1.5%

[*statistics include the latest stage of the production of each sector, for D-shape to completion : 400 welds and 200m welded length for each sector*]

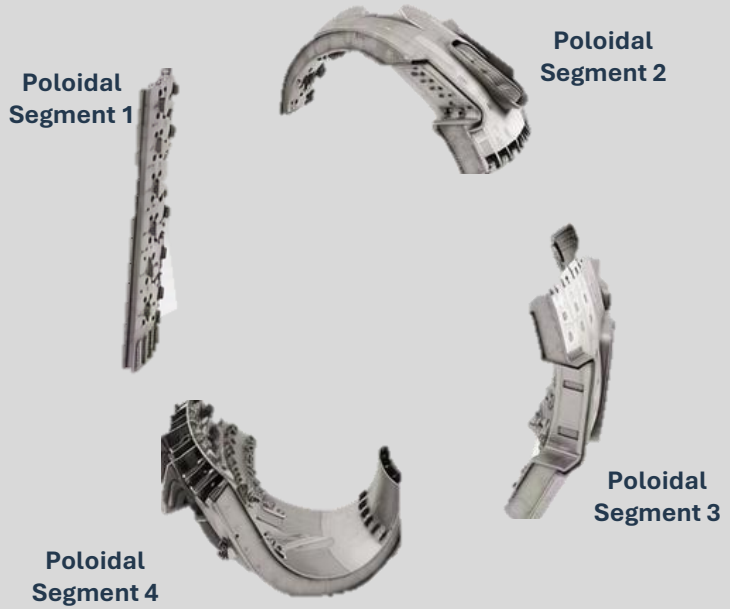
This improvement has driven the overall production performance forward keeping the overall rate well below that target

Events and Lesson Learnt

Field Joint Out Of Tolerances and Repair

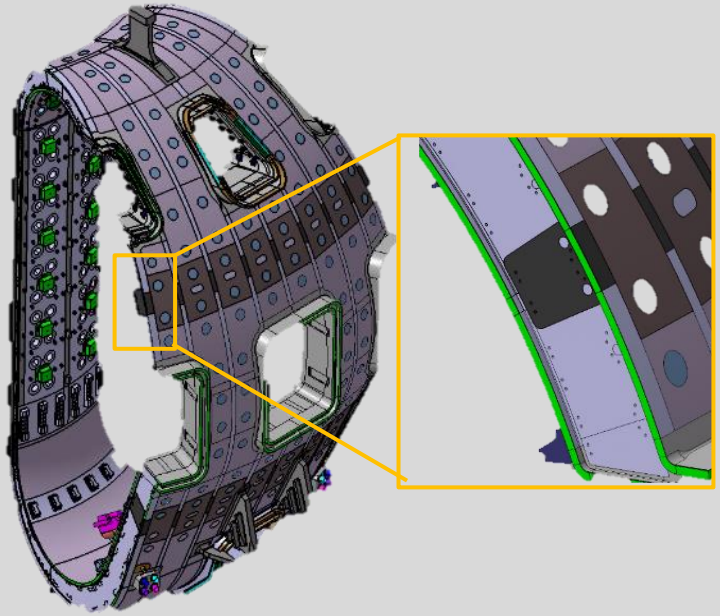
BASELINE BEFORE 2022

- Final machining performed at segment level before sector assembly and welding



IMPACT

- Out of tolerances on the Field joint profile (in-pit welding feasibility at risk)



REMEDIAL ACTION

- Field Joint Repair and machining introduced at end of Sector manufacturing route



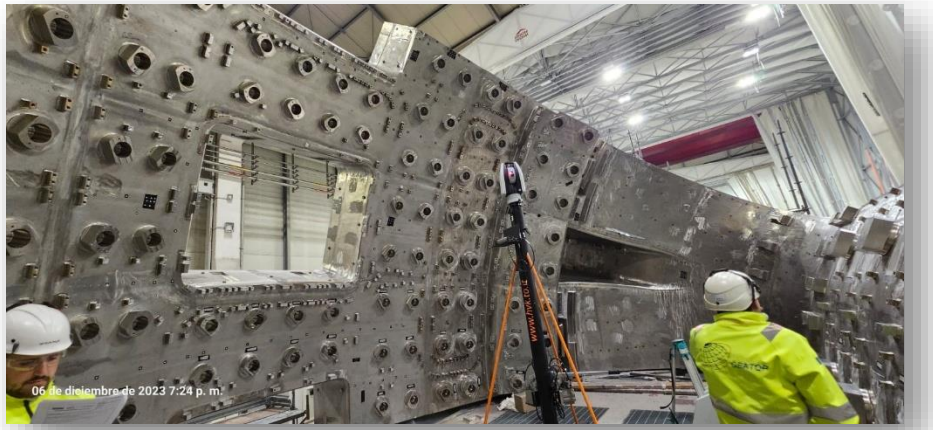


Events and Lesson Learnt

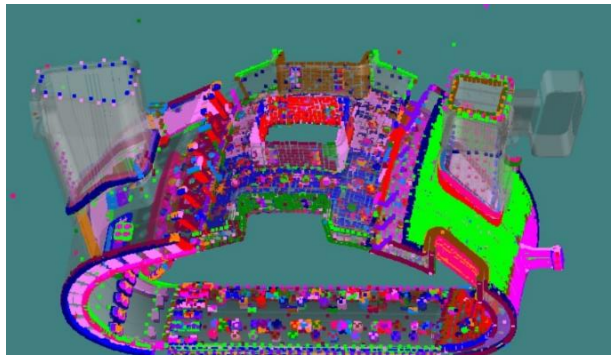
Metrology

- Metrology as an integral part of the manufacturing process → continuous in-process control of critical engineering parameters.





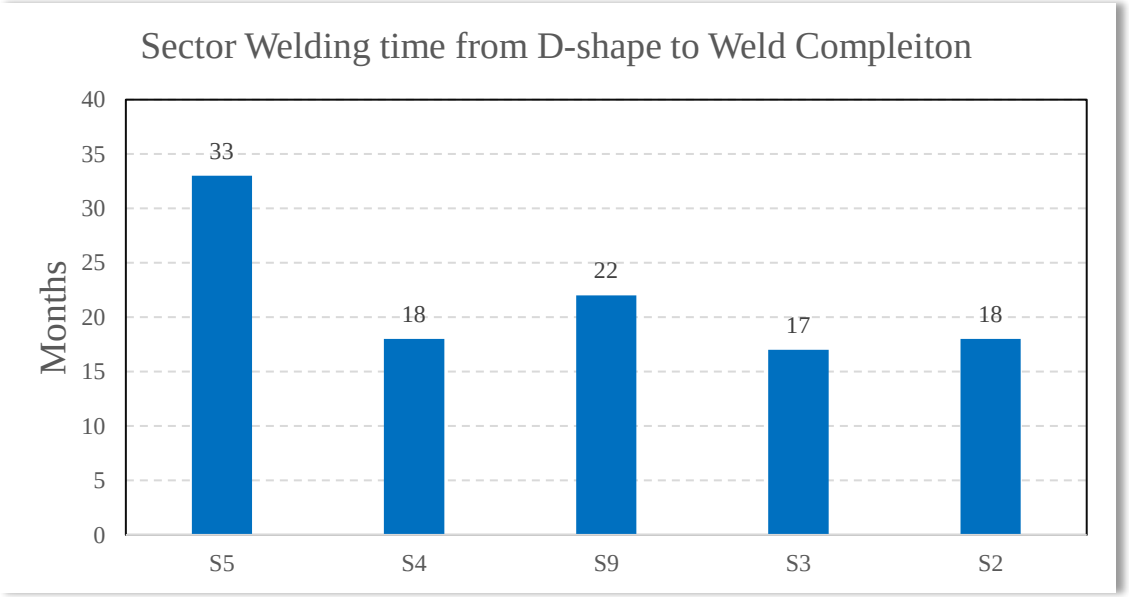
- Cutting-edge metrology instruments, (e.g. laser trackers, scanners, photogrammetry systems) used alongside conventional tools (e.g. callipers…)



Up to 7000 measurements per sector

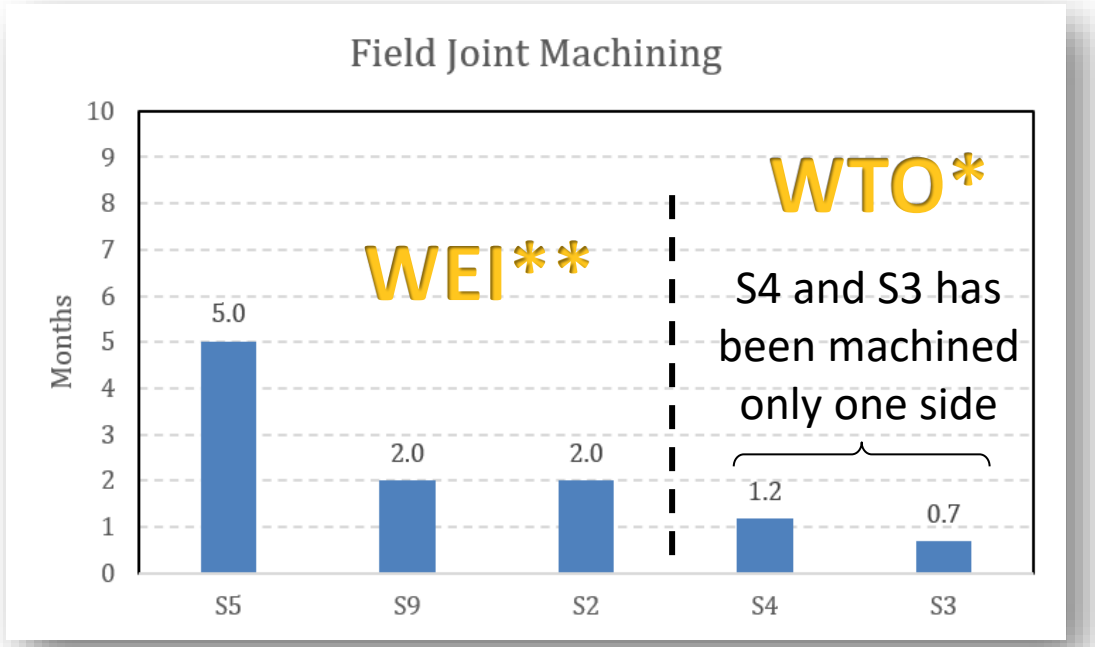
- Virtual Assembly techniques extensively used to speed up assembly steps and speed up acceptance processes

Effect of the Lesson Learnt



- S3 is the fastest sector to be completed
- 50% improvement factor!

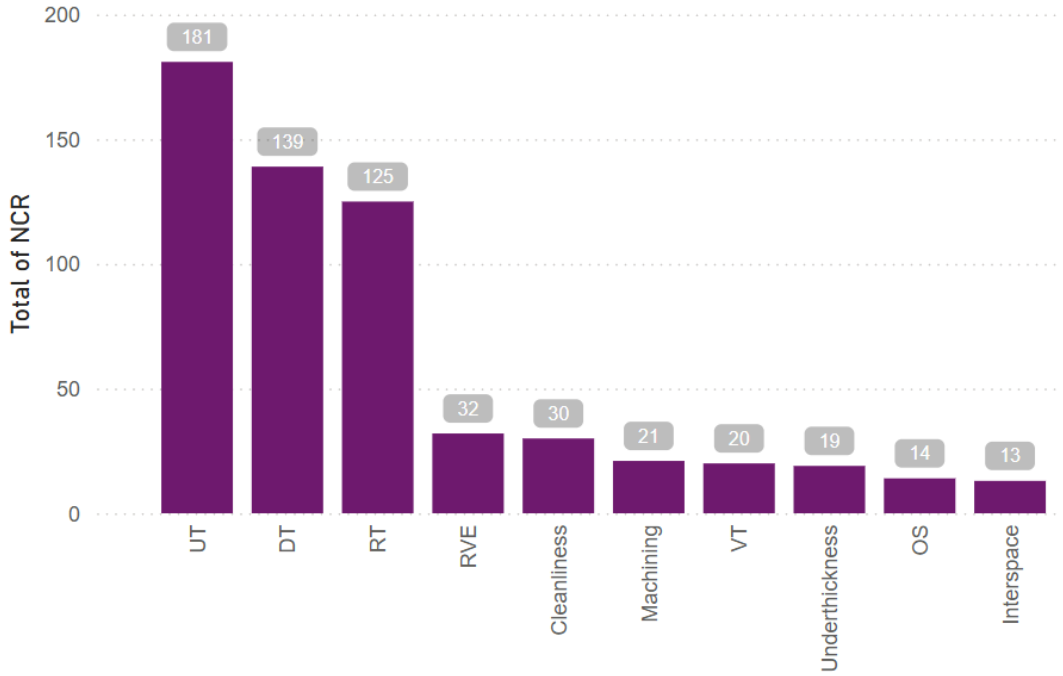
- Main debugging during S5 → from 5 to 2 months

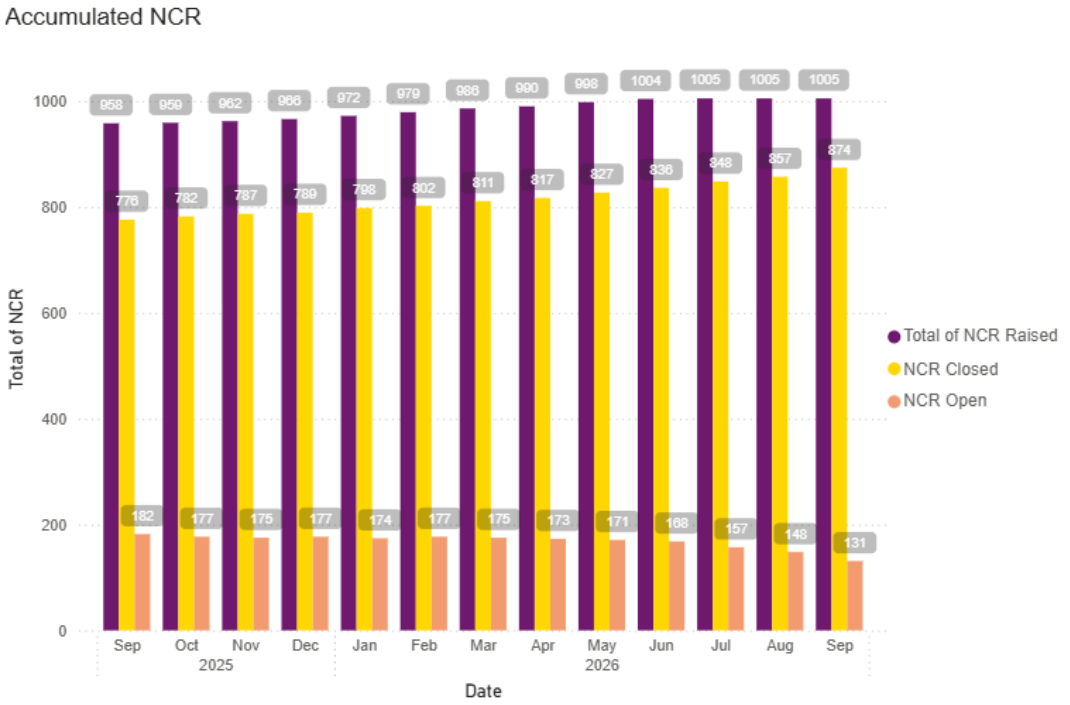


*WTO = Walter Tosto; **WEI = Westinghouse Italy

NCRs

First 10 causes of NCR





- NCR related to Welding quality accounts for more than 40% of the total

- 1005 issued NCR in 16 years of contract
- As of today: 131 open NCR
- Dedicated action to foster NCR closing has in Q2 2025.

Conclusions

- The completion of the European Vacuum Vessel Sectors procurement marks a historic milestone for F4E and ITER, Ansaldo Nucleare, Westinghouse Italy and Walter Tosto.

- This achievement is the result of 16 years of relentless effort, overcoming technical challenges, refining manufacturing processes, and ensuring uncompromising quality.

- The lessons learned—from welding improvements to metrology advancements—have not only resolved critical issues but also elevated the standards of precision and efficiency in large-scale fusion component production.

- As the last weld symbolizes the end of this procurement chapter, it also paves the way for ITER's next phases, reinforcing F4E's commitment the ITER project and to its supply chain.

FUSION FOR ENERGY

Thank you for your attention

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