Magnox

Use of Digital Engineering in SGHWR Decommissioning

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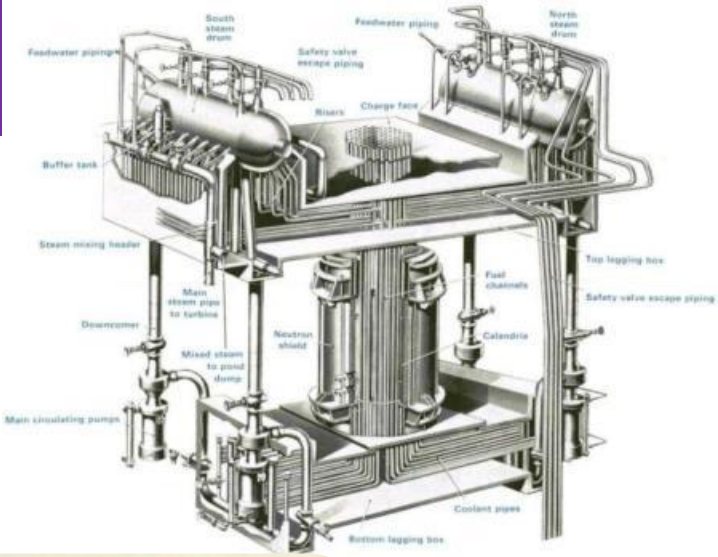
SGHWR Digital Engineering

Content

- **Introduction to SGHWR Decommissioning Project**
- **Use of Digital Engineering in SGHWR Decommissioning:**
  - Digital Imagery of Primary Containment
  - 3D CAD Model
  - Cloud Point Survey
  - Federated 3D CAD Model
  - Robotics
  - Virtual Reality Training
  - Use of Drones

SGHWR Decommissioning Project



Steam Generating Heavy Water Reactor

300 MW(th), 100 MW(e) Prototype Reactor

Operated 1967 – 1990

Remaining Work Scope:

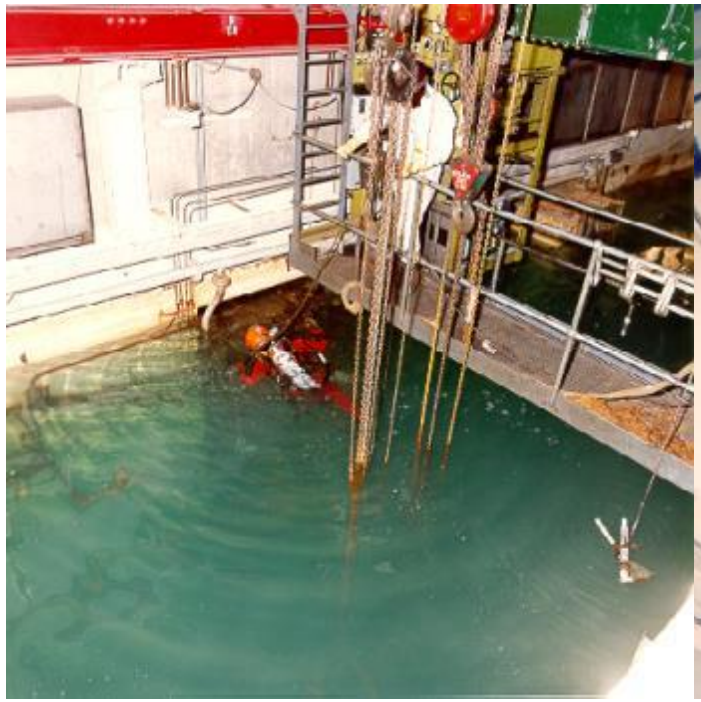
- Primary Containment Asbestos Clearance
- Reactor Core Decommissioning
- Final Decommissioning
- Demolition and Site Restoration

SGHWR Decommissioning Key Achievements

- **Secondary Containment Decommissioning:**
  - 1991-1994: Defueling, decontamination and POCO of reactor following shut down.
  - 1993-1996: Deplanting, drainage and decontamination of fuel ponds.
  - 2005-2007: Deplanting of Secondary Containment; 3,000T of plant removed including refuelling machines, rotating shields, turbine, alternator, condenser, and deaerator tank.
- **External Areas:**
  - 2001-2012: Processing of SGHWR sludges; demolition of sludge tanks and cooling towers.
- **Primary Circuit Deplanting:**
  - 2015-2020: Removal of primary circuit plant such as steam drums, valves, pumps, tanks, pipework and lagging from high asbestos and radiological hazard environment.

SGHWR Decommissioning Key Achievements

- **Secondary Containment Decommissioning:**



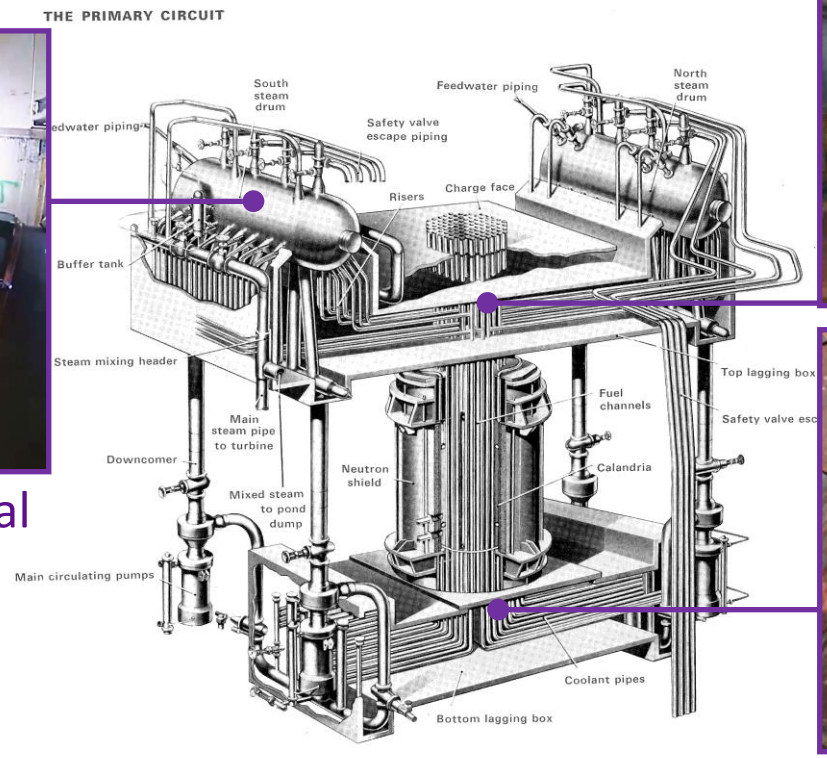
Fuel Pond Decommissioning

Refuelling Machine and Rotating Shields

SGHWR Decommissioning Key Achievements

- **Primary Containment Decommissioning:**

In situ size reduction and removal of Steam Drums in sections



Removal of Steam Risers back to Standpipes above Core

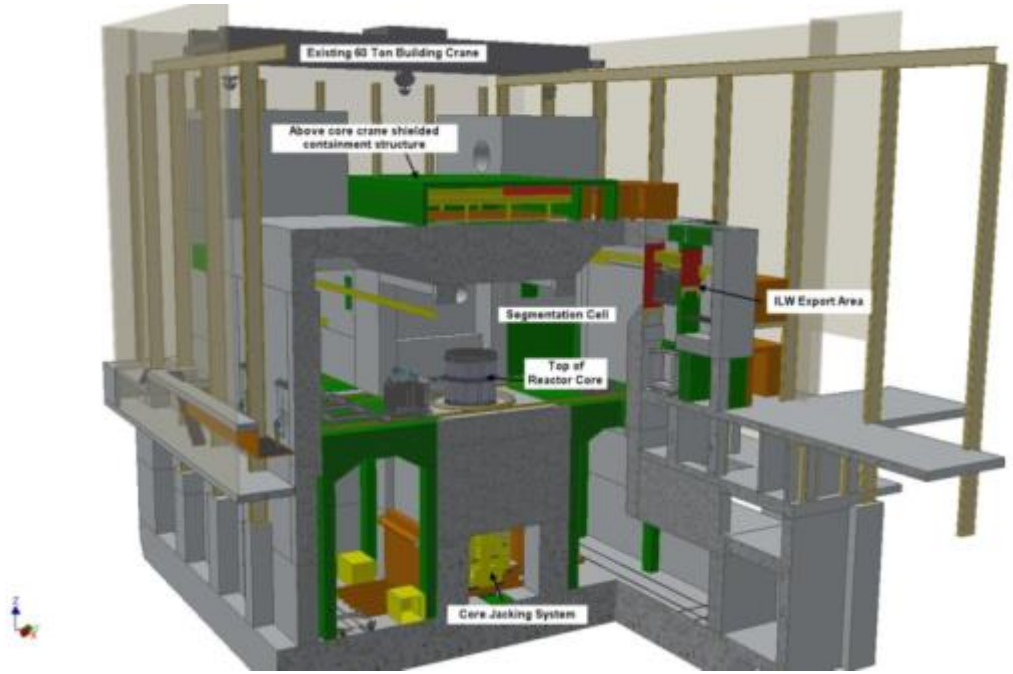
Removal of Feeder Pipes to underside of Core

SGHWR Decommissioning Key Achievements

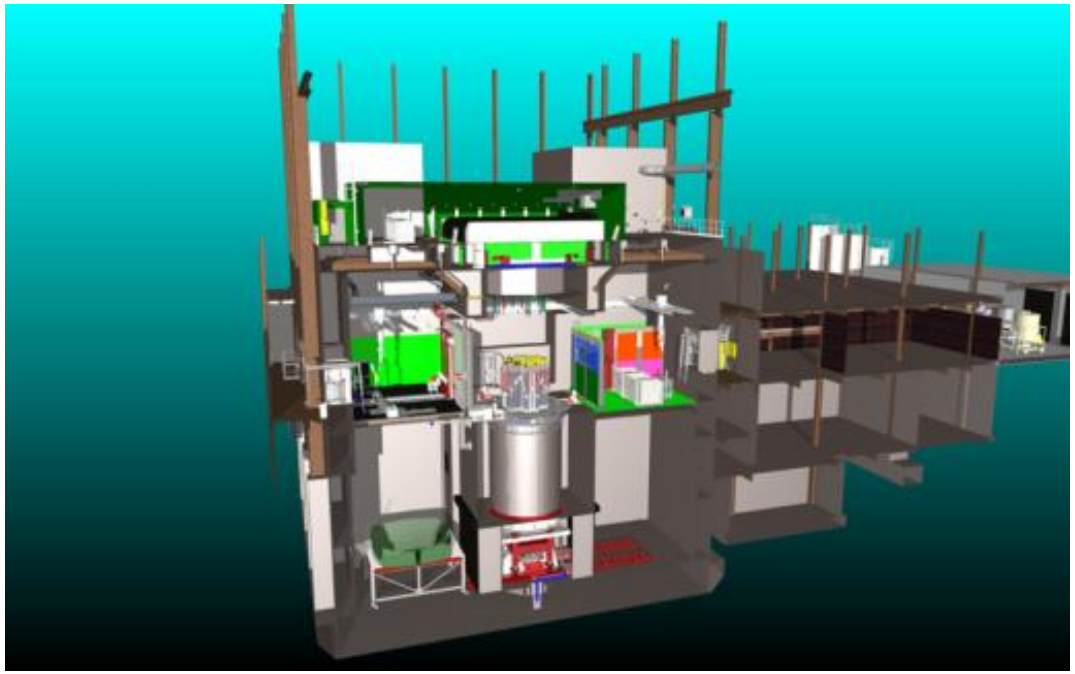
- **Reactor Core Decommissioning:**
  - 2005-2006: Preparation of Magnox Concept Design to decommission SGHWR core.
  - 2006-2007: Preparation of Magnox Scheme Design started but paused due to funding.
  - 2013-2014: Preparation of Magnox Scheme Design resumed and completed.
  - 2015-2016: Specification, tendering and award of Detailed Design and Build contract.
  - 2016-2017: Review and update of Scheme Design by DD&B contractor (JFN).
  - 2017-2021: Preparation of Detailed Design and Safety Case Documentation.
  - 2017-2020: Robot deployment trials, prototyping and remote cutting trials.
  - 2018-2019: Construction of Interim Curing Facility outside SGHWR.
  - 2018-2022: Manufacture and supply of long lead items (e.g. core jacking system).
  - 2019-2020: Installation of contractors cabins for main construction phase.

SGHWR Decommissioning Key Achievements

- **Reactor Core Decommissioning:**



Magnox Scheme Design completed 2014



JFN Scheme Design completed 2017

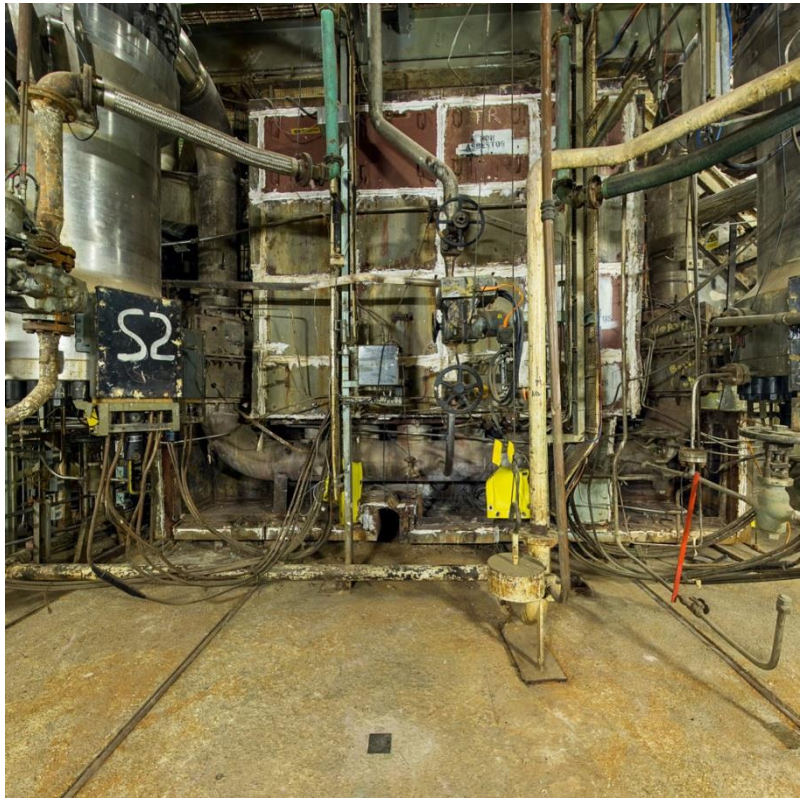
SGHWR Project Status

- **Primary Circuit Deplanting:**
  - All primary circuit plant now removed from Primary Containment.
  - Awaiting completion of four stage clean and asbestos clearance.
- **Reactor Core Decommissioning:**
  - SGHWR DD&B contract awarded to JFN in 2016; design and construction safety case modification nearing completion.
  - Some construction work in progress and long lead items in manufacture; main construction phase due to start soon.
- **Secondary Containment Decommissioning:**
  - High volume (350 rooms), low hazard and works progressing in parallel with above.

Primary Containment (PC) Digital Imagery

- **Electronic image system created to view PC remotely to enhance safety of PC deplanting operations:**
  - Primary circuit deplanting in the PC deplanting was high hazard work (both radiological and asbestos); access was strictly restricted and controlled.
  - Digital 360° images were recorded at multiple fixed points within the PC.
  - Interior of PC viewed from these positions and image rotated left and right, and up and down to see all viewing angles from each position (just like Google Street View).
  - Image system allows all areas of the PC to be viewed from a safe location outside the PC.
  - Image system also ipad based and image selected or changed by rotating/tilting ipad.
  - Used to minimise personnel entry time in the PC for planning, pre-work briefings, etc.
  - Valuable tool to show the condition of the PC to others and inform stakeholders.

Primary Containment (PC) Digital Imagery



Images of Plant in PC Basement Areas

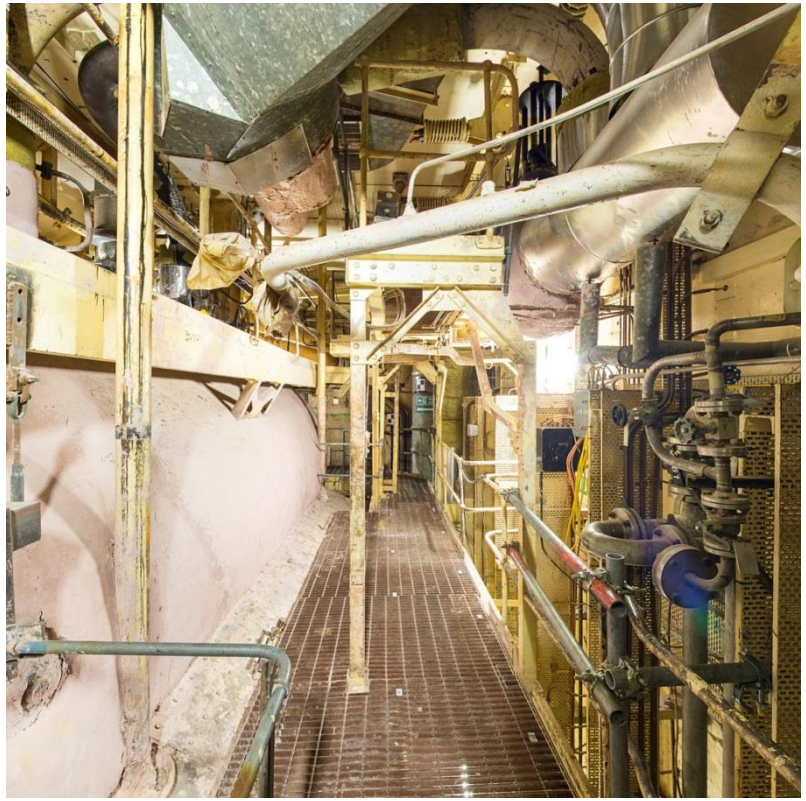


Image of Steam Drum Platform

3D CAD Model of Primary Containment (PC)

- **Autodesk Inventor 3D model of PC structure and interior was created as part of Magnox Scheme Design:**
  - 3D model created from archive construction drawings updated with known structural modifications, plus forecast condition of the PC after deplanting.
  - 3D model used to develop the core segmentation methodologies and identify required structural modifications and equipment requirements to decommission the core and process and package resultant wastes.
  - 3D model also used to prepare computer animations to present proposed core segmentation methodology to stakeholders.
  - 3D model and animations also used to present the Magnox Scheme Design to tenderers for Detailed Design and Build contract.

3D CAD Model of Primary Containment (PC)

Images of the Magnox Scheme Design completed in 2014

Cloud Point Survey of Primary Containment (PC)

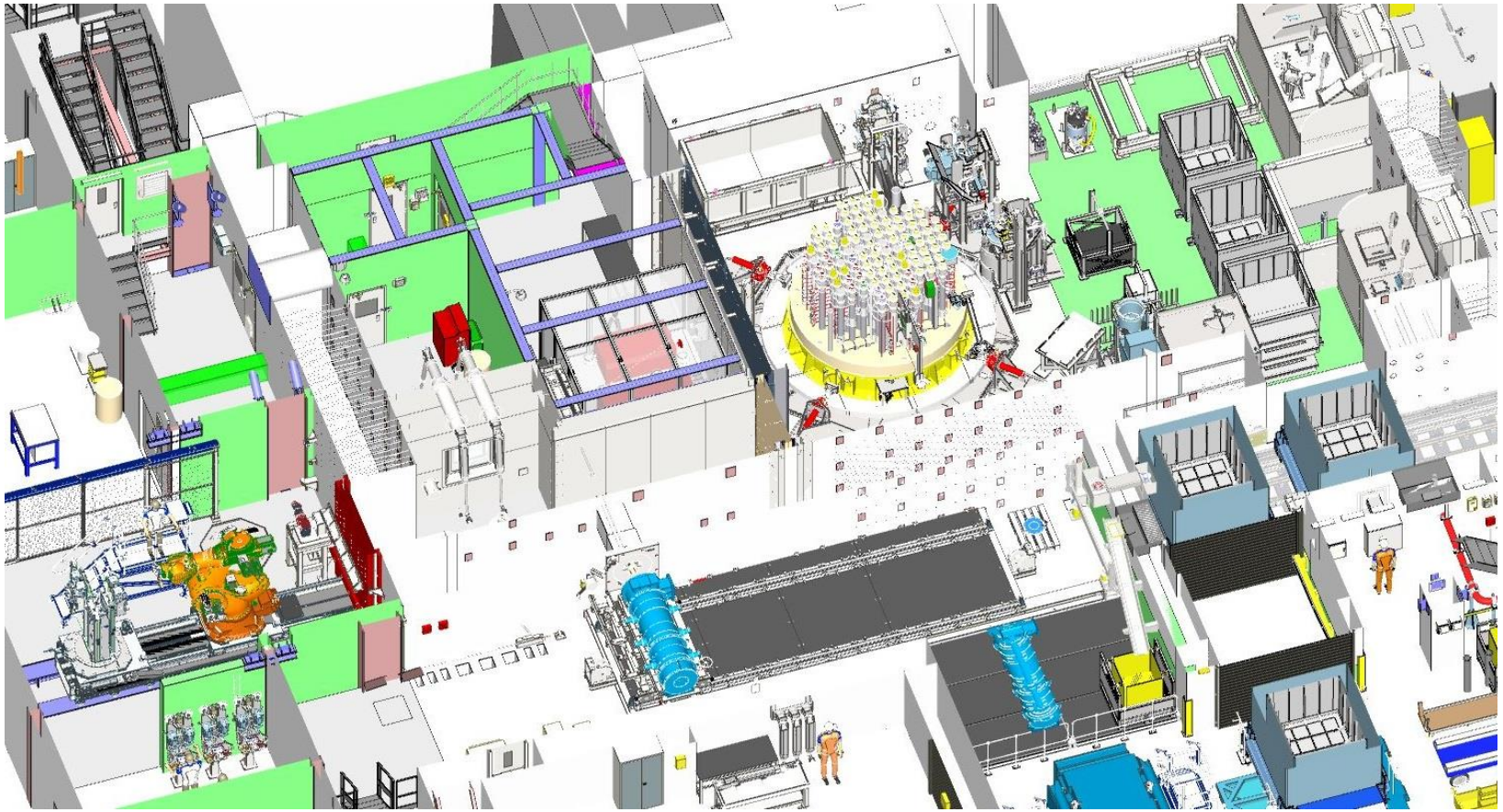
- **Digital cloud point survey (laser survey) of PC interior was taken to confirm actual positions and dimensions of the PC structure:**
  - Cloud point survey carried out by laser scanning at several positions inside the PC with fixed datum points.
  - Laser survey compared with construction drawings to confirm exact actual dimensions.
  - Cloud point survey carried out by the Detailed Design and Build (DD&B) Contractor early in detailed design phase to confirm critical civil and structural reference design information.

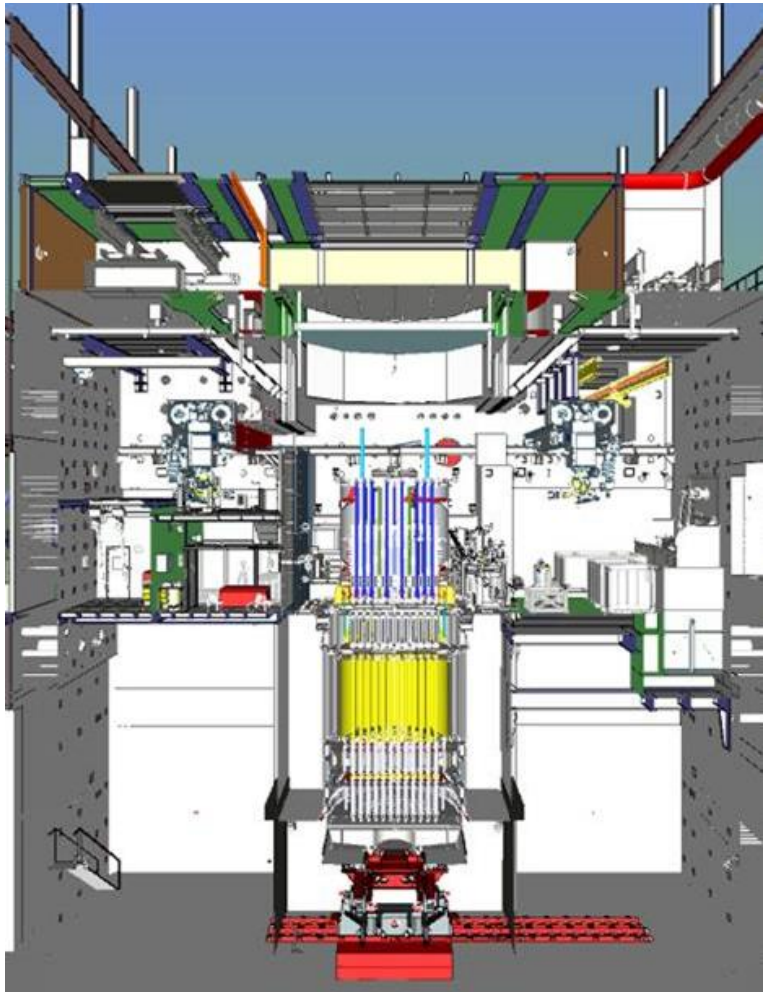
Federated 3D CAD Model

- **DD&B Contractor created 3D model for Detailed Design:**
  - DD&B Contractor created detailed Autodesk Inventor and Revit 3D models which are brought together in an integrated overall 3D model using Navisworks.
  - Federated 3D model used to develop and finalise segmentation methodologies, detailed civil and structural modifications, and detailed plant and equipment requirements.
  - Federated 3D model used to prepare Detailed Design information for required civil and structural modifications, manufacture, supply and install required plant and equipment, and identify quality management, testing and commissioning requirements.

SGHWR Digital Engineering

Federated 3D CAD Model





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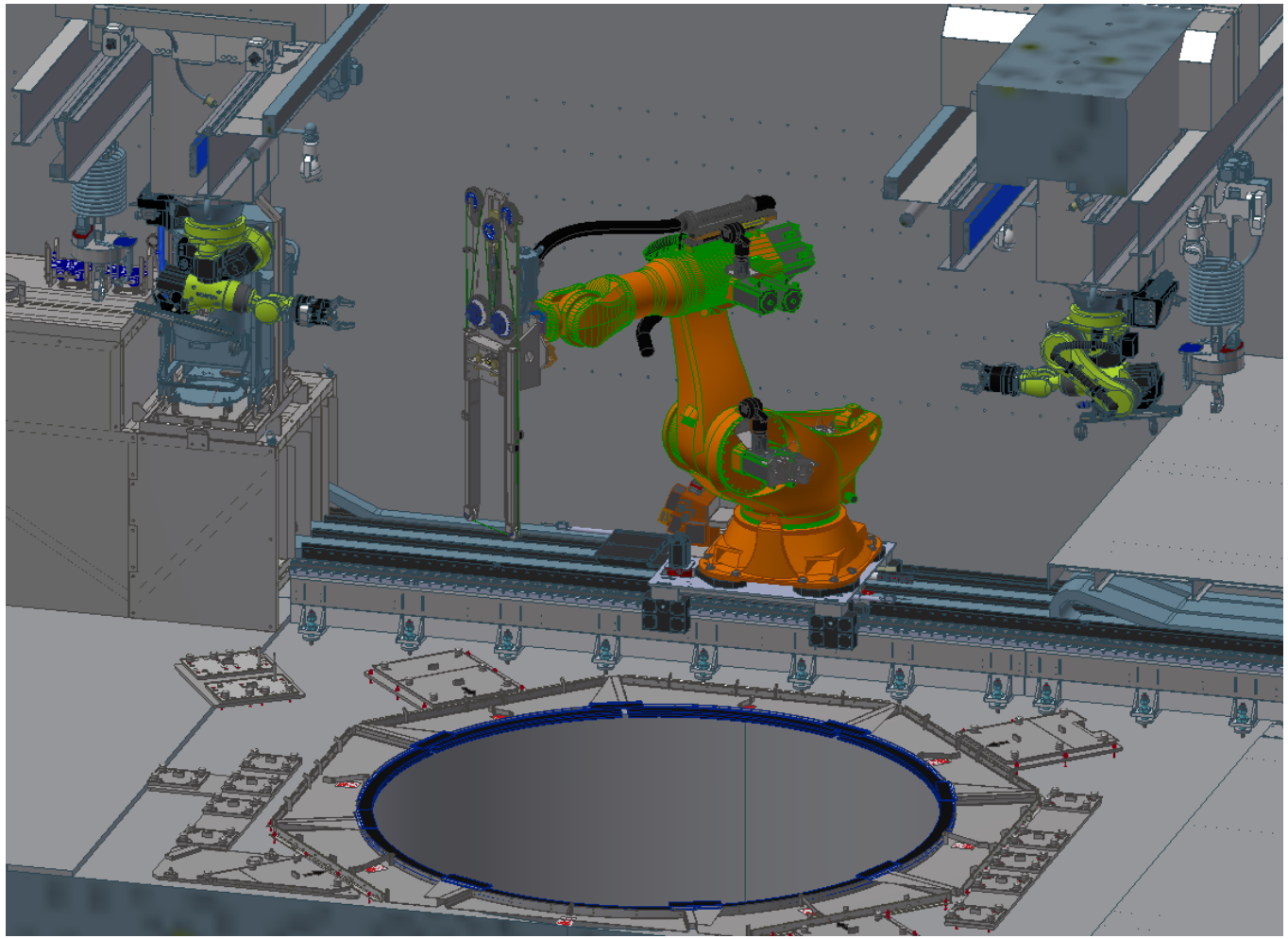
Use of Industrial Robots

- **DD&B Contractor using Industrial Robots as Smart Manipulators:**
  - The DD&B Contractor has identified the use of industrial robots to deploy remote cutting and handling equipment in the segmentation cell. This includes a large 750Kg capacity robot on a floor track system and 130Kg capacity robots on gantries.
  - Industrial robots are off the shelf and have programmable capabilities, e.g. automatic tool change and actuation of multiple joints simultaneously for linear movement in any plane.
  - Decommissioning is a series of sequential specific tasks; not repetitive operations (e.g. production line), hence only limited robot programmability functionality being used.
  - This is an efficient adaption of COTS equipment to avoid expensive bespoke alternatives.
  - Further cost efficiency has been achieved by reusing second hand units for the large 750Kg capacity robot.

Use of Industrial Robots

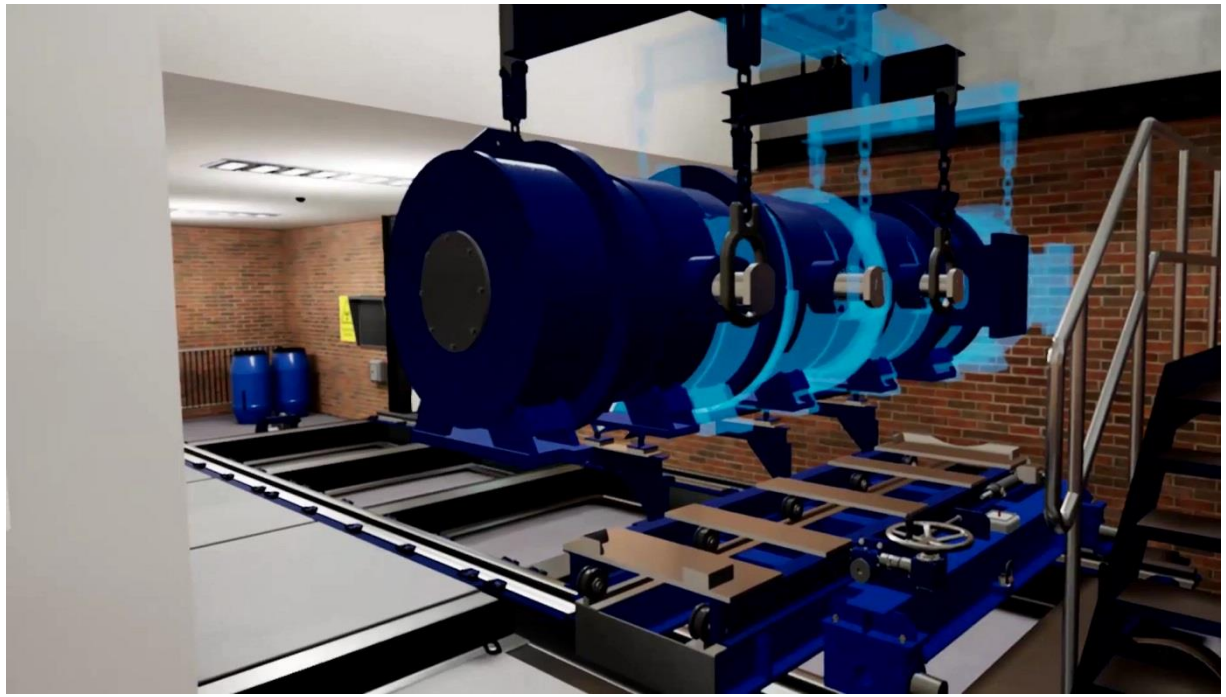


Virtual Reality Training

- **Virtual reality simulations developed to visualise as built plant:**
  - SGHWR VR simulations developed as an initial trial in conjunction with Exeter University.
  - The flask route to export high end ILW from SGHWR has been simulated from 3D model.
  - 3D images fed to a headset to visualise and move within the 3D model to experience the as-built plant, e.g. experience flask handling, positioning and loading and to visualise how much space there is, what the equipment and tooling looks like, and how it is used.
  - The trial is an initial demonstration to show how designs can be reviewed and operators trained in safe locations, before plants are constructed.
  - The SGHWR design was updated following feedback from operator simulations.
  - Further opportunities for virtual reality training in SGHWR will be explored as the design matures and is completed.

Virtual Reality Training

- Virtual reality simulations developed to visualise as built plant:



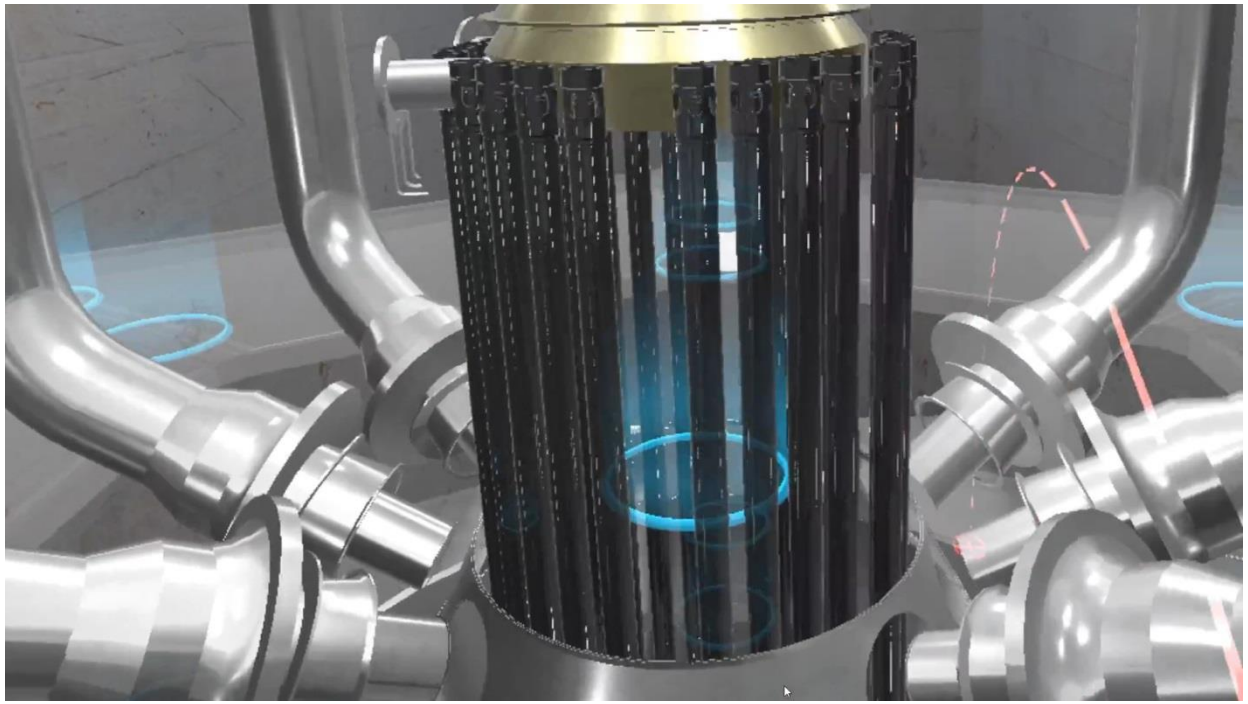
VR images of Modular Flask handling operations in SGHWR

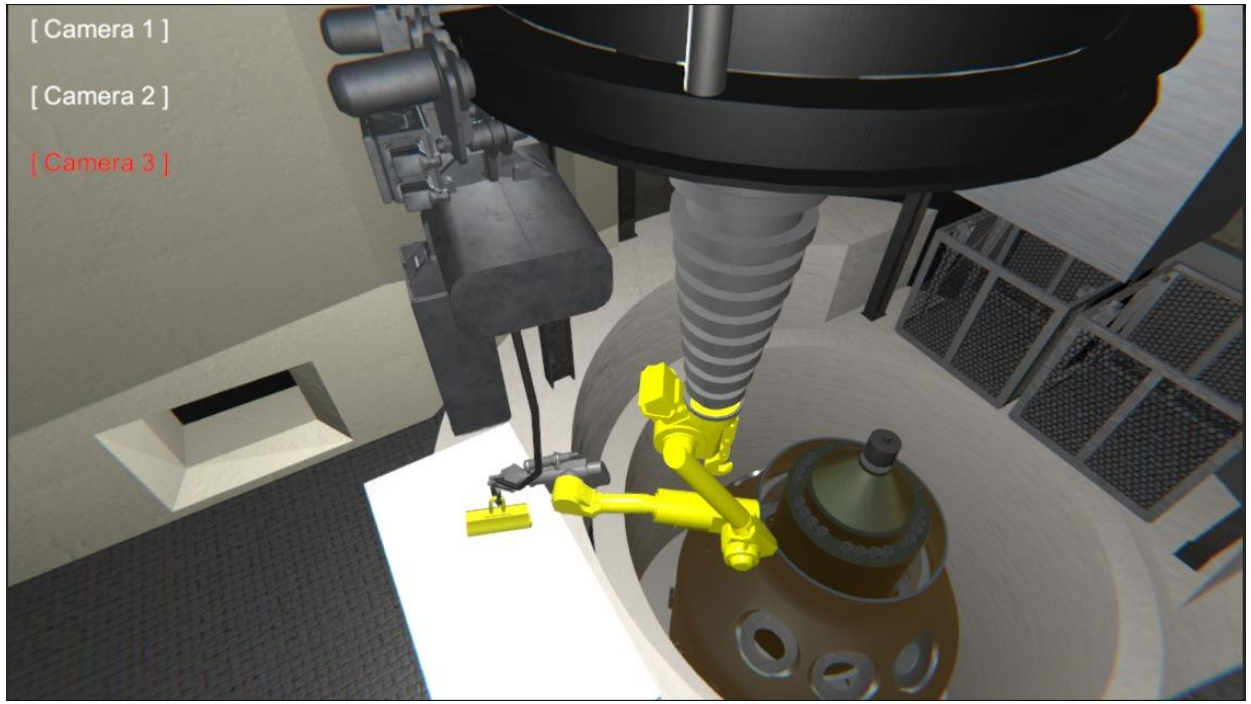
Virtual Reality Training

- **Virtual Reality technology also deployed at Dragon:**
  - Following SGHWR trials, further VR simulations have been developed at Dragon.
  - **Phase 1**: Conversion of 3D model of Dragon Reactor core into real-time head-mounted Virtual Reality allowing operators to familiarise themselves with the construction of the core. Enables operators to explore a life-size model of the core and investigate individual components to enhance their understanding of the working environment.
  - **Phase 2**: VR model augmented with manipulator and tools to simulate core dismantling operations. Operators can experience of cutting and manipulating virtual core components to enhance spatial awareness and trial and optimise different methods prior to using equipment for real. Also facilitates design review and improvement.
  - VR models have been created and trials with operators have started.

Virtual Reality Training

- Virtual Reality technology also deployed at Dragon:





VR images of the Dragon Reactor and deployment of Decommissioning Equipment

Use of Drones

- **Drones have been used to avoid personnel working at height:**
  - Drones are now in general use at SGHWR and elsewhere at Winfrith to supplement works that would otherwise require working at height, e.g. building inspections and surveys.
  - Internal and external structural building surveys are carried out initially by drone with localised manual inspection of any areas of concern. This significantly reduces the amount of working at height required and reduces the cost of providing safe access for working at height.
  - The potential to carry out asbestos clearance surveys of large interior structures by drones fitted with high definition cameras is being explored. If successful, this will also reduce the amount of working at height required and the cost of providing safe access.

Use of Drones

Drone used at SGHWR

Recent Drone view of SGHWR

Visual survey/inspection of roof by Drone

Questions?