Development of in-vessel rail deployment and connection method for ITER Blanket remote maintenance

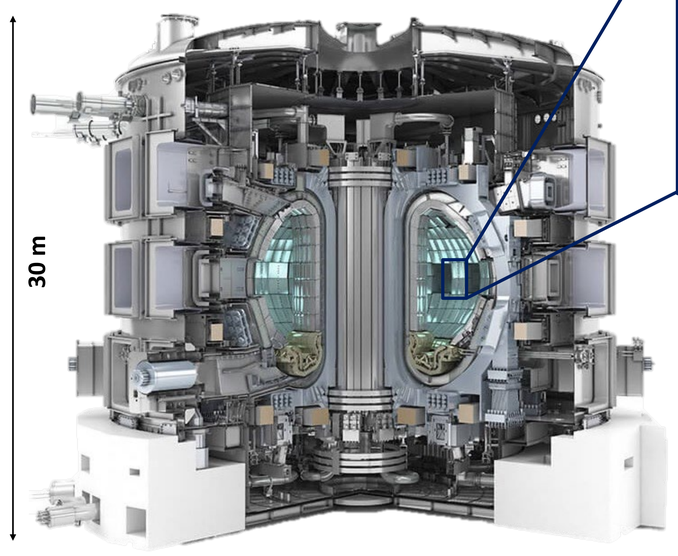
Y. Noguchi, T. Ito, T. Iwamoto, and N. Takeda

National Institutes for Quantum Science and Technology, Naka-city, Ibaraki-prefecture, Japan

Conclusion

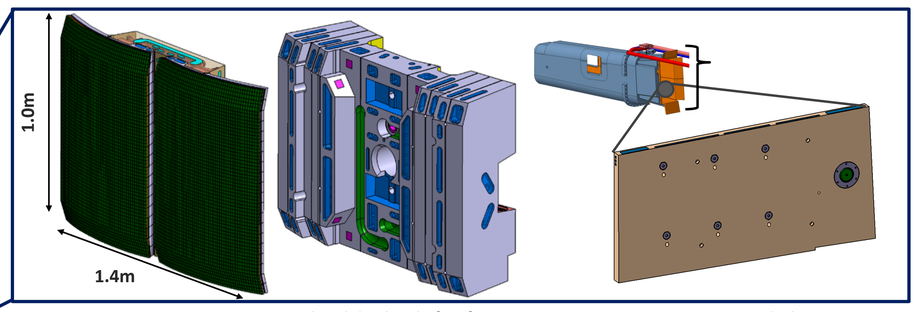
- **Novel rail deployment method: Conceptual design established to enhance recovery capability in case of device failure in inaccessible environments.**
- **Technical validation: 1/5 scale vibration tests verified analysis model; full-scale partial mockup confirmed structural integrity of rail connection parts.**
- **Ongoing development: Remote in-vessel rail connection design established; full-scale mockup under preparation to demonstrate the complete process.**

ITER Blanket Remote Handling System (BRHS) Overview

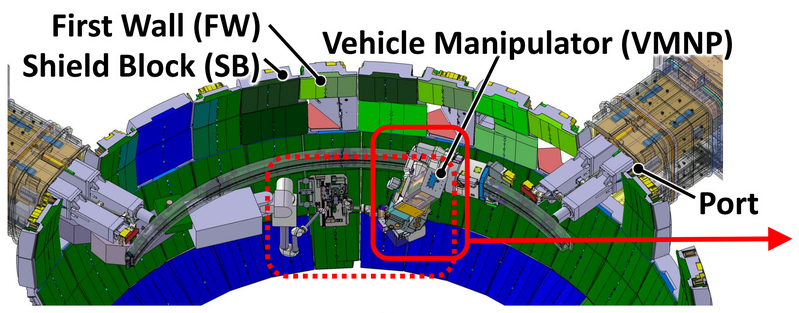


ITER Tokamak cutaway

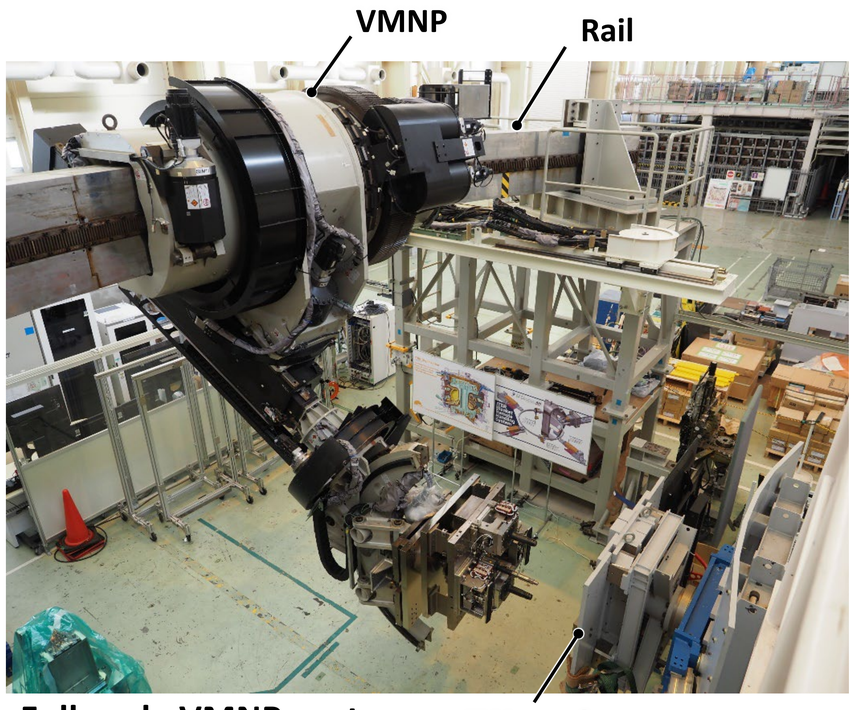
Remote Handling Target



First Wall (FW) Max. 1.0 ton | Shield Block (SB) Max. 4.0 ton | Duct Liner Module Max. 0.3 ton



Blanket Remote Handling System (BRHS)



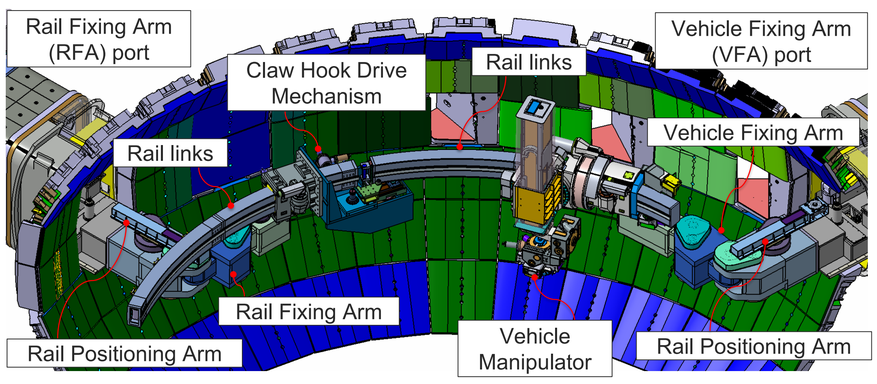
Full-scale VMNP proto

FW mock-up

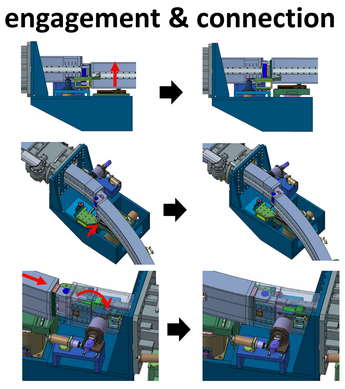
In-Vessel Rail Connection overview

New method : In-Vessel Rail Connection

- Deployment of rail from neighboring remote-handling ports for in-vessel connection
- Precise positioning by rail-holding arm facilitates reliable wrench mating

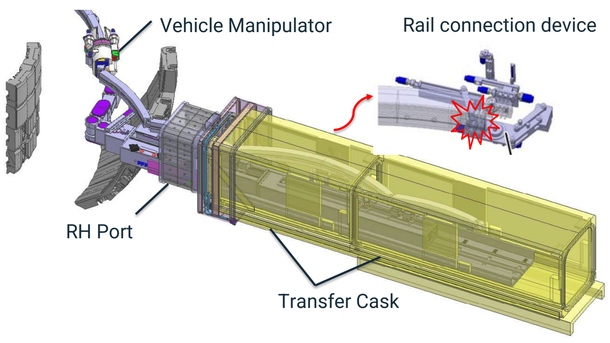


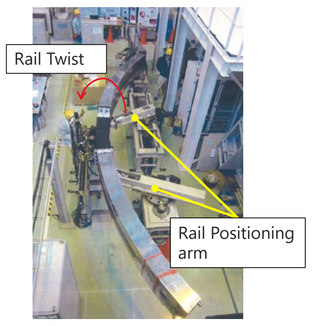
Rail Ends engagement & connection



Previous method : In-Cask Rail Connection

- The Rail is deployed from single remote handling ports
- Technical concern : Recovery of failed equipment in the Cask

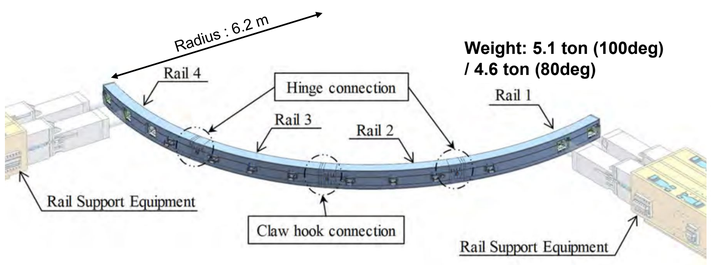


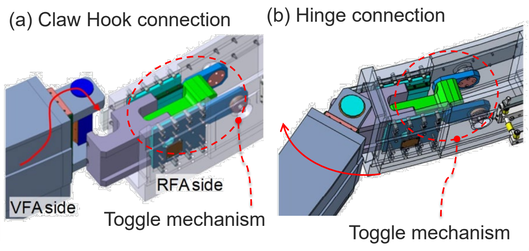


Rail Connection Test Equipment

The rail connection part : Structural challenges

- Design trade-off between remote connectivity & strength
  - Strength/rigidity to support the weight of entire system (>15 t)
  - Remote connectivity of the rail ends (needs clearance/flexibility)
- Verification tests were conducted for the feasibility of IVRC structural integrity
  - Gaps and localized contact at rail connection parts necessitates the vibration test to confirm its dynamic behavior.

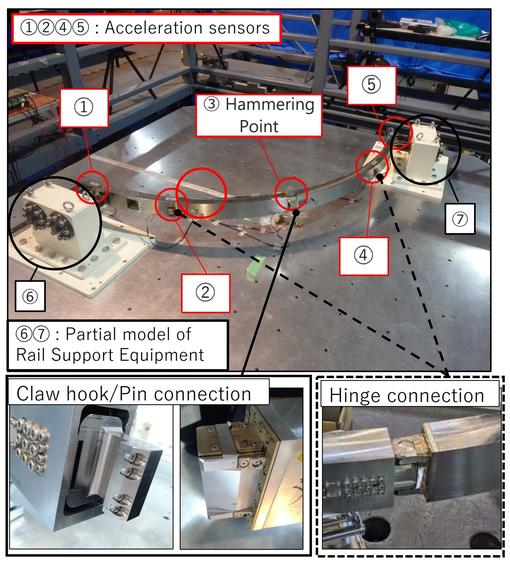


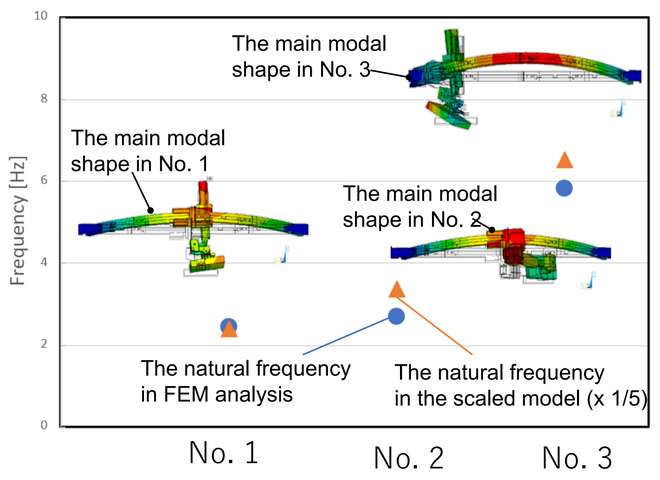


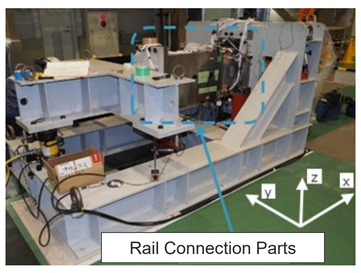
Verification tests

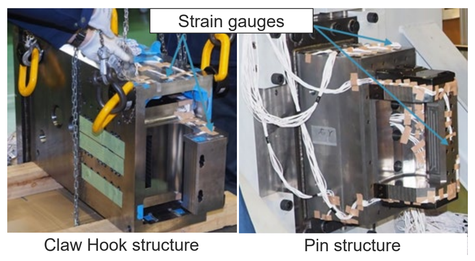
Vibration test with 1/5 scaled model to validate FEM model

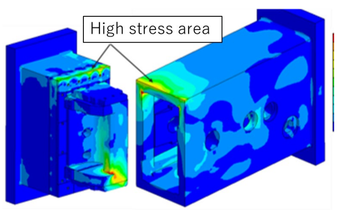
- 1/5 scale model test with actual design and identical material
- Comparison of fundamental mode frequency between hammer test and FEM ⇒ Good match was observed
- Under heavy load at rail joint (Case No.1), FEM and test matched within 1%





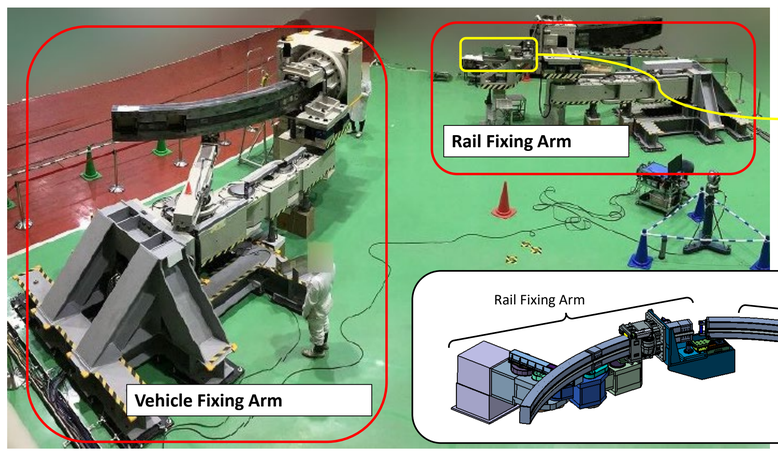


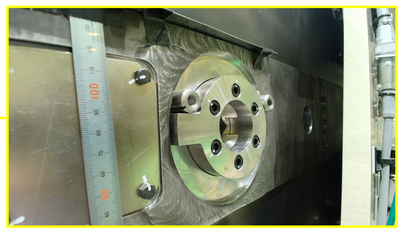




Full-scale mock-up are under preparation

- Full-scale mockup of the entire rail connection device is under preparation for the verification of the remote rail connection process





Engagement of the wrench to the rail connecting mechanism was confirmed.

In person: 18th October 2025 8:30 – 10:40
Presented by NOGUCHI Yuto (noguchi.yuto@qst.go.jp)

FEC2025
30th IAEA Fusion Energy Conference (FEC2025)
13–18 October 2025, Chengdu, People's Republic of China