RACE work on DEMO

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DEMO Remote Maintenance Project Leader

FinnFusion Seminar | Helsinki | 28th May 2024

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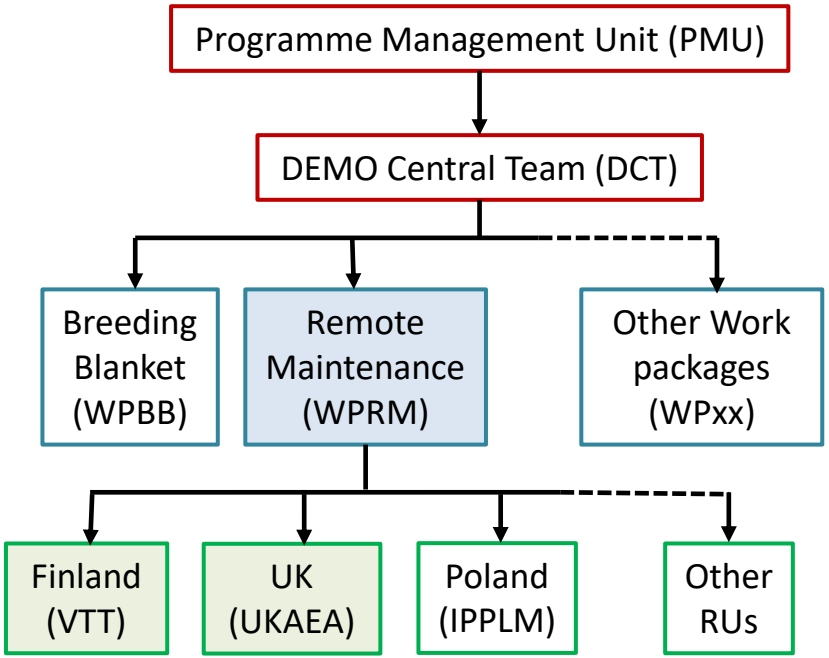
EUROfusion

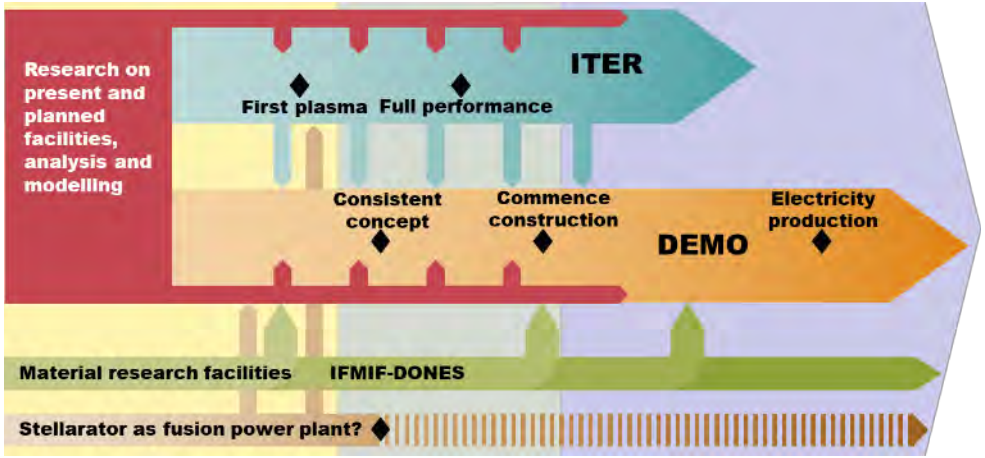
EUROfusion is a consortium formed by the fusion Research Units (RUs) in the EU, UK and CH



EUROfusion DEMO Organisation

EU DEMO is in the Concept Design Phase

- G1 DEMO, DEMOa (Low aspect ratio)
- DEMO Oriented Neutron Source (DONES)
- Divertor Test Tokamak (DTT)
- Volumetric Neutron Source (VNS) – Antti Snicker



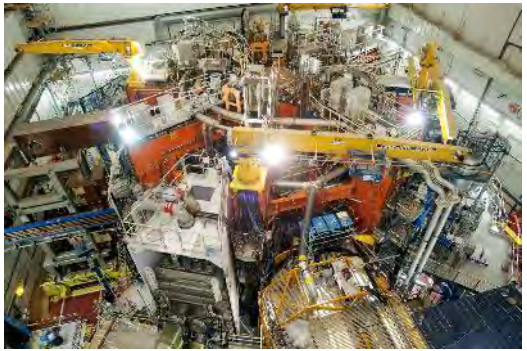
EUROfusion roadmap

UKAEA – the UK Fusion Association

Projects
- JET - decommissioning
- MAST-U - exploitation
- DEMO – concept design
- STEP – concept design
- Stellarator – preconcept
- DONES – construction

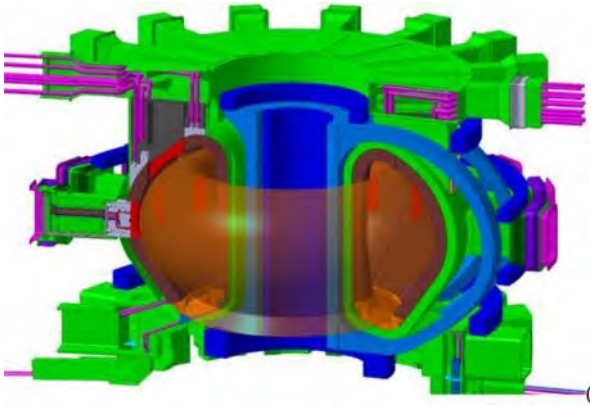
Technology
- Remote Handling (RACE)
- Fusion Technology

Test Facilities
- Liberty
- H3AT
- Chimera

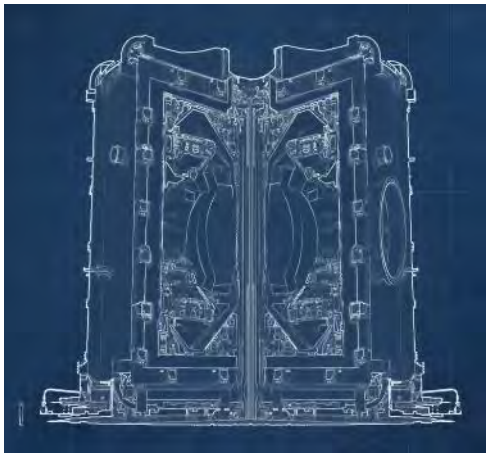


JET – Joint European Torus

MAST-Upgrade Spherical tokamak



EU DEMOnstration fusion powerplant



STEP Spherical Tokamak for Energy Production

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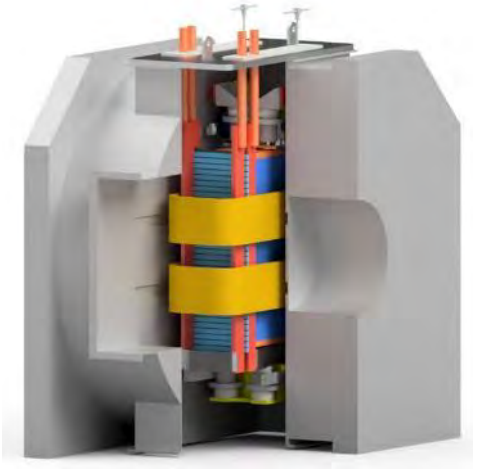
- H3AT
- MRF
- Chimera

H3AT - tritium research facility

To enable industry and academia to study how to process, store and recycle tritium

MRF – Materials Research Facility

Developing materials for the nuclear industry



Chimera

Metre scale component testing
- High temperatures
- High heat flux
- Static/pulsed magnetic loads
- Thermal cycling
- Vacuum, air, or inert gas

RACE

RACE – Remote Applications in Challenging Environments – part of UKAEA

300+ Remote handling engineers and scientists

- JET – decommissioning
- ITER – RM test facility
- DEMO – concept design
- STEP – concept design
- ESS – in construction
- Stellarator – preconcept
- DONES – RM consultancy

RACE work hall

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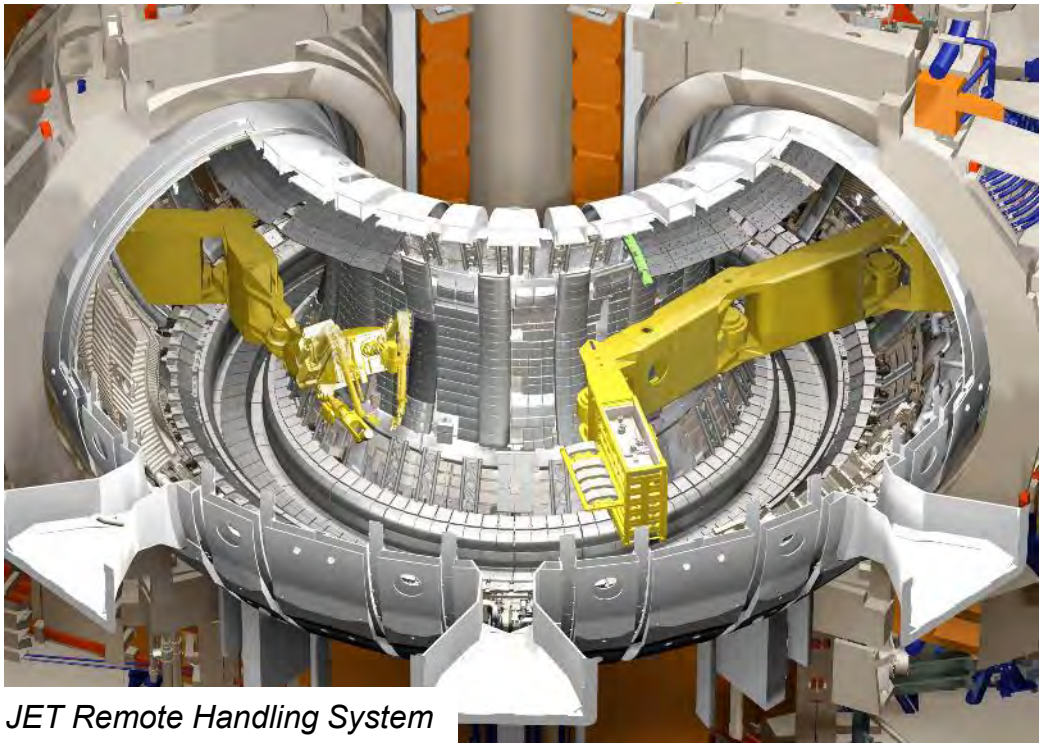

JET Remote Handling System

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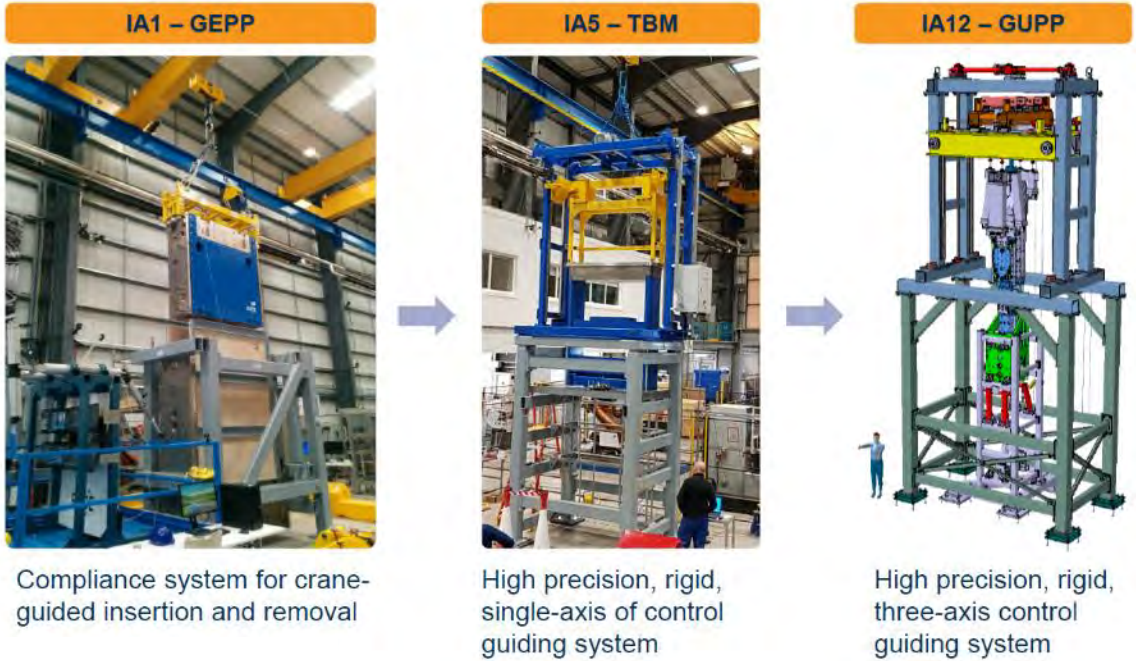

ITER Port Plug maintenance in the Hot Cell

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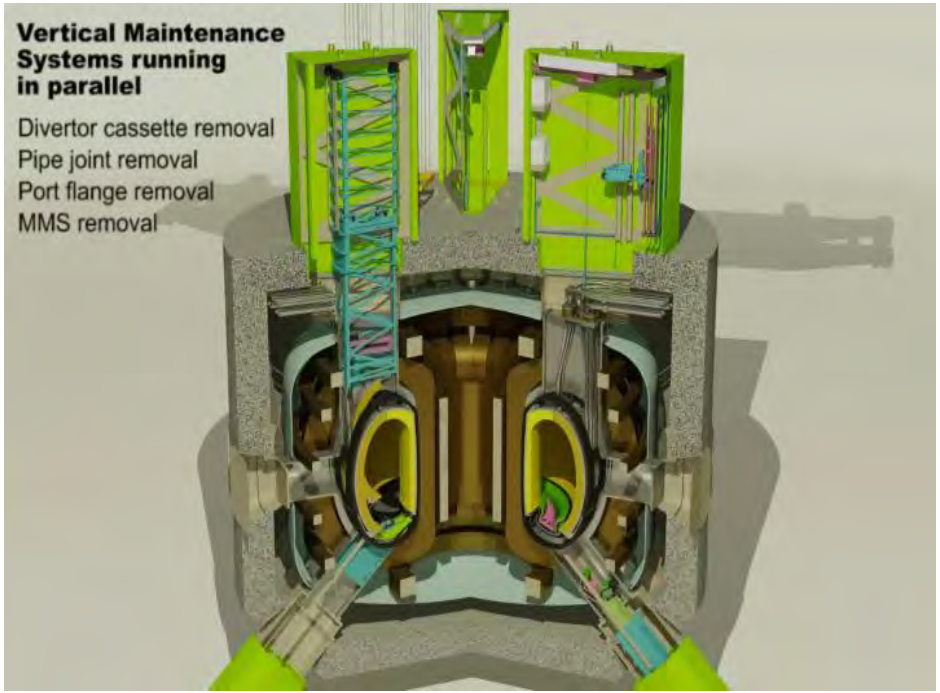

DEMO remote maintenance concept design from 2014

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STEP – Spherical Tokamak for Energy Production to be built in the UK

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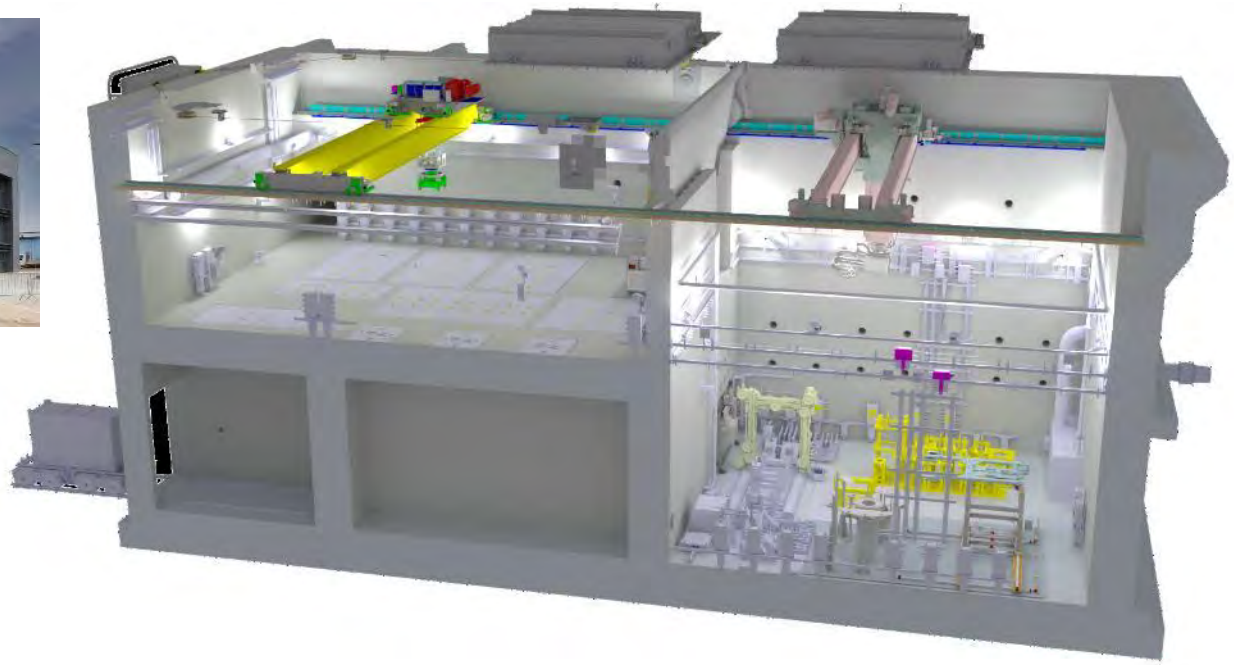
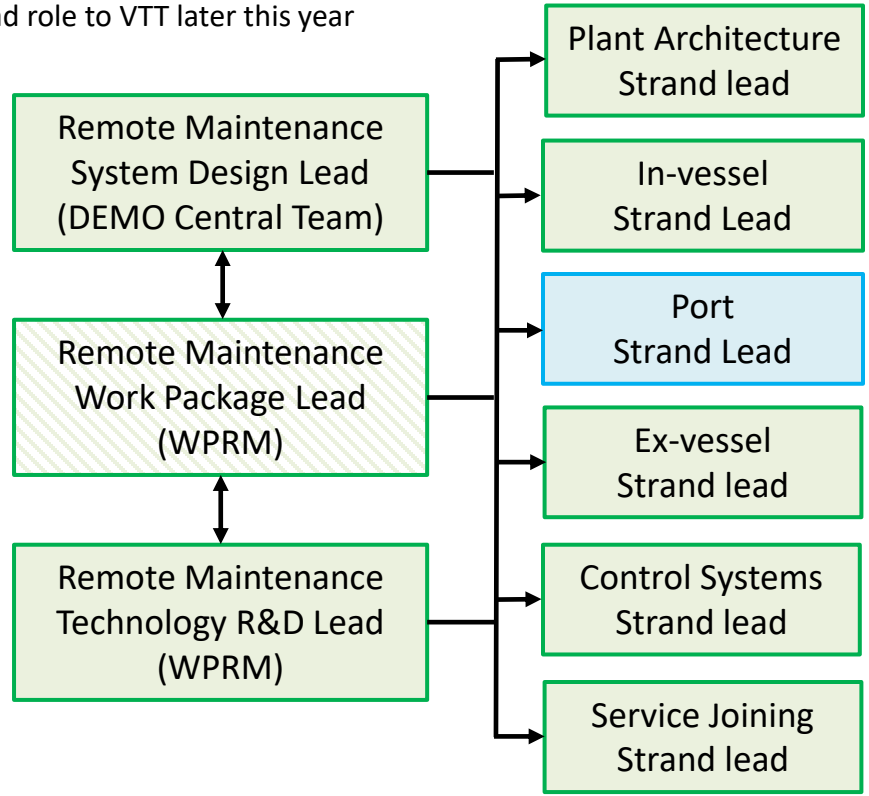


ESS – European Spallation Source windowless hot cell for size reduction of large components. In construction in Sweden.

RACE work on DEMO

RACE handing over Work Package Lead role to VTT later this year



UKAEA – UK Atomic Energy Authority

VTT – Technical Research Centre of Finland

KIT – Karlsruhe Institute of Technology, Germany

CEA - Commission Energy Atomic, France

IST - Instituto Superior Técnico, Portugal

ENEA – Brasimone Research Centre, Italy

SFA – Slovenian Fusion Association, Slovenia

EK – Centre for Energy Research, Hungary

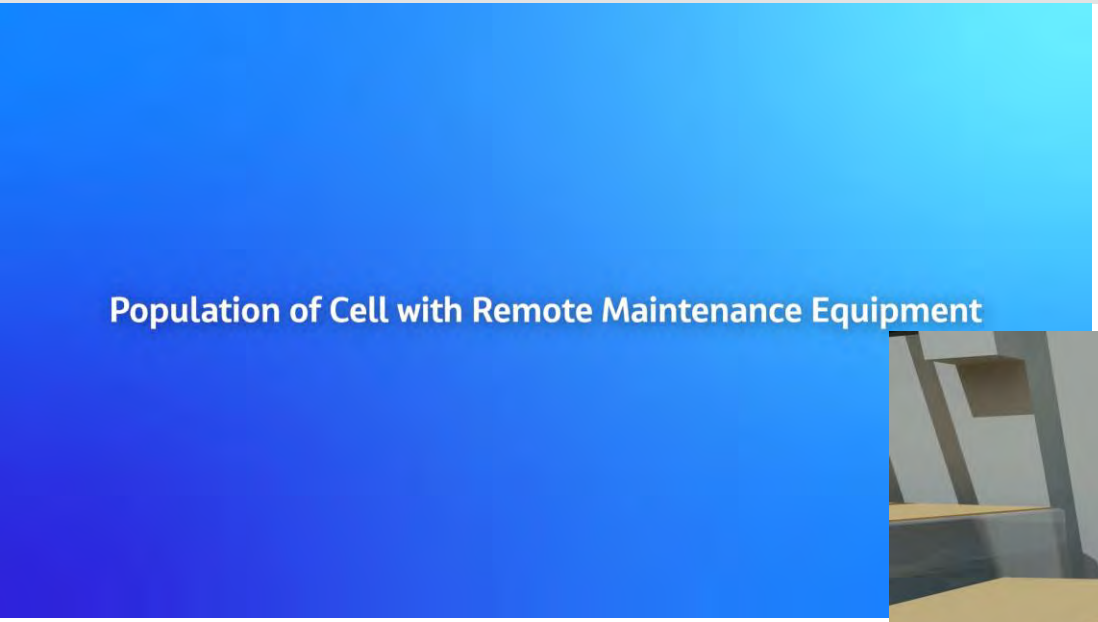
DTU – Department of Physics, Denmark

IPPLM – Institute of Plasma Physics and Laser Microfusion, Poland

DIFFER – Dutch Institute For Fundamental Energy Research

RACE DEMO visit to VTT this week to discuss integration of our work

In-vessel maintenance



Lower port remote maintenance

Rail system assembled in the port

- Divertor pipes cut
- Pipe module removed
- Limited clearance

Upper port remote maintenance

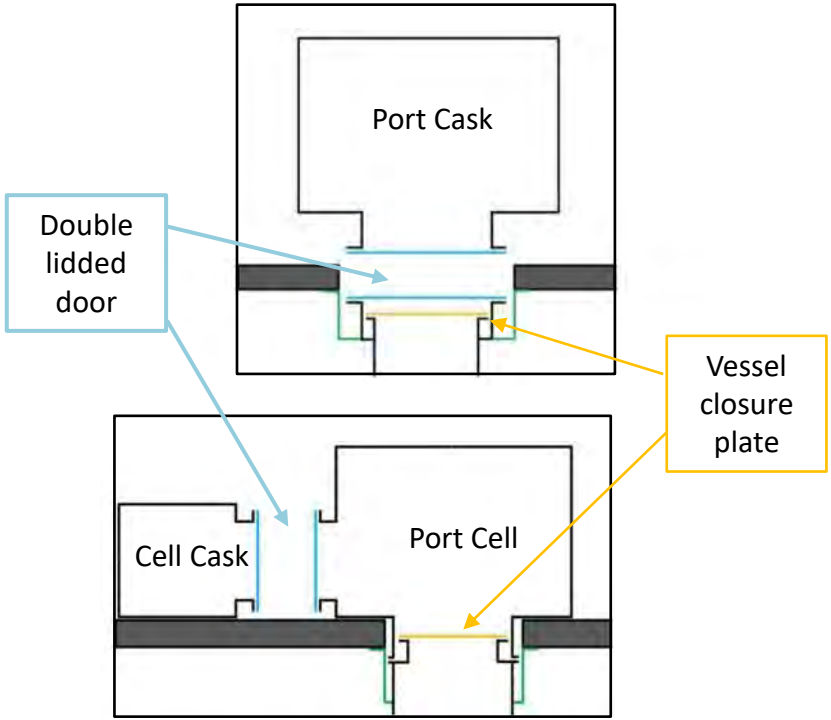
Tools are delivered to the cell and are deployed into the port to:

- Perform inspection and cleaning
- Remove the vacuum closure plate
- Remove the pipe modules

Port cell or port cask?

Ex-vessel layout is critical to efficient maintenance operations

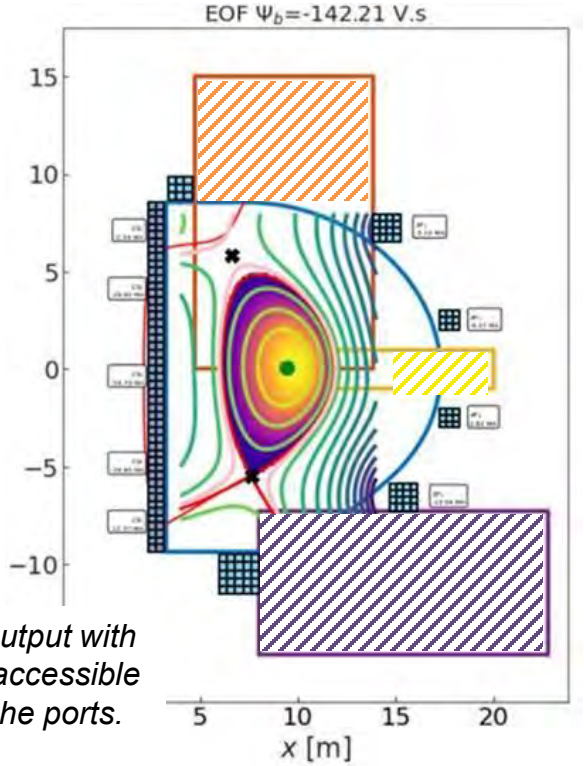
- Transfer casks can either dock directly to the port, or dock to a port cell around the port
- Advantages of a Port Cell
  - Space to assemble and store equipment and plant
  - Reduces the cask size and number of transfers
  - Reduced plant downtime
- Advantages of docking casks directly to the port
  - Reduced volume connected to the vessel
  - Takes up less ex-vessel space when not in maintenance
  - Can reduce ventilation and decontamination requirements
- Study needed in 2024
  - Compare port cell maintenance with port cask maintenance
  - Assessment of; maintenance duration, quantity of RME, number and size of casks, contamination levels, ventilation, flexibility of operations, recovery and rescue options



Computational assessments

Fusion design codes allow an initial check of the magnet and plasma viability

- PROCESS and Bluemira codes
  - Move Poloidal Field Coils to increase the space for the ports
  - Check viable magnet and plasma configurations
  - Result of the first assessment shown in the figure
- Promising architectural changes
  - Enlarge the vacuum vessel to accommodate a single IBB
  - Reduction in dominate handling loads by ~65%
- More space allows simpler maintenance
  - Lower risk
  - Lower cost
  - Faster – higher plant availability



Bluemira output with increased accessible space at the ports.

In-vessel component handling

In-vessel component removal and installation are the most demanding handling operations

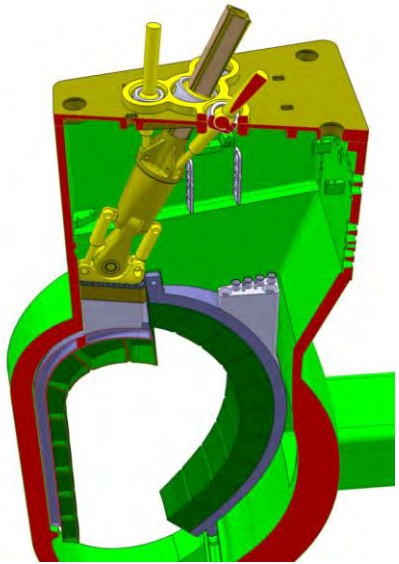
Blankets are 12m long and up to 80 tonnes

Clearance between blankets is 25mm

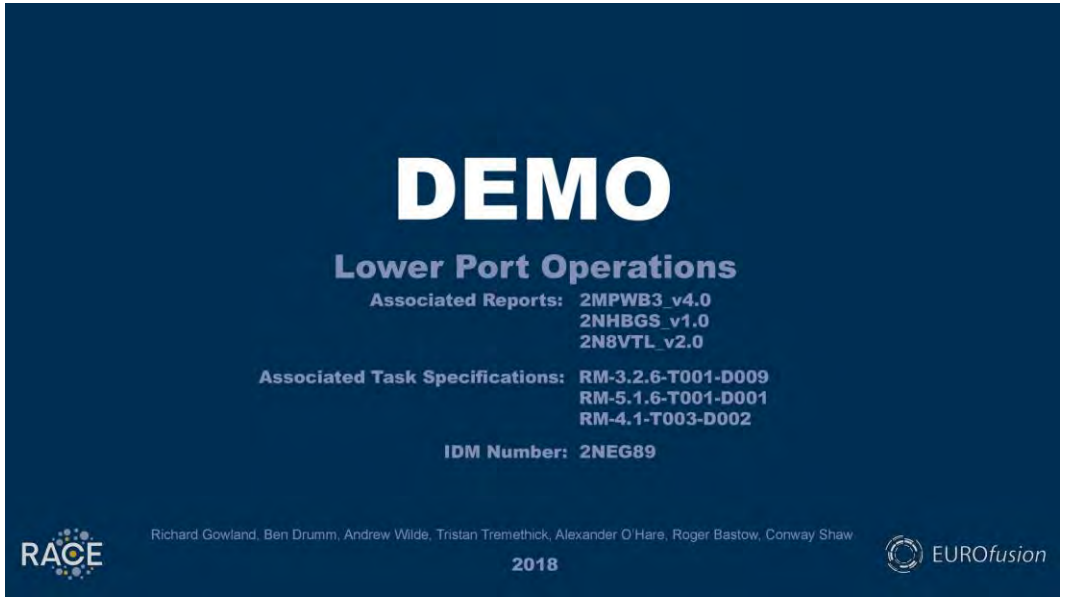
The access ports are long and narrow through the shielding and between the magnets

Engineering designs for the handling systems for Divertor removal and installation will be described by Stefan Mühlig-Hofmann of Comatec, later this morning

Maintenance access is through small ports



Blanket handling



Divertor cassette handling

An adaptive control system is required that can use the limited position data measurements available and compensate for dynamic effects

Service joining

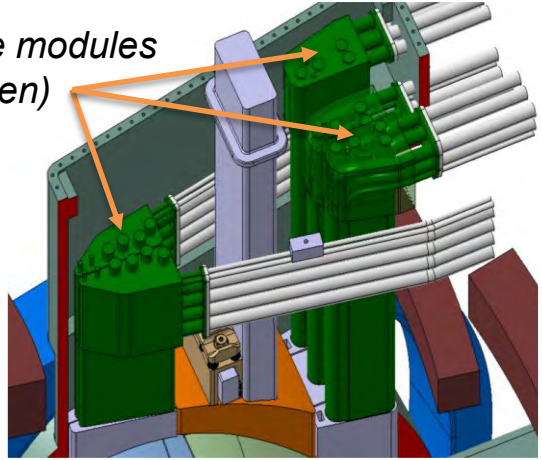
Pipe cutting and welding operations must be performed from inside the pipe

In-vessel component pipe connections are too close together to allow external operations or mechanical connections

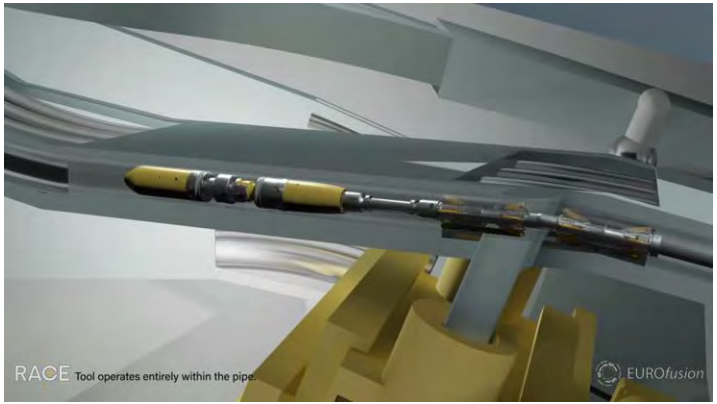
>500 pipes to cut and weld to replace the blankets and divertor cassettes

RACE has a programme of design and technology development to demonstrate feasibility of in-bore cutting and welding

Pipe modules (green)



Alignment testing



RACE Test Facilities

Laser Cell

TARM remote operations integration test rig

TR0 control system and sensor test rig

AIM-TU collaborative handling test rig

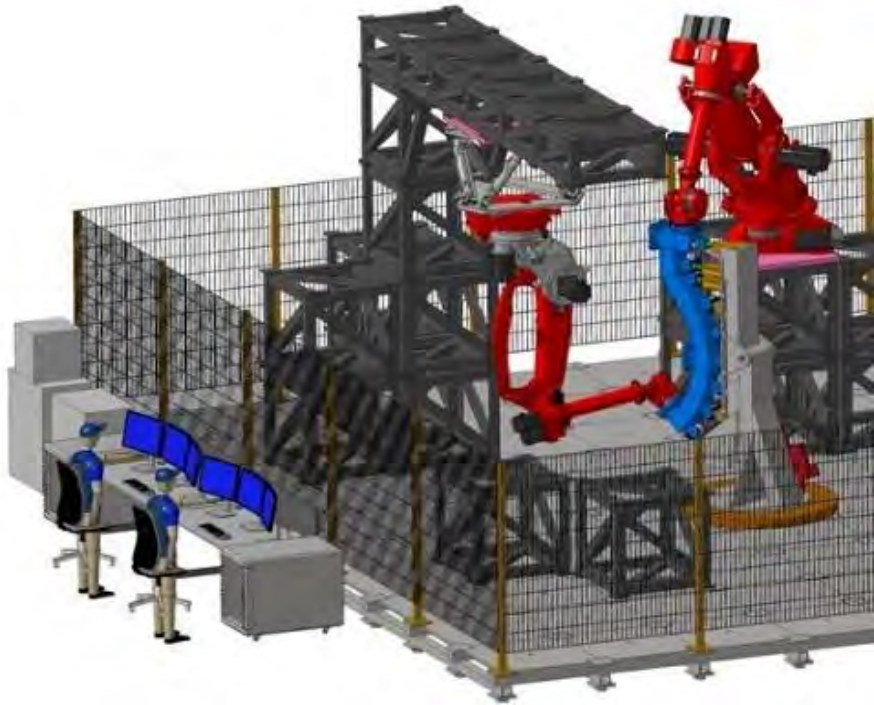
RACE research and development work for DEMO

Remote Maintenance Test Facility

DEMO maintenance requires novel handling and control systems to be developed

- Test technologies for handling massive flexible loads
  - Actuators, sensors, control algorithms
  - Feedforward control algorithms have been developed for handling flexible loads
- Series of Test Rigs that integrate into TR15
  - Reconfigurable layout
  - Test a range of parameters
- Integration with VTT test rigs
  - RMTP – William Brace

Reconfigurable test payload



RMTF TR15 integrated test rig

EUROfusion Ethos

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