Sellafield Ltd

GAMECHANGERS
DELIVERING NUCLEAR INNOVATION

Dounreay

CHALLENGE: ROV positioning in featureless pond environments

The Sellafield and Dounreay sites both contain ponds which have been used in cooling and storage of nuclear fuel rods as part of the decommissioning process. Sellafield Ltd and Dounreay Site Restoration Ltd (DSRL) are seeking improved and/or novel solutions to enable them to reliably and repeatedly position ROVs and associated characterisation equipment in a pond, without use of the stored inventory as a x/y coordination guide, to aid in retrieval of radioactive waste.

These opportunities are highlighted in this Game Changers challenge statement. In addition to ROV positioning, DSRL would like to comprehensively characterise their pond structure and its contents over the next 3 – 5 years.

Both organisations have similar pond designs and are collaborating via the Game Changers process. This call for innovation is open to applicants from any sector including industries such as oil and gas, mineral mining, chemicals, civil engineering and construction. Sellafield and DSRL are seeking a proof of concept capable of deployment as soon as practicably possible.

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Introduction

Nuclear fuel ponds are typically used to store spent fuel from nuclear reactors. Fuel rods are exported from the reactor to the nuclear pond for immediate “cooling” which allows short-lived isotopes to decay and thus reduce the ionising radiation emanating from the rods.

In addition to cooling the fuel, the water provides radiological protection shielding until the rods can be sent for reprocessing or further long-term storage. In Sellafield, the pond was used solely for waste storage, whilst in DSRL, it was used both for temporary nuclear waste storage and for size reduction of irradiated material.

Sellafield Ltd and DSRL are seeking improved and/or novel solutions to enable them to reliably and repeatedly position ROVs and associated characterisation equipment in a pond, without use of the stored inventory as a x/y coordination guide, to aid in retrieval of radioactive waste.

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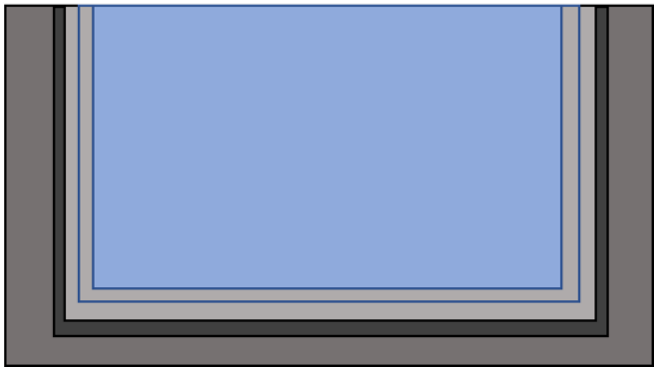
DSRL

The pond at DSRL which is the focus of this challenge was built in the late 1950s. Irradiated fuel rods were discharged into the pond where they were weighed and reduced in size, prior to being removed for the next stage of chemical reprocessing.

Figure: Pond walls with double inner layer of ceramic brick, 19mm bitumen lining, 300mm exterior concrete



The pond measures approximately 7m x 7m x 4m deep, with the water level maintained to a depth of 1.56m (max. water depth is 2.7m).

Its walls are 300mm thick reinforced concrete with a 19mm inner bitumen layer and a further two layers of grouted ceramic brick providing the inner pond wall and floor finished surface.

Historically, the pond was used to size-reduce fuel rods coming out of Material Test Reactors. As such, it is congested with decommissioned tooling associated with this process, and associated by-products (mobile particulates) as well as cables, ropes and hoses, abandoned from various attempts at decommissioning.

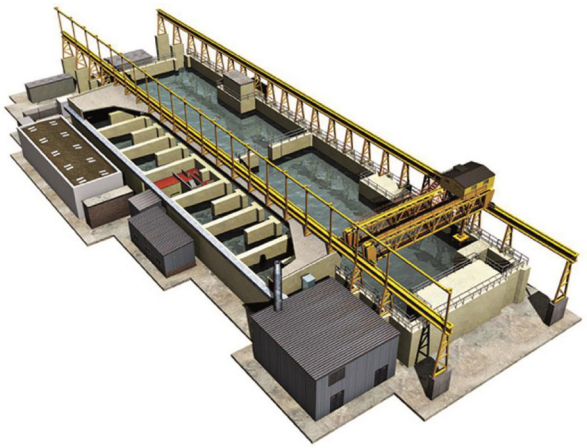
Within the next 3-5 years, DSRL are seeking to comprehensively characterise the pond structure and its contents to aid in the retrieval of waste materials as part of the decommissioning mission. Other potential opportunities beyond this specific challenge include other ponds and effluent tanks at DSRL.

Sellafield

Sellafield’s pond structures are significant in size. For example, built and commissioned between 1948 and 1952, the Pile Fuel Storage Pond (PFSP) at Sellafield provided the storage, cooling and decanning facility for the Windscale Pile reactors and early Magnox reactors. The PFSP pond structure is subdivided into an East Pond and West Pond separated by a sluice gate. The internal pond dimensions are approximately 98m long x 13m wide x 7m deep.

Sellafield are seeking technologies to accurately determine the position of their current ROV fleet (x/y coordinate) to carry out mapping activities. There is a desire to have at least one prototype system deployed within the next 12-18 months.

Across the Sellafield sites, there are several ponds which require deployment of an ROV to map stored radioactive waste and features on the pond walls and floor.



Current Practice

DSRL

At present, operators can only approach the pond (for maintenance, repair or sampling) using Air-Fed chemical suits and for a limited time period (up to 2 hours, dependant on the task). Chemical assessment is carried out via 6mm nylon tubes inserted into the pond. The congested nature of the pond means there is limited visibility, despite some external lighting above the water level.

Sellafield

ROVs with floating tethers, providing power, communication and data, are typically deployed with a range of sensors (e.g. radiometric, visual and barometric).

These can be broadly classified as:

- Inspection class machines (including Gnom and VideoRay Pro 4)
- Medium class machines (typically Seabotics and VideoRay Defender)
- Work class machines (Saab Tigers)

As the ROV moves across the pond, an operator counts the skips in the pond to determine the x/y location. Depth positioning is currently determined by a barometric gauge attached to the ROV, which is deemed suitable for purpose at an accuracy of ±150mm.

Determining x/y positioning using acoustics has proven difficult due to the close proximity of the pond's contents.

Challenge Aims

Both Sellafield and DSRL are seeking improved and/or novel solutions to enable them to reliably and repeatedly position ROVs (or similar), and associated characterisation equipment, in the pond.

The solution must be capable of mapping their respective ponds without using the stored inventory as a x/y coordination guide and must provide a reliable and repeatable method of returning the ROV (or similar) to the same point of interest. The positioning system cannot use GPS or satellite in any capacity.

The technology must have the ability to overlay multiple data feeds onto a common User Interface and store the collected data as well as viewing in real time.

Additionally, DSRL and Sellafield have some unique challenge aims which include:

DSRL

- Accuracy of the solution in the x/y orientation to be at least ±50mm
- Accurately map the pond contents from a visual (or similar), chemical and radiometric perspective, in this order of priority
- There is a strong desire not to use an umbilical as this may pose a distinct hazard meaning the ROV (or similar) may become entangled and unrecoverable
- The ability for the device to have collision avoidance capability due to the congested nature of the pond
- The deployment of secondary technology into the pond to facilitate positional location within the pond is permissible
- Aim to have a commercially deployable system within 3-5 years
- Ability to collect samples from the pond for analysis [desirable]
- Ability to add additional characterisation functionality to the device beyond deployment e.g. modular approach [desirable]

Sellafield

- Accuracy of the solution in the x/y orientation to be ±0.5m
- ROV can be attached by a floating umbilical (power, emergency recovery, data transmission etc.)
- The deployment of secondary technology into the pond to facilitate positional location within the pond is permissible
- Aim to have at least one prototype system deployed within the next 12-18 months

Benefits to the challenge owners (DSRL & Sellafield)

It is expected that solutions will bring benefits to Sellafield Ltd and DSRL's decommissioning programmes, including:

- Mapping of hazards to increase safety of divers deployed within ponds
- Potential to increase the speed of inventory retrievals, thus reducing operating hours, increasing operator safety and meeting regulatory requirements
- The ability to accurately determine the location of an ROV (x/y coordinates) without using the stored radioactive waste in the pond
- Ability to accurately determine the radiological condition of the stored waste
- Ability to accurately map (x/y coordinate) and create a record of both the pond contents and pond structure without the need for clear water
- Ability to quickly return to a point of interest in the future
- Ability to use this technology in a range of other scenarios across the NDA estate

Constraints to DSRL and Sellafield

These constraints need to be considered when developing potential solutions for either challenge:

Visibility

- Visibility is typically several metres but can be reduced to zero if sediment on the pond floor is disturbed. Operation of devices (e.g. crawlers) has proven difficult due to issues with agitation of sediment as well as congestion within the pond
- Existing stored radioactive waste within the pond is transient and therefore should not be used to determine or infer the x/y position of the ROV (or similar)

Communication

- Ability to determine x/y location in a GPS and satellite denied area. This also includes other positioning systems outside of the perimeter fence
- System to act in isolation and without requiring connection to the internet / cloud computing [desirable]
- Collected data to remain on site for processing and interrogation [desirable]
- Ability to attach positioning technology to standard Sellafield ROVs. The technology should not exceed 0.5kg (inspection class), 6kg (medium class) & 10kg (work class) ROVs
- Congestion in the DSRL pond may be an issue and the size of the ROV should be no greater than 600-900mm (length) x 300-400mm (width) x 300-400mm (depth)

Environment

- Neither ponds have any fixed datum points from which to work (bar the walls). However, points can be installed if required and should remain in-situ long-term
- Disturbance to pond surface during operation should be limited to minimise aerosol contamination

DSRL

- Must be able to operate in a pond with a pH of approx. pH 7.5
- The pond provides significant challenges to all work sub-surface where radiation levels can reach up to 7.5Sv/hr in the fine mobile particulates
- The walls of the pond, primarily the grout between the ceramic bricks, are contaminated
- The pond contains a significant quantity of heavy metals (e.g. Zinc) and some organic material
- The pond is covered with a metal chequer plate. It would be possible to allow an opening in the grid of up to ~1.5m^2. However, the size of the opening will impact on dose accruals for the operators and reduce deployment times
- Deployment of a technology is possible via a small crane (SWL 6 Tonnes) or directly by the operator
- Operator deployments are time limited (depending on the duration and frequency of the task, as well as the size of the opening noted above) and the operator will be in an Air-Fed suit

- The physical space around the pond is constrained (~2m) with access via a hatch ($3m^2$)

Sellafield

- Must be able to operate in ponds with a pH of approx. 11.5
- Dose rates of the PFSP pond provides a significant challenge to all work within the pond areas. Typical radiation levels range from 20μSv/hr to 2.5mSv/hr
- The pond has limited visibility and contents (skips) should not act as reference points as contents are transient
- The device will be required to travel the length of the pond (up to 100m) and therefore have an umbilical capable of that distance and which can float on the water surface to avoid hazards and snagging

Functional Requirements

Proposed solutions should consider the radiation levels outlined within the constraints section and the need for staff to be trained in usage, as well as the following functional requirements:

DSRL

- Technology must be able to operate in water depths of up to 2.7m and temperatures between 0°C to 20°C
- Ability to confirm location within at least ±50mm accuracy in the x/y direction and to reliably and repeatedly go to a position within the pond with an accuracy of at least ±50mm
- Semi-autonomous operation is possible
- The device must be capable of being carried by an operator (e.g. <25kg per module) and deployed within a reasonable timescale to reduce operator time in a hazardous area. Ideally, deployment would be skid-mounted or mounted on a trolley to enable routine launch or recovery to be operated remotely or semi-remotely
- The technology should be considered as non-recoverable due to contamination from the pond
- The device should allow additional characterisation functionality to be added post-deployment e.g. via a modular approach [desirable]
- As far as possible, electronics should be kept remote from the pond due to radiation levels [desirable]
- Ability to provide single or 3-phase power with a preference for power to be provided electrically or via water hydraulics over oil-based hydraulic systems
- Local lighting capability is highly likely to be required (as limited in-situ)

Sellafield

- Technology must be able to operate in water depths up to 5.5m and temperatures between 0°C and 20°C
- Ability to confirm location within ±0.5m accuracy in the x/y direction and to reliably and repeatedly go to a position within the pond with an accuracy of ±0.5m
- Ability to work in a confined space with metallic objects causing congestion
- Positioning equipment must be capable of attaching to existing ROV fleets
- Devices are typically deployed over the handrail, using a standard cargo net and jib hoist (SWL 2 Tonnes)
- Ability to provide single or 3-phase power with a preference for power to be provided electrically or via water hydraulics over oil-based hydraulic systems

What Next?

Game Changers are hosting a webinar for this challenge where delegates will have the opportunity to meet challenge owners.

Details are available on the Game Changers website www.gamechangers.technology

If you have new ideas or innovations which can be applied to address this challenge, we invite you to join us.

If you'd like more information about the funding available through the Game Changers programme, please visit Our Funding Process (gamechangers.technology)

The deadline for applications for this challenge is 30th July 2021 at 12 noon.

Sellafield Ltd

Dounreay

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