Sellafield Ltd

GAMECHANGERS
DELIVERING NUCLEAR INNOVATION

CHALLENGE: Asset inspection through 19mm diameter access ports

Sellafield Ltd are seeking solutions to enable the remote, visual inspection of duct systems.

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The duct systems are long and congested areas, with tank rooms positioned along their length. Access is restricted to a 19mm bore inspection port through 0.35m - 1m of concrete. Inspection of this ductwork and the adjoining tank room areas are required in order to understand more about their condition and the condition of the assets inside. To-date, this has proven challenging, and this is primarily due to the access constraints.

A solution that can be deployed through narrow access ports that provides reliable, high-quality images of the areas inside, would be of high interest to Sellafield Ltd and the Nuclear Decommissioning Authority (NDA) estate more widely.

Introduction

Sellafield Ltd are responsible for a wide array of activities designed to ensure safe and cost-effective nuclear decommissioning of legacy nuclear waste contained within ageing buildings. Their mission is to create a clean and safe environment for future generations. To achieve this aim, significant R&D investment will be required to provide solutions to the complex challenges that are presented. Recent estimates predict the total taxpayer bill for decommissioning the UK's nuclear waste will exceed £260bn. Game changing developments in technology offer an incredible opportunity to reduce this overall bill, whilst providing sustainable economic and societal impact across the UK.

Routine visual inspection of existing assets across the Sellafield site are important for understanding their condition, predicting their lifetime, and characterising any hazards that may be presented. Some of these assets are often located in hard-to-reach areas (no manned entry) and the deployment of equipment (e.g. a camera) is often restricted to a limited number of access ports. Many of these access ports are very small in diameter, which makes routine inspection of the assets contained inside particularly challenging. The areas requiring inspection are often voids and/or ducts, which are variable in size and shape, with no natural light. Furthermore, the areas inside may be congested and vast, which further complicates the ability to inspect them accurately.

In one particular facility, a duct system and the 6 adjoining tank rooms require detailed inspection, where access is constrained to 19mm diameter access ports, through 0.35m - 1m of concrete. Along the length of the duct system there are estimated to be approximately 105 access ports, some of which are blocked and cannot be used. To gain sufficient coverage of the entire duct system, it is predicted that access for inspection through at least 49 of these ports will be required. Inspections of these areas are typically prompted approximately every 5 years, with the next one scheduled for 2025.

Whilst capabilities exist for inspection of assets through larger access ports, inspection through narrow diameter access ports remains challenging and this constraint is central to this challenge. Sellafield Ltd have identified a further 18 inspections that will benefit from this solution, across 7 plant areas, including inside tanks and pipe bridges, as well as other ventilation ducts. These inspections are similarly constrained by narrow access ports.

A solution to this challenge will likely find use across the NDA estate more widely and it is expected that improving the capability to provide high-quality asset inspections through narrow diameter access ports may open the potential to inspect areas that have not previously been considered due to access constraints.

Current Practice

The inspection of assets through narrow diameter access ports is achieved using current practice, however, the quality of those inspections is limiting. Several attempts have been made to inspect these areas, with varying degrees of success. To-date, the best results came from recent inspections using a bullet camera on the end of a pole. However, the image quality provided was inadequate for sufficient characterisation of any defects present. The image quality for these inspections was 480p and images were in black and white (see Figure 1). Furthermore, control of the positioning and directionality was made difficult, and limited to a rudimentary 90° hinge (in either direction) or a rotation of 360°, resulting in a reduced inspection coverage (see Figure 2).

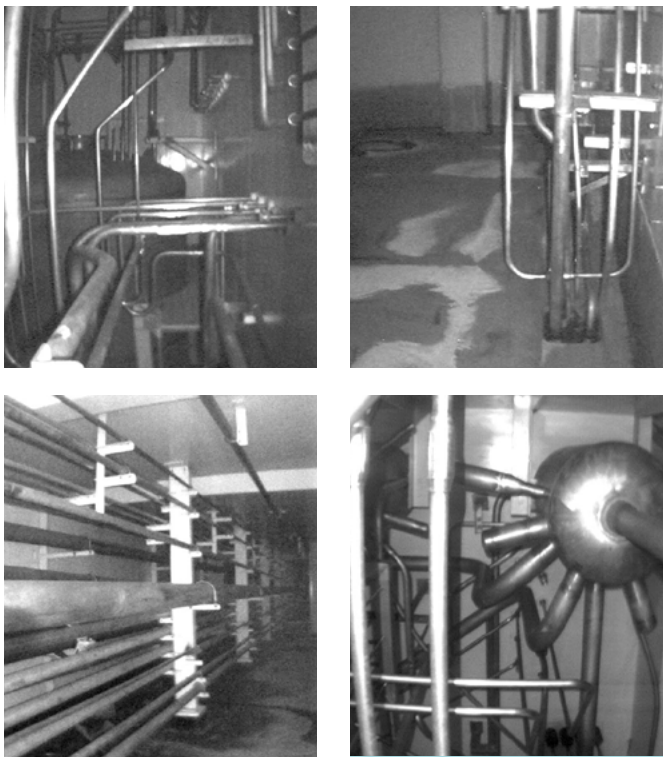

Figure 1. Examples of the quality of images from previous inspections (2018 - 2020)

Various endoscopes and other commercial off-the-shelf (COTS) solutions have been considered, however, the image quality from these solutions is expected to be insufficient. Furthermore, reliable deployment, positioning and directionality of the imaging device is critical. Current practice does not provide sufficient control over the movement of the camera once inside, which limits the inspection to only certain areas.

Challenge Aims

The solution to this challenge must be capable of providing a detailed visual inspection of an entire duct system, and the 6 adjoining tanks rooms, providing high-quality still images and real time video feed to the operator, where access to the duct system is constrained to a 19mm diameter bore through 0.35m - 1m of concrete. The duct systems (L x W x H: ~270m x 3m x 3m) are long and congested areas, with tank rooms positioned along their length. The deployment system must provide a method of determining the depth of entry of the camera system. Remote operation is required, and the operator can be stationed at the entrance of the access port.

The next scheduled inspection is in 2025, and Sellafield are seeking a step-change improvement over the existing capabilities. Due to the time-limited nature of this challenge, there will be an emphasis on well-developed technologies.

Benefits to Sellafield

The principal benefit to Sellafield will be to enable the mission and to improve upon existing capabilities for inspection of these areas. It is anticipated that solutions for this challenge may also find use more widely across the NDA estate for routine inspection of other hard-to-reach areas, including pipework, trenches and pipe bridges, thus presenting additional commercial opportunities in the future.

There are a number of secondary benefits that will be gained by improving the capabilities to inspect areas where access is constrained by narrow entry points. Improving the quality and

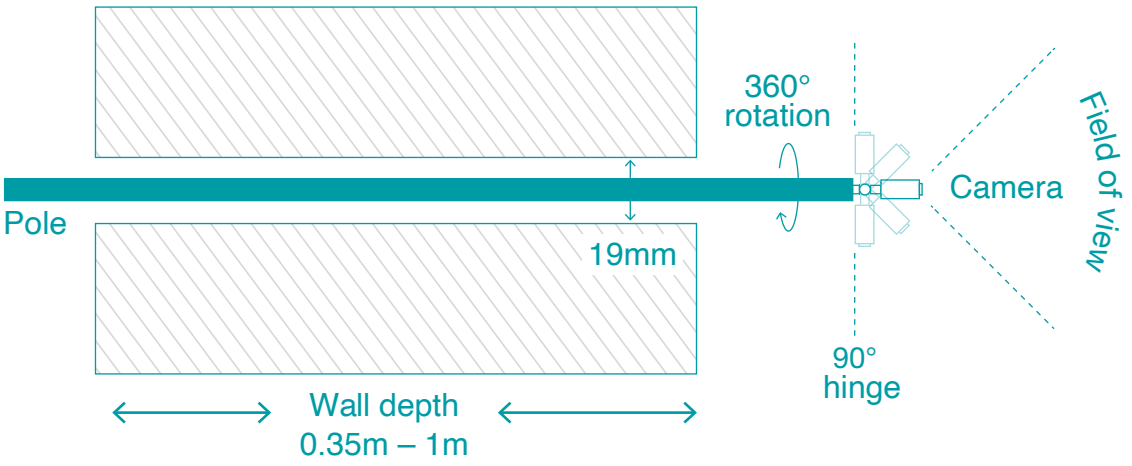

Figure 2: Diagram illustrating the limitations of current practice

efficiency of these inspections, and enabling new inspections in otherwise unattainable areas, will help enable a better understanding of existing assets and the hazards that they pose. This will support significant risk-reduction through improved management and understanding of their condition. Improving the quality of the data obtained from each inspection may result in a reduced requirement for repeated (substandard) inspections. This would reduce any potential risks to the operators during deployment and would offer a significant cost-reduction, without compromising on overall safety.

Constraints

Due to the conditions of the expected deployment, there are several constraining factors to be taken into consideration for all potential applications. The proposed solution must be:

- Able to fit through a 19mm diameter access port, through 0.35m – 1m of concrete (see Figure 3);
- Mains power operated (or battery-powered allowing a minimum of 6 hours of continual operation);
- Able to be carried by only one person. The total weight of the device, including the control system, should not exceed 25kg;
- Able to be operated and provide high-quality images with no natural light;
- Fully retrievable, including in the event of deployment system failure;
- Easy to clean, with as few contamination traps as possible;
- Detachable from the deployment device (for cleaning or disposal if contaminated).

Additionally, any proposed solution to this challenge must consider the following:

- The duct systems are vast (L x W x H: ~270m x 3m x 3m) (see Figure 4). The typical distance between access ports ranges between 4 - 6m and there is not always a clear line of sight between each access port;
- Occasionally, there are access ports located at the top of the duct, however most are located on the side of the duct, providing horizontal access;
- The tank rooms are variable in size, the largest being approximately 21m in height. Typically, there are multiple access ports available, which tend to be located at different heights. A representative diagram is provided in Figure 5;
- The maximum distance between a given access port and an inspection area of interest is likely to be 10m;
- Radiation levels are not expected to be high in these areas, however, consideration should be given to how low levels of radiation might affect the image quality;
- Access ports can remain open for the duration of the inspection. Opening of multiple ports at the same time is a possibility if required, but this may not always be an option.

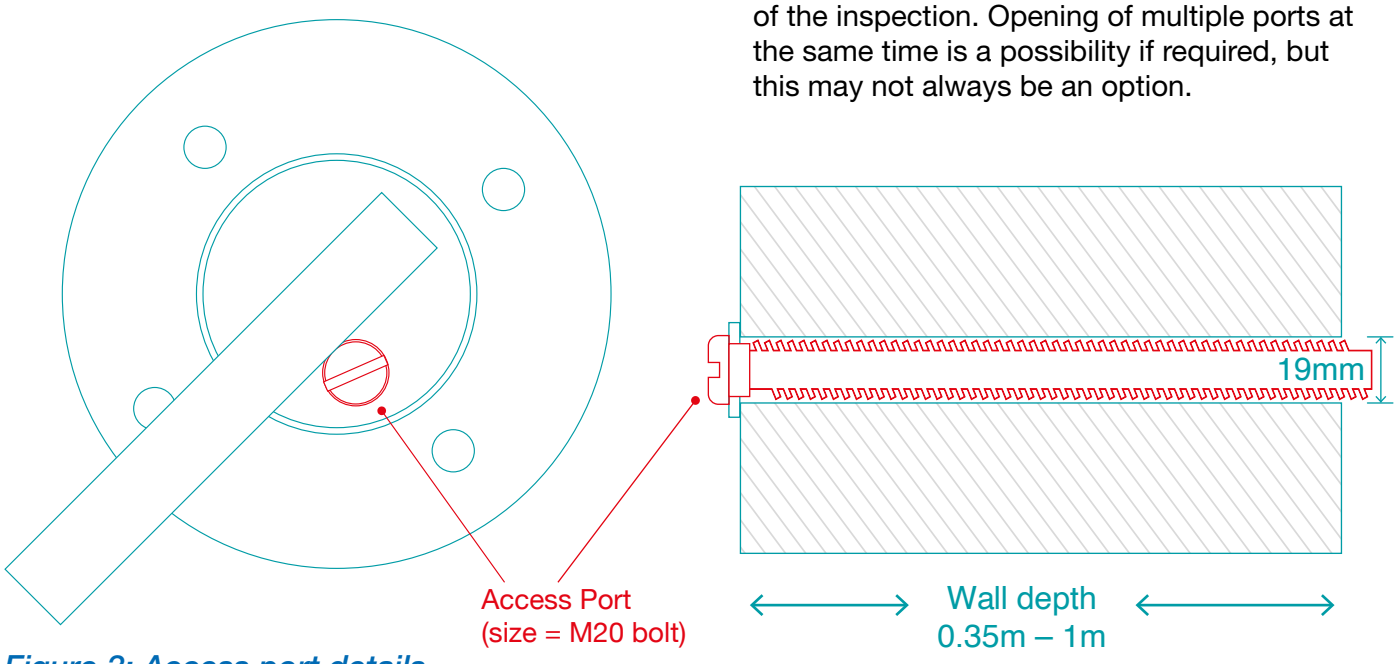

Figure 3: Access port details

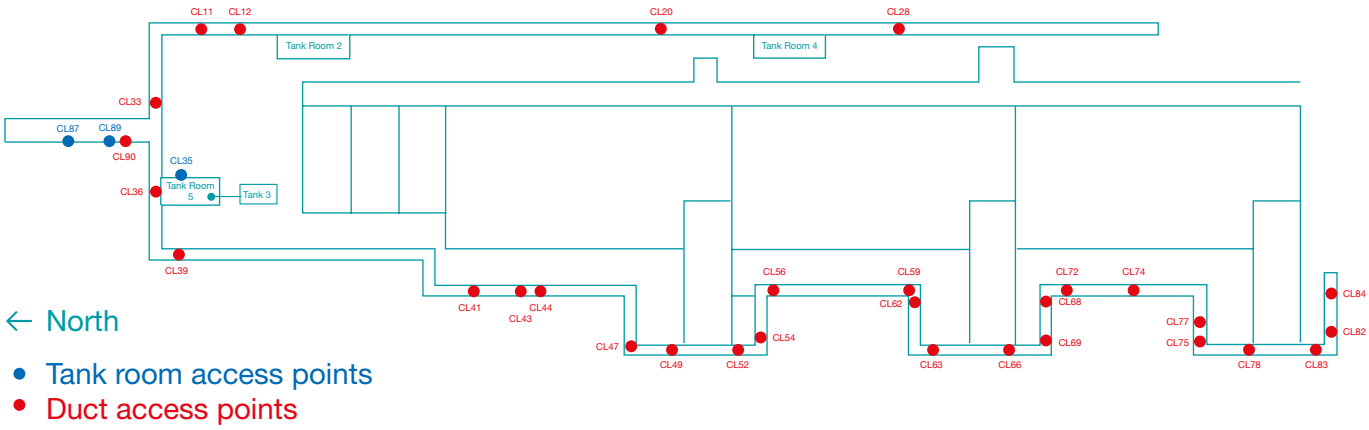

Figure 4: Schematic of duct system at 5.5m level

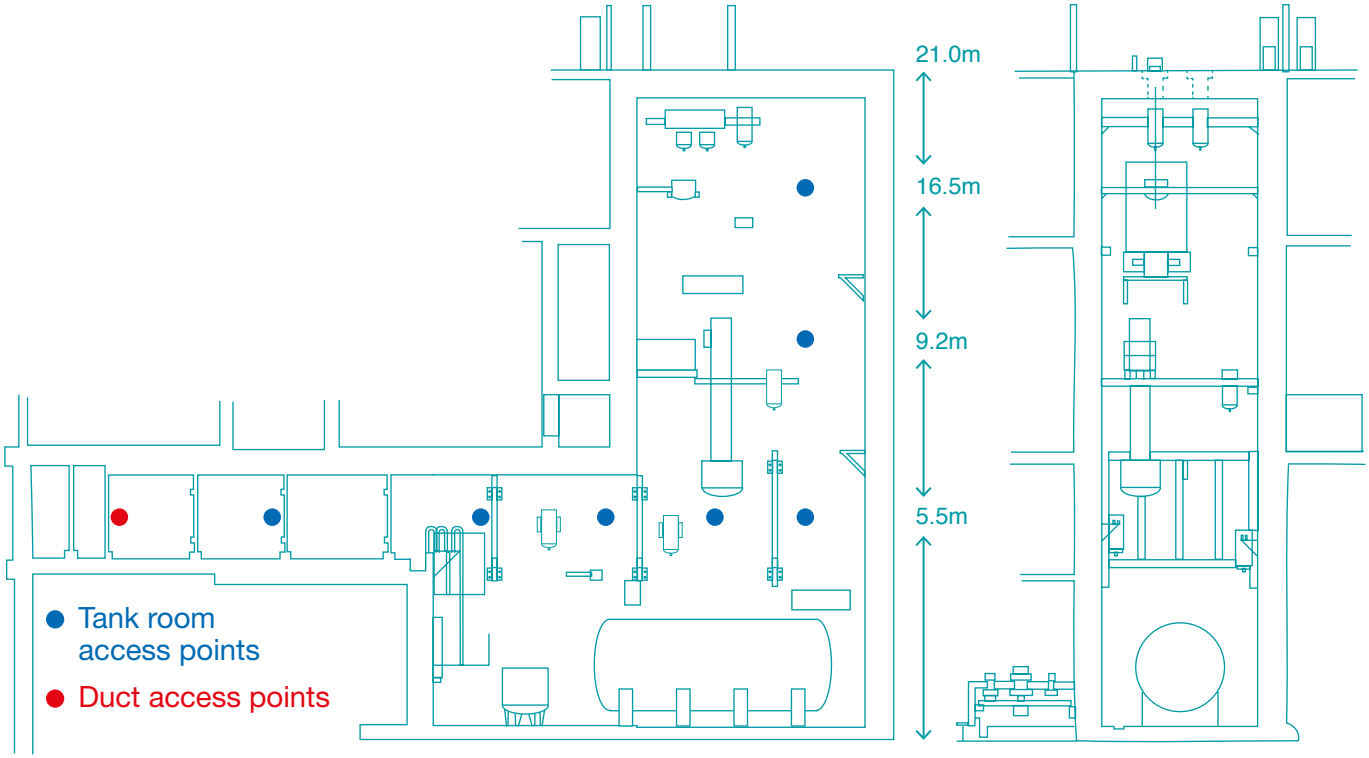

Figure 5: Representative tank room elevation diagram

Functional Requirements

The solution to this challenge must be capable of providing a detailed visual inspection of an entire duct system and the 6 adjoining tank rooms, providing high-quality still images and real time video feed to the operator. Solutions to this challenge should meet the following functional requirements as a minimum:

- Provide static, high-resolution, colour images, with a minimum of 22 megapixels;
- Provide high quality images of objects located between a minimum of 0.1m up to a maximum of 10m from the nearest access port;
- Provide a real-time video feed to the operator in Full HD quality (1080p);
- Significantly improve the field and depth of view over existing capabilities (e.g. a system that has pan-tilt-zoom (PTZ) functionality);
- Have integrated lighting on board to allow sufficient quality imaging of objects located between a minimum of 0.1m up to maximum of 10m away;
- Transmit the data to the operator in real-time and the camera system can remain tethered if required. Consideration must be given to the concrete wall thickness in relation to the transmission of data;

- Able to be controlled remotely by the operator positioned at the entrance to the access port;
- Provide a method of determining the depth of entry of the camera system (to the nearest centimetre as a minimum requirement).

In addition, the following features are desirable, but not essential, for this challenge:

- Automated deployment and positioning of the camera system;
- A deployment system that enables access to areas inside the ductwork that may be obscured or difficult to reach;
- Provision of additional sensors (e.g. radiation, temperature, humidity);
- A deployment mechanism that provides reliable and accurate positioning of the camera.

Find out more

Game Changers are hosting a workshop 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 application deadline for this challenge is Thursday 4th May at 12 noon.

Sellafield Ltd

Delivered by

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Twitter @GC_Innovators
email: apply@gamechangers.technology