



oxford technologies

Practical Experiences from Remote Handling in Fusion

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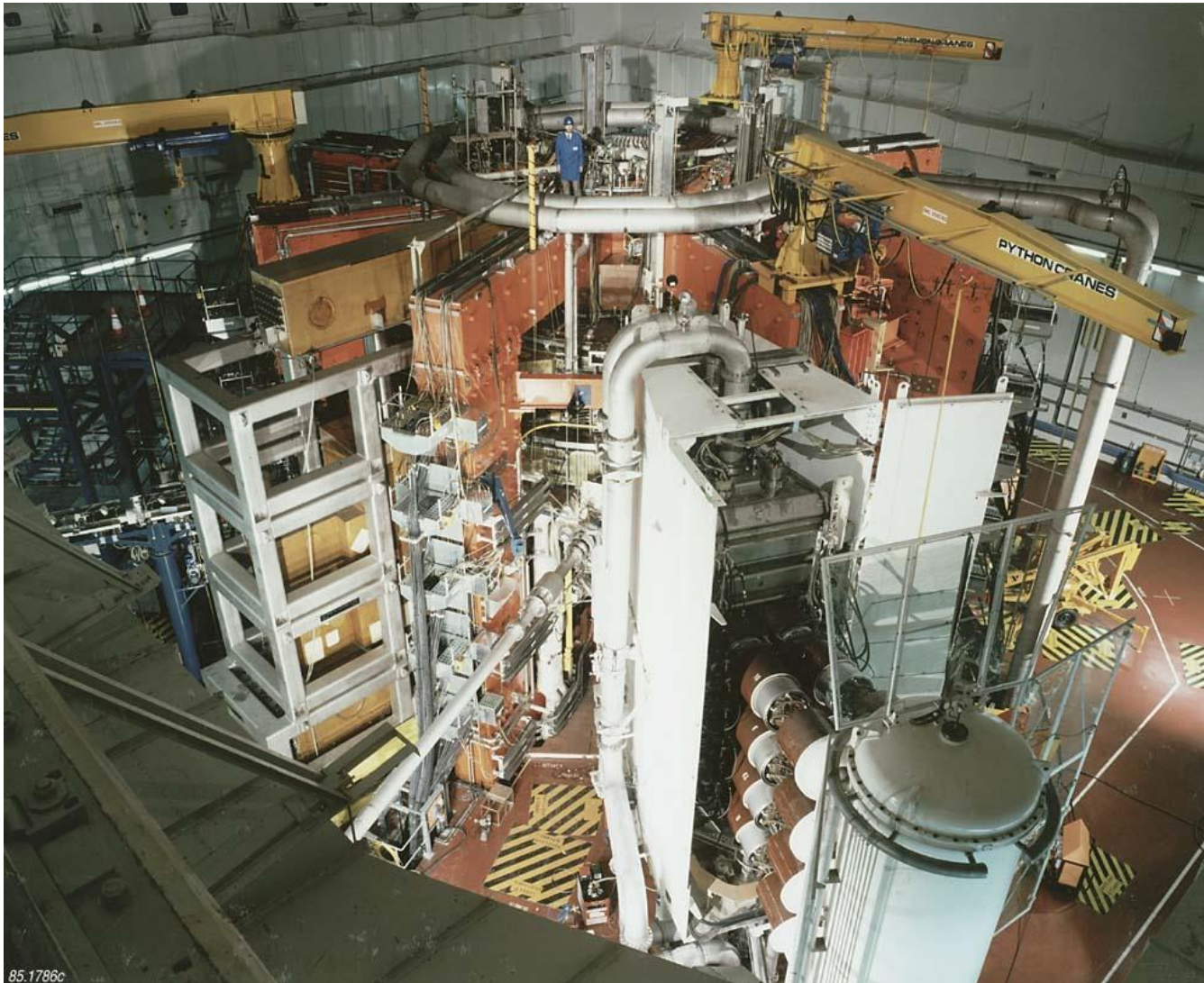
21st January 2015



Aim

To stimulate your thoughts about the meaning of Remote Handling for High Energy Physics Experiments

JET – Europe's leading Fusion Experiment

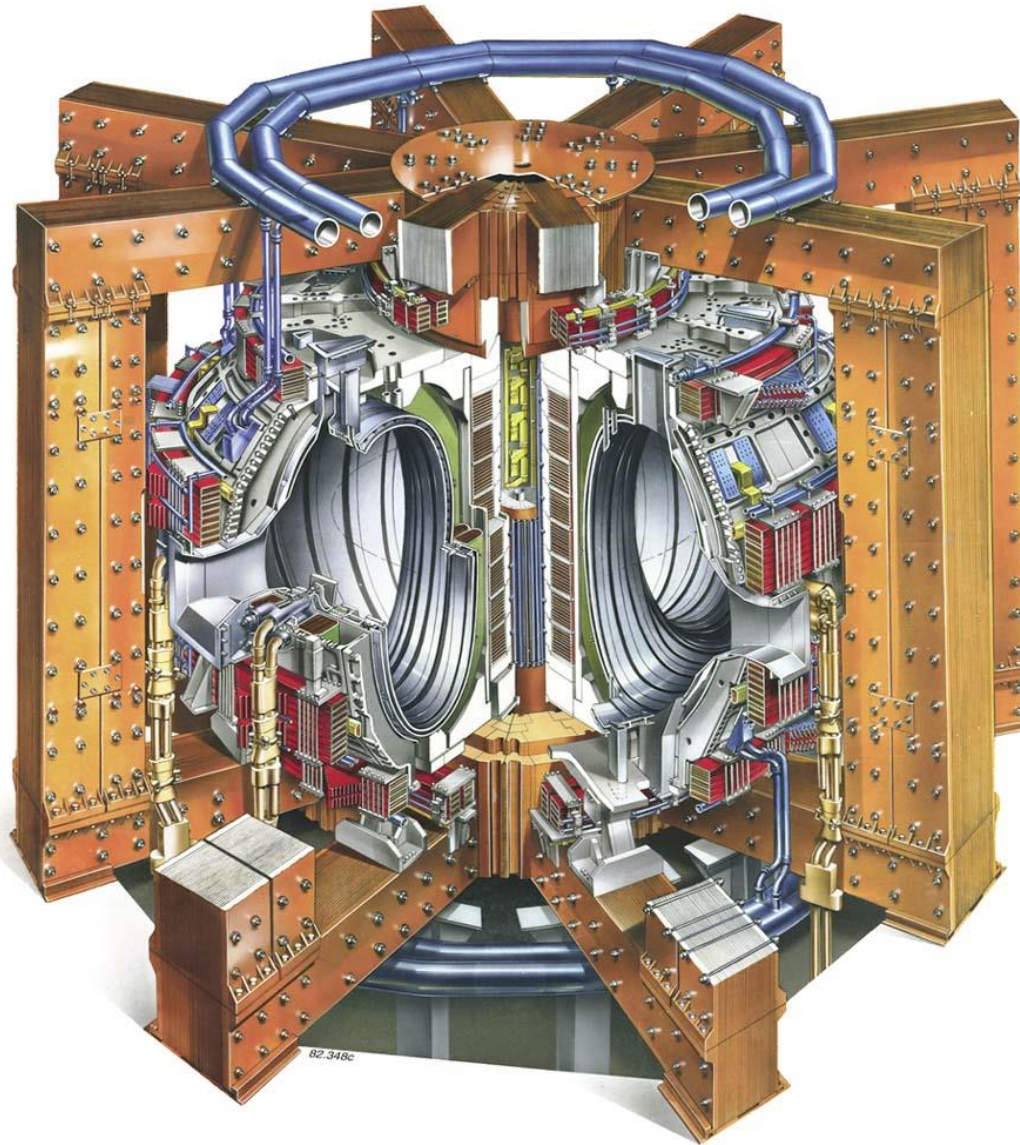


Context

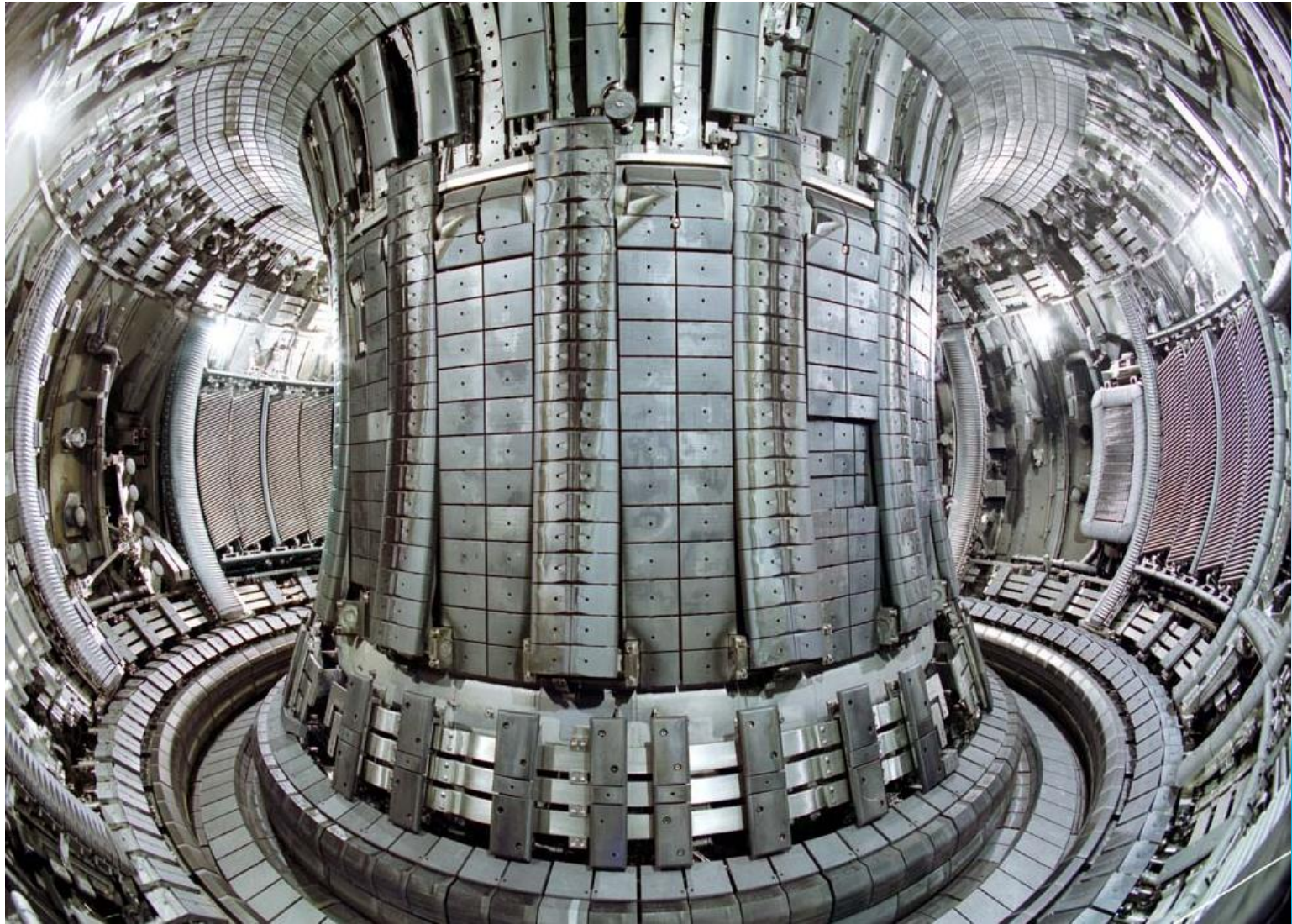
- Large Science Experiment
 - Operational since 1983
 - > £1B spent to date
 - > 20 Nations involved
 - > 500 Scientists & Engineer
 - Remote Maintenance since 1998
- High Energy
 - Generated >16MW Fusion Power
 - >10kV plasma
 - Total input power ~50MW
 - 4 Tesla Field
- Maintenance & Modifications in a hostile environment
 - Gamma
 - Beryllium
 - Tritium



The Tokamak



Remote Handling Arena



Remote Handling Requirements

- >20yr operational lifetime
- >1000 different types of task
- High Availability
- Tolerance to radiation, tritium & beryllium environment
- Wide range of components
 - grams to tonne
 - delicate components
- Fixed duration shutdowns – intensive operations
- Recovery/Rescue of RH equipment after failure
- Decontamination of RH equipment



Remote Handling System – Key Drivers

- Safety Case
- Limited Working Space
- Potential RH System Failure
 - Detection & Location of Faults
 - Recovery
 - Rescue
- RH Compatibility of the Plant
 - As built
 - When damaged
- Inaccurate/Incorrect Configuration Control data
- Need for Adaptability
 - Plant condition
 - Endless list of new tasks
- Large variety of task
- Delicate components
- Hostility of Environment



JET Remote Handling Approach

- Human-in-the-loop (Aiming for “Telepresence”)
- HMI and Control System support to the operator for
 - Safety
 - Operational efficiency
 - Minimising Operator fatigue

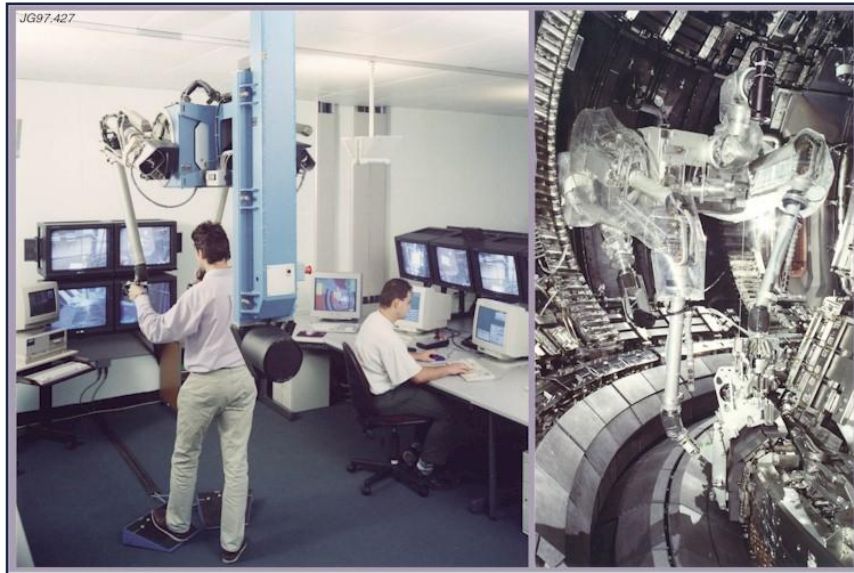


JET Remote Handling System

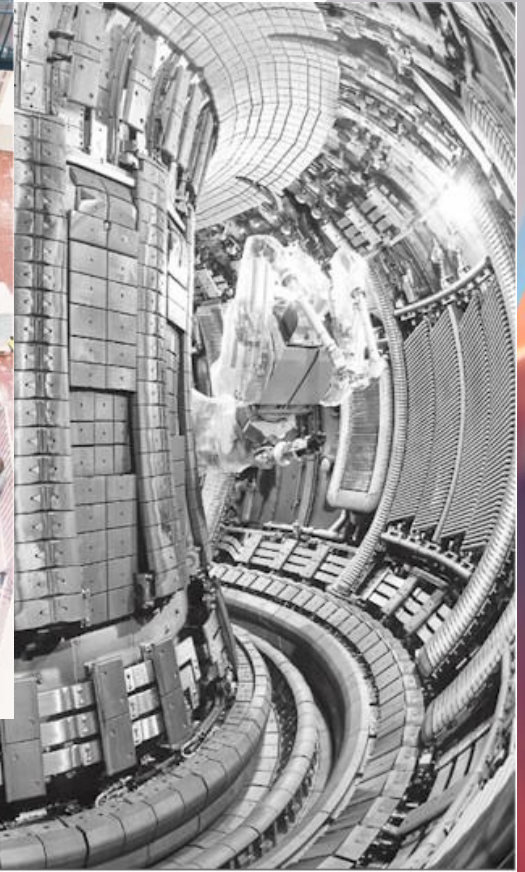
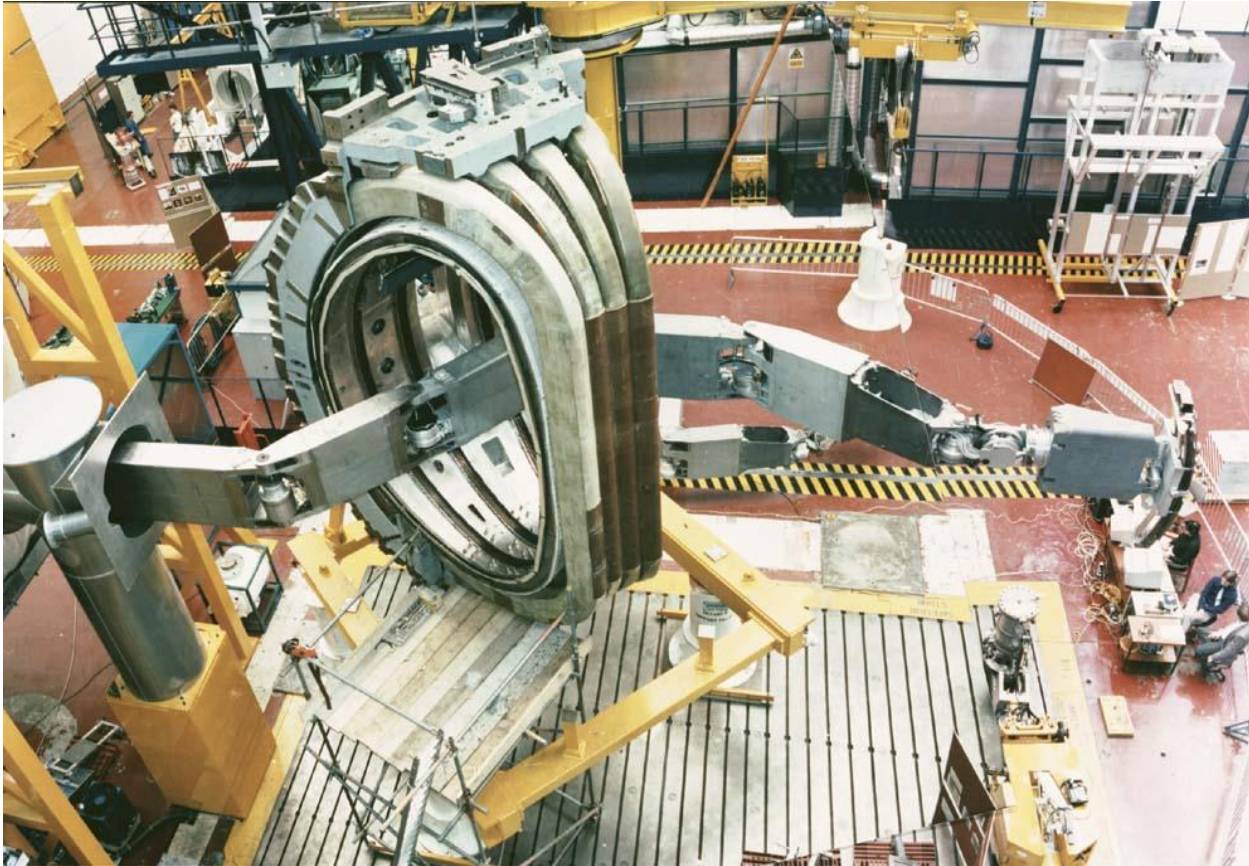
The background of the slide features a dark blue upper section. A large, white, wavy shape curves across the middle, resembling a stylized wave or a ribbon. Below this, the bottom portion of the slide is filled with a blurred, abstract pattern of red and orange colors, suggesting a fiery or energetic environment.

Dexterous Manipulator

- Dexterous, Force Reflecting, Master-Slave Manipulator
 - 20kg per arm
 - 100gm sensitivity
 - High bandwidth
 - Very smooth motion
 - High resolution



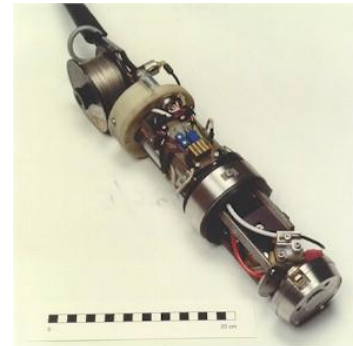
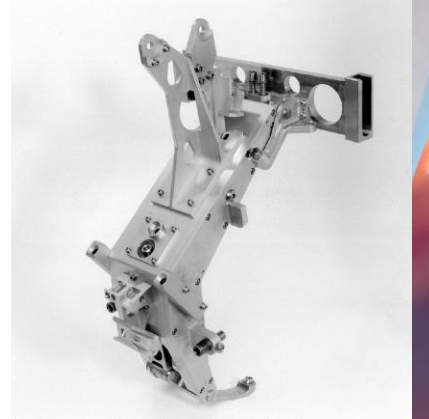
Remote Handling Transporter



Remote Handling Tooling




- Fastening & Torqueing
- Lifting/Manipulation/Handling
- Inspection
- Cutting
- Vacuum Quality Welding
- Structural Welding
- 2D & 3D Metrology
- Swabbing / Sampling
- Monitoring
- Cleaning



Remote Handling HMI



JET Remote Handling Achievements and Challenges

The background of the slide features a dark blue upper section. Below this, there are several overlapping, wavy, organic shapes in light blue and white. The bottom portion of the slide is a solid, bright yellow color.

Achievements

- Fully Operational since 1997
 - > 30,000hrs remote operations
 - > 25,000 individual RH tasks
 - > 40 fully trained operators
 - < 5 RH system failures needing recovery
 - 0 RH system failures needing rescue



Challenges

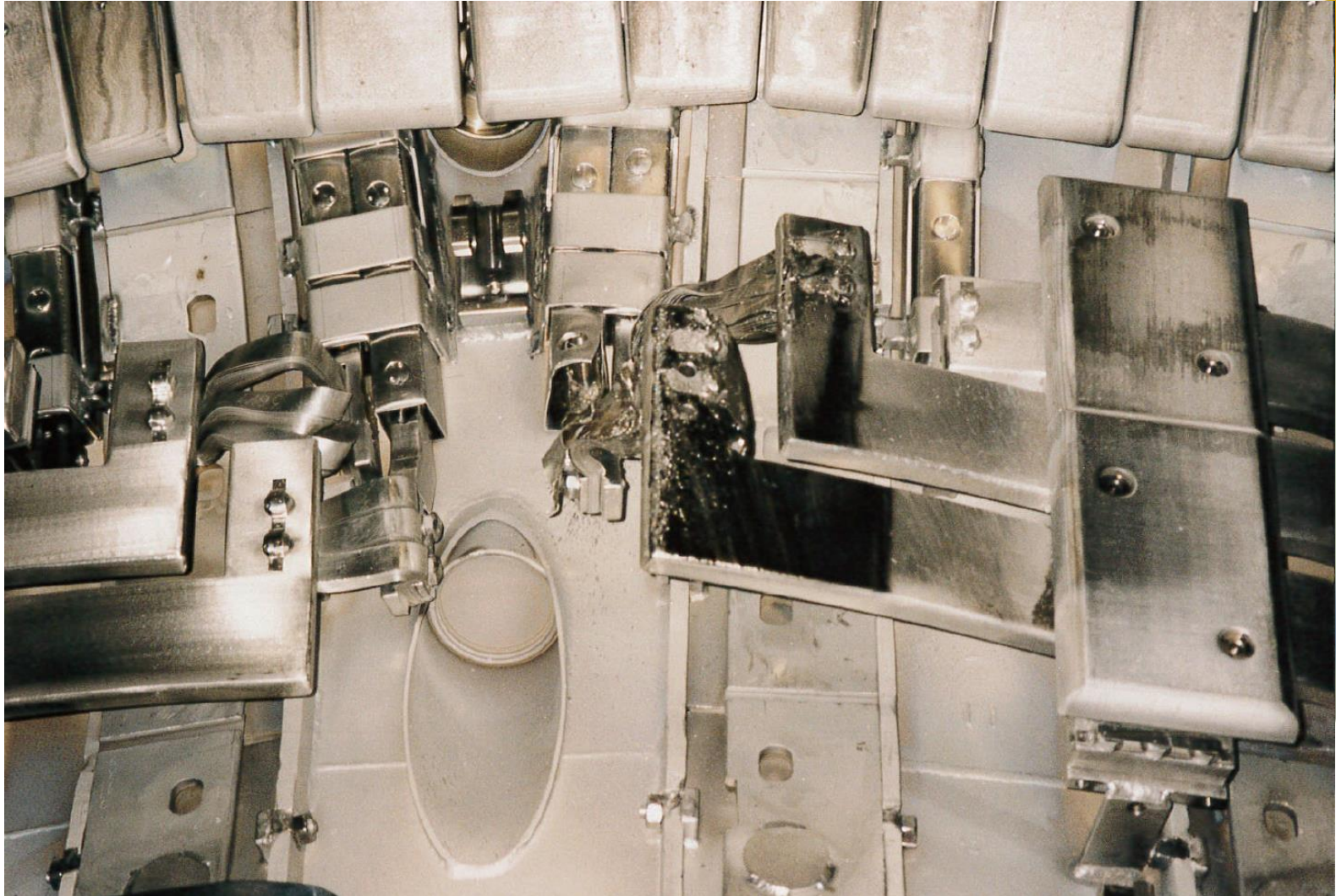
- Unplanned Operations
- Components not designed for RH compatibility
- Changes driven by the Experimental results
- Faults within the RH system



Challenge – Damaged Components



Challenge – Damaged Components



Challenge – Damaged Components

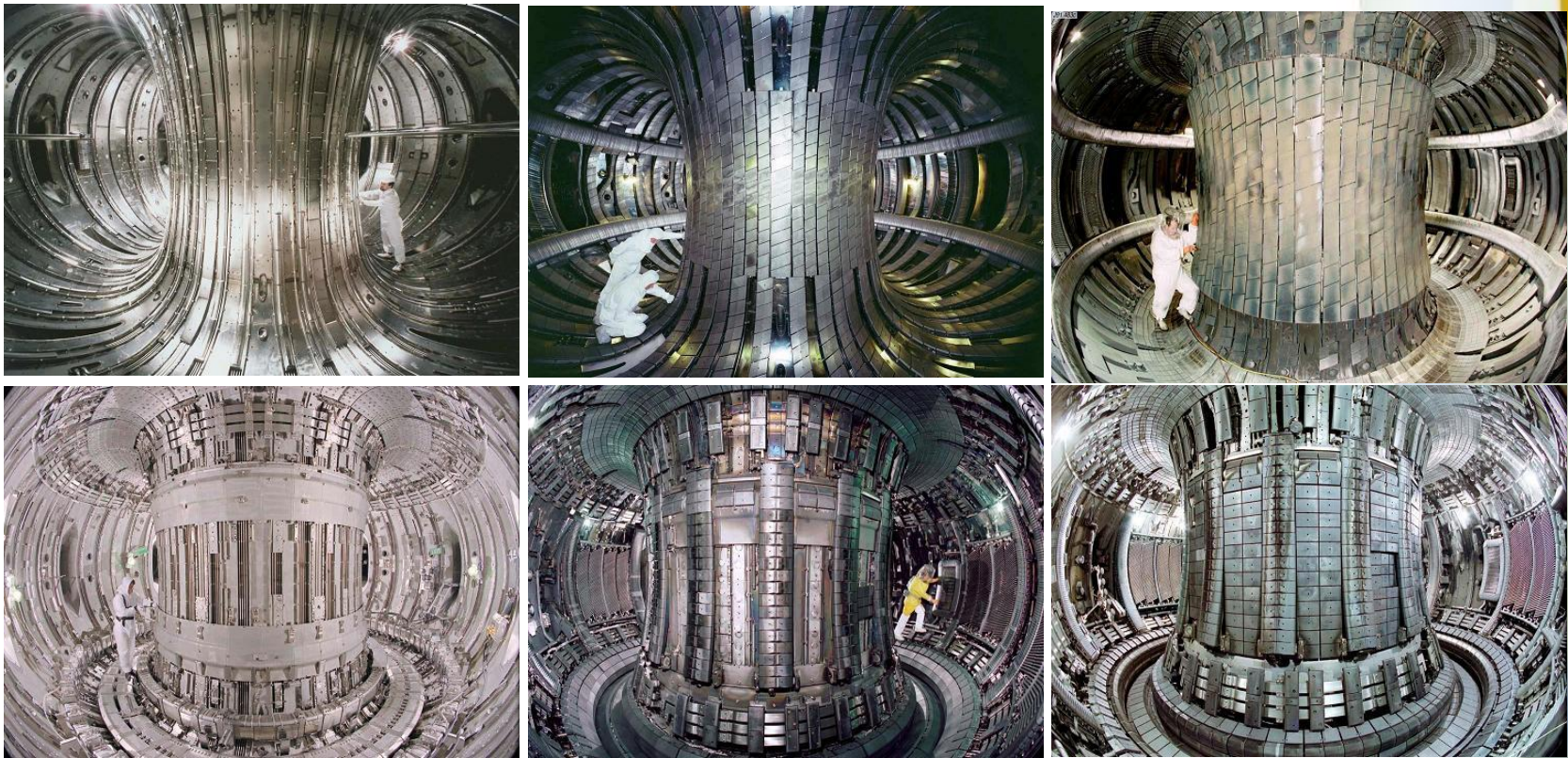


Challenge – Component Design

- Components not designed for RH compatibility
- Typical problems are:-
 - lack of small part captivity
 - no visual cues
 - no alignment guides
 - no information about weights and c of g
- Tasks take 5-10x longer than with RH compatible components



Challenge – New Tasks



Challenge – RH System Faults

- Faults within the Remote Handling system
- Detection
- Location
- Recovery or Rescue
- Repair



Benefits of Experience

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Seek a simple philosophy

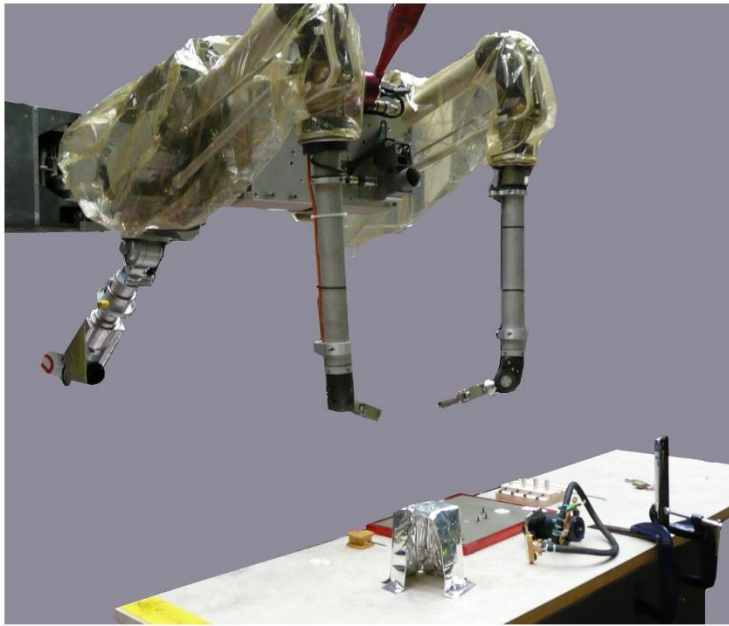
“Imagine each RH task to be done as you would do it if there was no hostile environment”

“ A trained RH operator can do any task remotely that the same operator can do hands-on”



Value of a simple philosophy

Challenge from the UK Space Industry



Value of a simple philosophy

Challenges from CERN

- Handling of chain type clamps for water pipes
- Handling of gaskets
- Cutting of cable ties
- Guidance during crane lifting
- Disconnection & reconnection of vacuum flange
- Painting resin around beam pipe bellows



Summary

- The nature of High Energy Physics experiments is that they are variable and demand an adaptable RH approach.
- The JET RH System has demonstrated the feasibility and practicality of creating “Telepresence”.
- Approach each remote handling challenge by mimicking how the same tasks are done in a non-remote environment.

Acknowledgments:

The work presented here is the result of the combined efforts of the JET Joint Undertaking remote handling team 1984-1999 and the EFDA-JET remote handling team 2000-date.

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Questions Please....

