

OC Robotics: Nuclear remote handling

Remote handling in radioactive environments often requires dextrous manipulators that can access a radioactive space through a small opening and avoid obstacles between the entry point and work site. OC Robotics is the world leader in snake-arm robots: remote tele-operated manipulators that can 'follow-their-nose' into confined spaces.



OC Robotics snake-arm robots

To date OC Robotics has focused on life extension projects for power generating plant. Customers around the world, including Ontario Power Generation, Areva and Ringhals AB (Sweden) have used OC Robotics' systems to conduct 'minimally invasive' maintenance and repair operations through small (typically pre-existing) access holes.

Focusing on profit-generating plant has enabled OC Robotics to grow and develop nuclear capabilities. This experience can also be applied to decommissioning tasks. This document provides an overview of OC Robotics' snake-arm robot technology and previous nuclear experience.

Whilst OC Robotics' core technology is snake-arm robots, a turn-key solution would be tailored to the demands of the specific application. OC Robotics products include a mobile vehicle, vision systems, sensors and tooling, user interface, software and electronics infrastructure that allow remote control.

- **Tooling:** Confined spaces often require specialist tools which are small enough to be manoeuvred in the space available. OC Robotics has designed tools for visual and UT inspection, manipulation (gripper), cutting/cropping, welding and fastening (below).
- **Tool services:** Snake-arm robots all have a hollow bore, which means that services are routed inside the arm to the base avoiding the risk of snagging and maintaining a smooth external surface. Snake-arm robots can also be used as a guide for delivering active or passive tools, e.g. another snake-arm robot or a videoprobe.

- **Contamination:** Snake-arm manipulators can be designed without prominent 'elbows' making them straightforward to seal against contamination or water. OC Robotics has also delivered systems that are fully sealed and air-tight to prevent air-borne contamination being taken up into the mechanisms.



Example tooling

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- **Materials:** OC Robotics has delivered systems with specific material requirements. Systems can be designed without any prohibited materials so that they are suitable for use in the nuclear industry.
- **Electronics:** A design principle of snake-arm robots is that the motors and related electronics are located in the base of the arm. There are three reasons for this: first, a lighter arm can be a longer arm; second, motors are bulky so an arm can be either smaller in diameter or have more space internally for services; third, main systems, including electronics, can be kept in an accessible area. This final point is critical for high radiation dose and wet environments.
- **Control:** The OC Robotics user interface is intuitive and easy to understand. It can be tailored to each application to ensure that the user has all the information required without being overloaded.
- **Data collection and management:** OC Robotics' user interface is able to record video and images alongside text or audio.
- **Technology integration:** The customer's own capabilities can be integrated with a solution. For example a solution may combine a snake-arm manipulator with in-house UT inspection developments.
- **Quality Assurance:** OC Robotics has worked as prime contractor to the nuclear sector and operates to a Quality Management System certified to ISO 9001.



Intuitive user interface

Explorer range of Snake-Arm Robots

Explorer range snake-arm robots vary in size from 40mm to 150mm in diameter and from 1m to 3.25m in length. These dimensions represent the mid-range of our capabilities. The strength of the Explorer design is that it is scalable, so both smaller diameters and longer reach versions are possible.



General purpose Explorer™ snake-arm robot

Options include “quick release” mechanisms between the arm and the actuators, 1 or 2 degree of freedom wrists, and a variety of different tools. Snake-arms can be integrated with an introduction axis – a linear rail, industrial robot or vehicle – to enable controlled ‘nose-following’ motion.

The Explorer range of snake-arm robots is designed to operate as a standalone unit or with an OC Robotics introduction axis. Alternatively it can be integrated with a standard industrial robot, a crane or a mobile vehicle. Using industrial robots as an example, the Explorer range can be considered as a tool on the end of the industrial robot or as a flexible fore-arm for the robot. Our proprietary software controls both the industrial robot and the snake-arm to coordinate their motion.

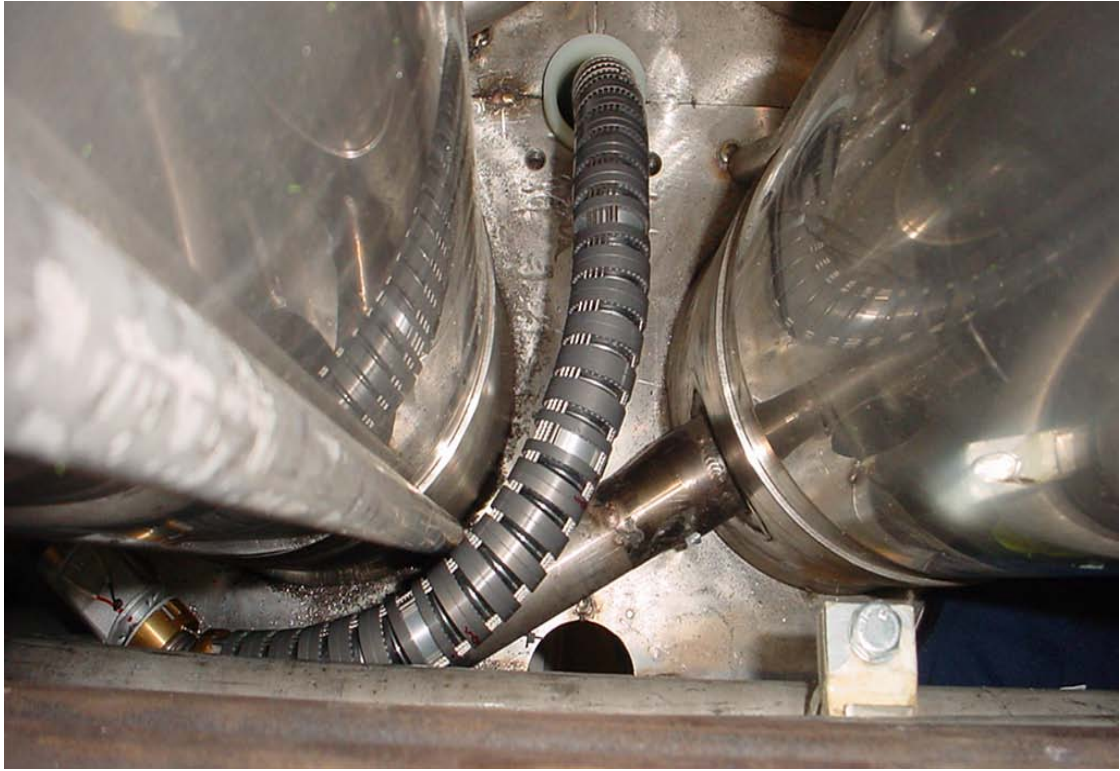
More information on the Explorer range is available at www.ocrobotics.com/catalogue.

Current and previous nuclear work

More information is available from www.ocrobotics.com/applications/nuclear.htm

Ringhals AB, Ringhals, Sweden

OC Robotics completed its first commercial nuclear contract in the summer of 2004. Working with Areva, two types of snake-arm robot were supplied to Ringhals AB to complete an urgent pipe replacement in an extremely awkward area below Ringhals 1. The Inspection Arm, the more flexible of the two snake-arms, was 1000mm long and 35mm in diameter and was used to get the ideal camera location to monitor the process. The Manipulation Arm, which was 800mm long and 60mm in diameter, was used to deliver the processing tools and fixtures, remove the old pipe, introduce the new pipe and conduct tasks such as welding and inspection. Replacing the leaking section of pipe involved more than 30 distinct procedures with the majority being conducted by the robots working cooperatively.



Ringhals Inspection Arm



Inspection arm cameras viewing the work site



Manipulation arm within the mockup and in situ

Ontario Power Generation, Pickering, Canada

OC Robotics' SAFIRE (Snake-Arm Feeder Inspection Robotic Equipment) was designed to conduct inspections within the Upper Feeder Cabinet (UFC) of CANDU nuclear reactors in Ontario, Canada. The 2.2m long, 25mm wide snake-arm is mounted on a tracked mobile vehicle which is driven along walkways in the UFC. The snake-arm is stowed coiled for compactness and is deployed by unwinding and 'nose-following' between pipes. The snake-arm can be deployed at any angle to reach below or above the walkway, and can reach 100% of the UFC. Side and forward facing tool-mounted cameras are used for navigation and image capture. Pan-tilt-zoom cameras on the mobile and base units provide scene views and additional inspection capability.

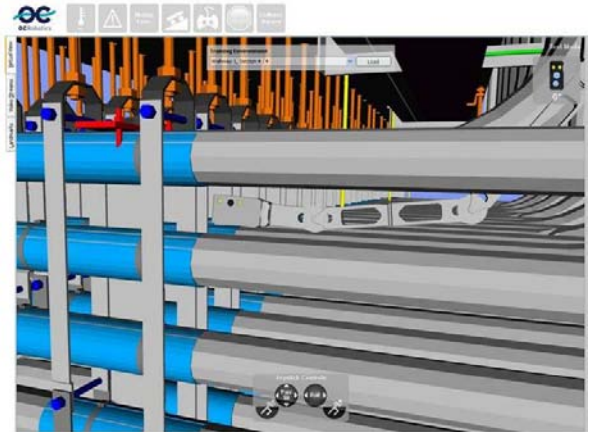


SAFIRE with arm stowed coiled

Prior to SAFIRE, inspections of the UFC were performed manually with cameras attached to the end of long probes, with inspection times limited by radiation levels. The use of SAFIRE to complete a full inspection has not only enabled improved data collection but has also reduced the total operator dose by an estimated 90%. In addition to the health and safety benefits, operator dose reduction leads to substantial cost savings to the owner of the plant.



Upper feeder cabinet (UFC)



Simulation used for rehearsals

Set-up was completed in 70 minutes from first entry into the vault to remote operation. Tear-down took 30 minutes. The first deployment at OPG's Pickering plant achieved all the target objectives, including set-up and tear down times, operator dose reduction and full inspection scope in one 12 hour shift.



SAFIRE operator console



SAFIRE with arm deployed below the walkway (in mock-up)

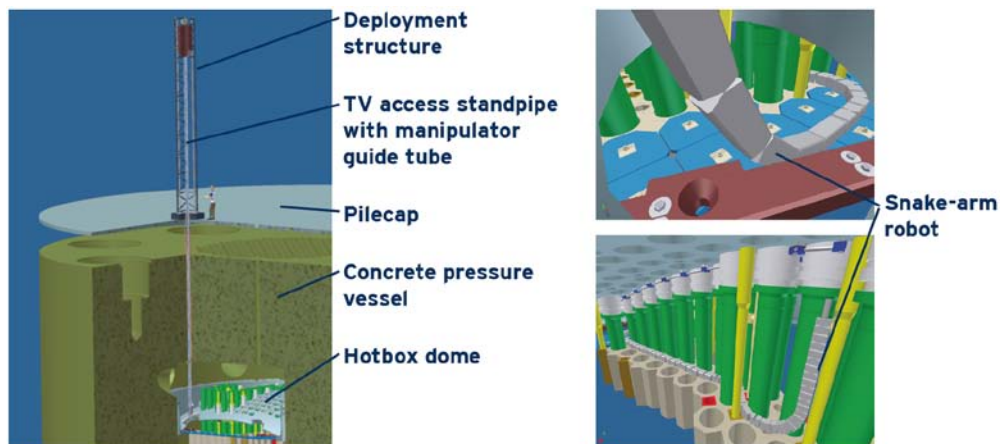
Feasibility/consultancy projects

OC Robotics has conducted a number of feasibility studies for customers in the nuclear and other sectors. These often contain analysis, simulation and concept design work which can be used to assess the viability of snake-arm technology compared to other alternatives.

Heysham hotbox dome inspection (British Energy)

OC Robotics was approached by British Energy to provide a solution which could inspect components underneath the hotbox dome at Hartlepool reactor. OC Robotics conducted a detailed feasibility contract and proposed the system below:

The device was required to operate in temperatures up to 80°C and to see a radiation dose of up to 1Sv/hr. This limited the materials and components that could be used. The proposed snake-arm was approximately 9m in length and able to carry a 1.5kg payload at the tip.

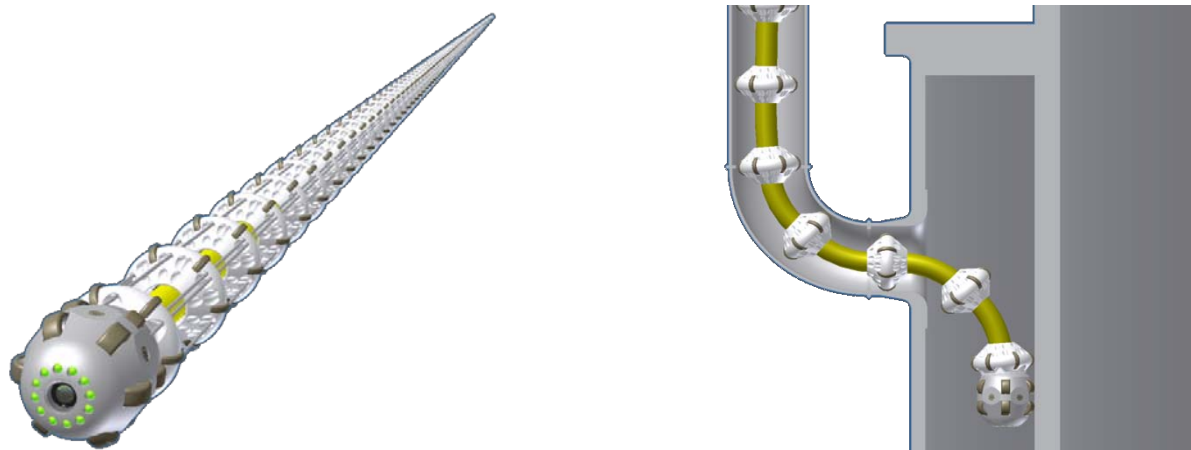


Snake-arm robot designed for Heysham hotbox dome inspection

Sellafield - vessel jacket inspection

OC Robotics investigated the design of a snake-arm to reach in excess of 10m down a multi-curved pipe in order to measure vessel wall thickness from within a vessel cooling jacket, see image below. Working within pipework requires a device which is compliant and will adapt to the bends in the pipe. However, to reach deep into a pipework system an endoscope will not suffice – friction will simply stop it going round more than a few bends. A snake-arm robot, on the other hand, is controllable along its length which means that the body of the device can be biased around each of the bends, not just at the tip.

The OC Robotics PipeSnake™ needs some structure to support its weight, such as a pipe, yet it is steerable and can be guided around bends. The biggest benefit of a snake-arm robot over an endoscope is that a snake-arm robot can be designed to include shape measurement which means that the user can know the shape of the arm and therefore the location of the tip. Users can record where defects are found and then return to the same spot during subsequent inspections to check defects over time.



The OC Robotics PipeSnake™

Sellafield - nozzle inspection

OC Robotics investigated the use of snake-arm robots to deploy remote tooling to the top of processing vessels in a high dose area. OC Robotics designed a 6m long, 150mm diameter snake-arm robot that could reach the required locations. The arm was capable of deploying a 10kg tool and sensor payload.

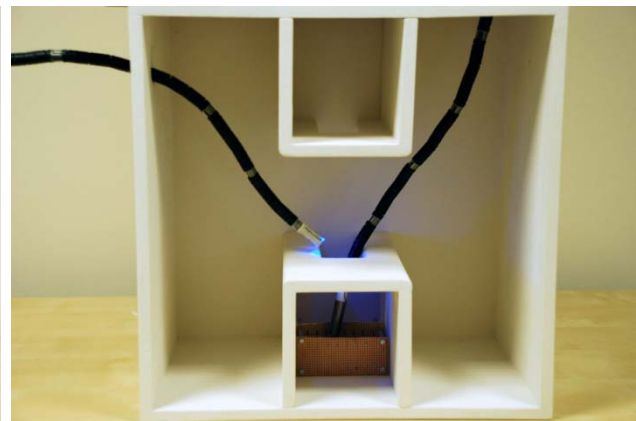
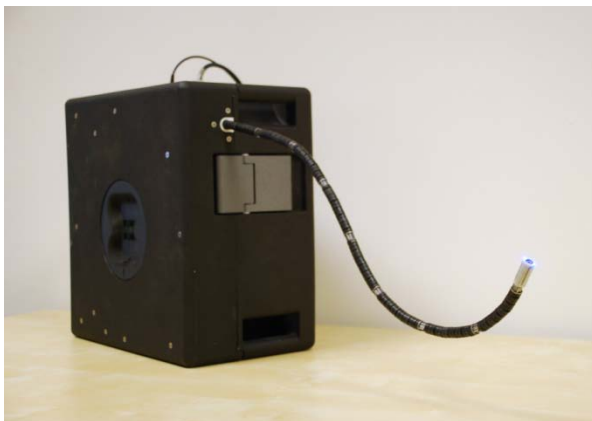


Vessel nozzle inspection

OC Robotics portable snake-arm tools

Standard flexible endoscopes - also known as borescopes or video scopes - have a long flexible body with a steerable tip. They are useful for inspection in confined spaces but they suffer from a lack of control and a reliance on the environment to support the body of the device. This means that flexible scopes cannot bridge large horizontal gaps and cannot advance around multiple corners. Snake-arm robots do not need support from the environment, they are self-supporting, and are steerable along their entire length.

The smallest fully self-supporting arm to date is 12.5mm in diameter and 400mm in length (below). It is stored in a self-contained portable unit and can be battery or mains powered.

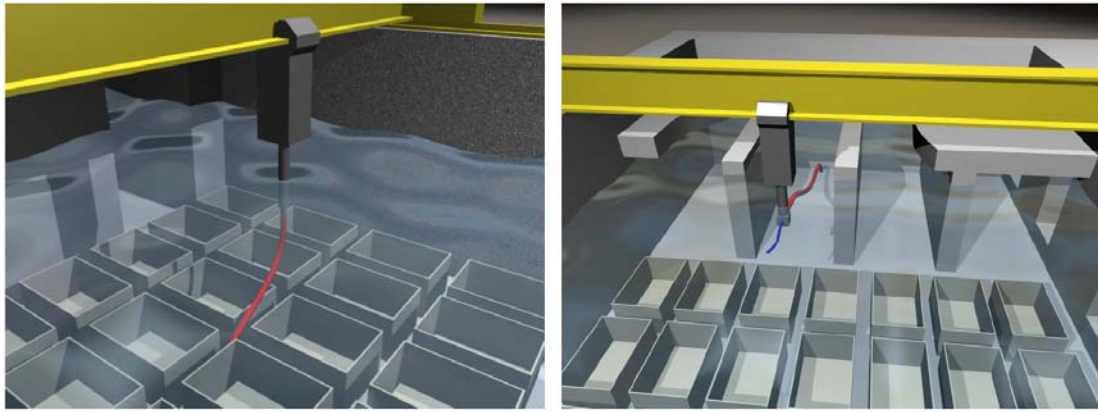


Portable snake-arms

Ponds and wet environments

When the environment can be used for support then snake-arms can be much more slender. This is also true when gravity is no longer an issue, for example if the arm is hanging vertically or operating underwater. We have designed a neutrally buoyant arm for underwater operations.

Snake-arm robots can have smooth, continuous external surfaces with all services running internally, which greatly reduces the likelihood of snagging and makes sealing and resealing easier. The combination of an easy-to-seal smooth arm and an actuator pack within an air tight container means that snake-arms are the ideal platform for washable, wet or fully submerged applications.

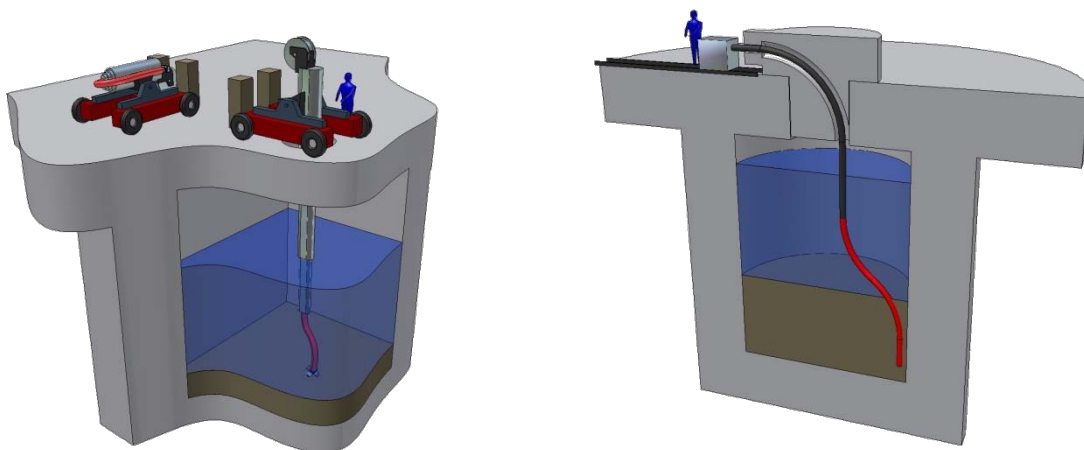


Pond clearance

Long reach and high payload manipulators

The general snake-arm robot design is very scalable and OC Robotics has talked to customers about manipulators up to 15m in length to carry significant payloads.

While very slender snake-arm robots will inevitably be unable to move large tools, a shorter, thicker arm can carry significant payloads. These arms will likely have fewer segments and are ideally suited to glove box work as an alternative to master-slave manipulators.



Long reach manipulators

Contact details

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