

Testbed for Dexter Capabilities in Fukushima Daiichi

Abingdon, UK



| The Challenge

The Small scale Fuel Debris Retrieval system (SFDR) will be retrieving small amounts of fuel debris from the inside of the unit 2 reactor at the Fukushima Dai-ichi nuclear power plant for collection and analysis. The 18m long SFDR boom system is retracted into an enclosed cell of 8.8m x 2.2m x 1.9m equipped with ports to allow the clean import and export of tools, as well as the fuel debris. The containment cell also holds a Dexter manipulator which will be used to perform tasks such as changing tools on the boom, collecting and sealing fuel debris for export, as well as decontaminating the boom and cell.

The Testbed project investigated these remote handling tasks and identified the challenges for Dexter when performing remote handling operations in this environment.



Fukushima Dai-ichi - Japan



Contract Facts:

PROJECT: Testbed
PROGRAM: SFDR
CLIENT: MHI
EXPERTISE: Remote handling analysis and dexterous manipulators

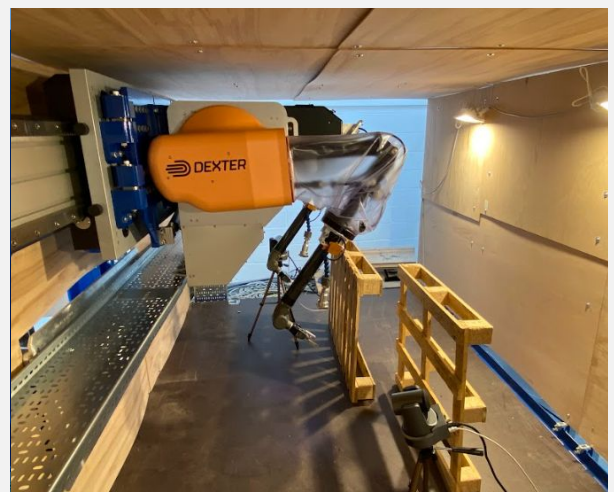
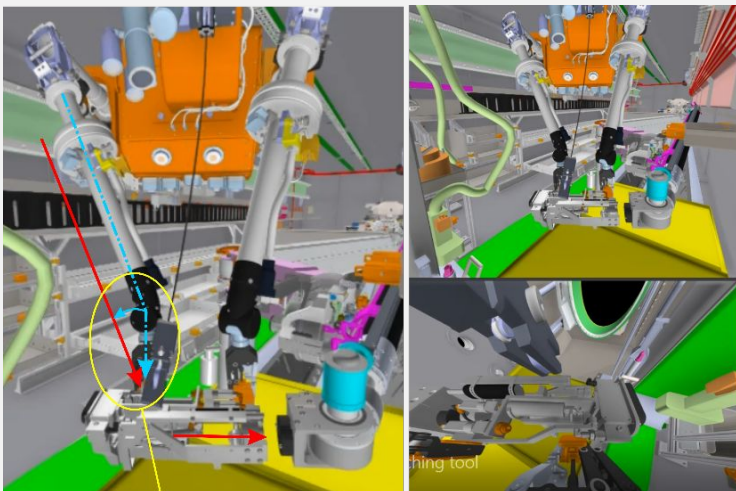
Dual arm local and remote manipulator pair

Human-in-the-loop control

Mockup environment representing the containment cell for robotic retrieval of fuel debris samples at Fukushima Dai-ichi

| Veolia's Solution

VNS UK created a mockup environment representing the containment cell, both in virtual reality and as a full-scale physical mockup. As part of our Retiina Digital toolkit, VR4Robots was used to plan and practice the remote handling tasks, study the motion and loading on Dexter, as well as the camera views and tools that would be required. VNS UK remote handling operators then performed the same tasks from a representative control room using Dexter in the physical mockup. This allowed us to validate the remote tasks handling tasks and design within the environment.



The Testbed trials and analysis: The Testbed project combined the use of digital tools and a physical mockup to test and analyse a variety of tasks that will need to be performed by the Dexter manipulator within the SFDR containment cell. These include changing the tool on the end of the SFDR boom, collecting and packaging the fuel debris samples recovered by the boom and posting them out of the containment cell for analysis, and wiping down the boom and tools to minimise radiation exposure in the cell.

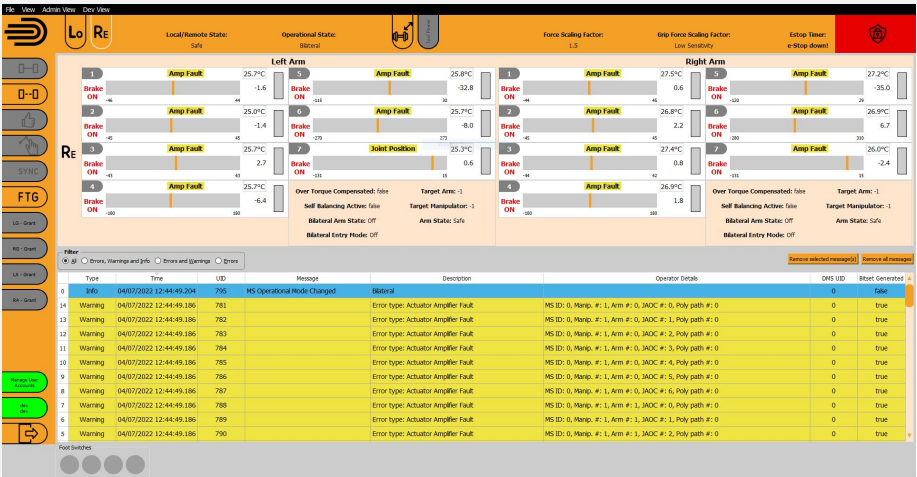
The digital mockup is created using the Retiina Digital Toolkit for remote handling operations, consisting of VR4Robots, a Human Machine Interface (HMI), and an Operations Management System (OMS). The VR4Robots Simulator contains all of the features of the SFDR enclosure, with the boom and the Dexter able to be manipulated. Measurement systems and collision warnings are used to plan and then assess each move needed for a remote handling task. The tasks are recorded in the OMS as Operations Sequence Descriptions (OSDs) including images of the VR that will help operators understand the task and their surroundings when performing the physical trial. The OMS database allows operators to follow an OSD step by step, recording observations, signing off milestones, and updating the OSD based on any issues encountered during the trial. Operators use Retiina alongside the physical mockup to give them as much information as possible about the task, such as using the VR to visualise the next step and supplement camera views.

The physical testbed mockup consists of a 1:1 scale of the cell, equipped with rails to allow the Dexter manipulator to travel along the full length of the enclosure, and wooden replicas of the SFDR boom system and in cell structures. Running through the tasks in the full-size mockup and representative control room allows operators and remote handling analysts to consider the full trial, from dexterity of the remote manipulator and suitability of the tools, to reliability and comprehensiveness of the OSDs, and physical and mental load on the operator.

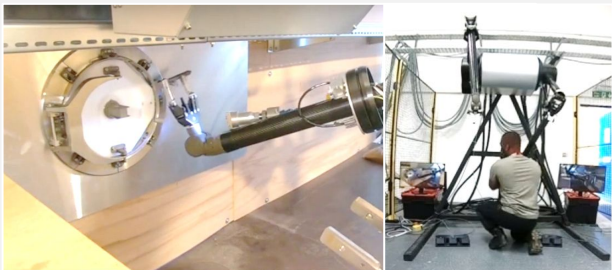
Dexter description: Dexter is a modern, distributed, force-feedback telemanipulator suitable for use in highly hazardous environments at long distances (>4 km). The high sensitivity, large range of motion and intuitive human-in-the-loop control approach makes it very easy to use for a large variety of tasks such as those found in the Testbed use cases studied.

Dexter is intended to project the human operator into the remote environment and has similar capabilities to a human arm with a continuous load of over 12kg, a peak load of 20kg, sensitivity down to tens of grams, a similar range of motion and a very transparent feel in use. This minimises the cognitive load on the operator and allows them to focus on the remote task for extended periods comfortably.

Dexter also features a range of assistive features to assist the operator such as adjustable force feedback ratios, weight compensation, virtual walls, etc. and has been integrated with a variety of third party systems in areas including safety, viewing, and control.



Dexter HMI Dexter Remote manipulator



- VNS Expertise:
- Design & build of Dexter
 - Design of remote systems for use in hazardous and complex environments
 - Retiina Software solution for remote handling operations
 - Planning, trial, and analysis of remote handling operations