



CHALLENGE: Special Nuclear Material Package Inspections – Ex-situ

Sellafield Ltd is responsible for the storage of Special Nuclear Materials (SNM) that are a legacy of 60 years of reprocessing activities on the Sellafield site. To provide confidence that SNM packages remain safe for continued storage within Sellafield's stores, it is necessary to obtain reproducible visual images of the entire exterior of the packages. This is performed ex-situ and does not require radiation hardened equipment. The aim is to identify structural changes through storage of precisely located visual images that can be referenced against at points in the future to monitor change. The essence of this challenge is to find a precise, reproducible and possibly automated method for gathering inspection images.

Introduction

Sellafield are responsible for the safe, secure, long-term storage of the UK's stockpile of special nuclear materials (SNM). These materials have been produced as a result of spent nuclear fuel reprocessing activities undertaken on the Sellafield site over the last 60 years.

In order to deliver Sellafield's mission to create a clean and safe environment for future generations, existing SNM will be repackaged into more robust containers for safe and secure long-term storage. The Sellafield Retreatment Plant (SRP) is a facility that will play a key role in this operation.

Prior to repackaging, the existing SNM packages must be stored safely and securely so inspection is necessary to provide confidence that they remain safe. The design of the current stores did not account for the inspection capabilities required for long term storage.

SNM Packages

SNM packages are cylindrical and vary in size, with a typical length of 310mm and diameter of 152mm and typical mass of around 10Kg (maximum 20kg). An SNM package typically consists of a lidded outer body (outer can), within which resides an inner sealed body (inner can) which contains the SNM. Both the inner and outer parts of the packages are constructed from 316L stainless steel with some having additional LDPE protective layers. Sellafield has around 30,000 such packages on site and these mainly fall into two key populations as illustrated in Figure 1.



Figure 1: Images of typical SNM canisters, the left hand image is a welded SNM package and the right hand image is a screw-top 'overpack' SNM package.

Inspection of SNM packages

Sellafield have developed inspection strategies that detail the number of each type of SNM package that should be inspected on an annual basis. The safety case that underpins the inspection strategies has moved away from assigning expiry dates to packages to using inspection data to support the justification for continued storage.

SNM packages may be inspected both in-situ and ex-situ, although this does depend on the layout of each SNM store. During package inspections, it is only the outer surface of the package that is inspected. **This challenge is purely focused on ex-situ inspections.** An ex-situ inspection involves the removal of an SNM package from the store and transportation to the inspection area, such as the one shown in Figure 2, where an operator performs the inspection routine.

A key aspect of the SNM package inspection is the ability to obtain **reproducible visual images of the entire exterior of the package**. This is currently performed manually by an operator using a hand-held camera. Due to ergonomics and human nature, it is not possible to obtain accurately positioned images each time a package is inspected. Finding a precise, reproducible and possibly automated method for gathering inspection images is the essence of this challenge.



Figure 2: Image of a typical ex-situ inspection area. SNM packages rest on the central rail between the shielding blocks.

Current Practice

Currently all inspections are carried out manually on SNM packages that have been removed from the store.

- The operator inspects the package at an inspection area within the store. This is defined as being within engineered containment so there is no risk of dropping the package.
- The package will be positioned horizontally at this point.
- Images are obtained of the package(s) using a hand-held Canon Powershot G16 camera or similar standard ISO camera.
- Capturing images of the whole of the exterior of the package requires the package to be rotated, this is currently done purely by eye and so it is likely that photographs are not actually taken of 100% of the surface as the package is only rotated once and by no set amount.
- Images are uploaded to a storage system, with each individual package being identified via its alphanumeric ID number which appears in various locations on each package depending on the package type.

The overall operation is difficult due to the orientation and cramped location of the package on the inspection bench. Therefore, the reproducibility of the images captured is highly questionable.

Challenge Aims

The challenge owners at Sellafield are seeking a solution that provides accurate and reproducible positioning for the capture of images of the entire surface of each SNM package during ex-situ inspection. This includes the top and bottom of the cylinder as well as the sides.

Such solutions might target the precise rotation of the SNM package or provide an image capture system that does not require rotation of the SNM package.

There are a number of physical characteristics that are of interest and must be captured by any proposed imaging system. Full details of these are provided in the Functional Requirements section.

Sellafield ideally require a solution that can

be deployed within approximately one year of successful completion of a Proof of Concept project.

Benefits to Sellafield

A system that can generate reproducible, standardised images from visual inspections will contribute to Sellafield satisfying one of its site licence conditions, which is to obtain robust and accurate data.

Generating images of a fixed location, with consistent lighting and focal length will enable the application of digital image correlation (DIC) and other image analysis techniques to generate meaningful quantitative trending data on any defects. This will enable Sellafield to prove that the packages are safe for continued storage and provide evidence for the substantiated extension of the lifetime of these packages.

Devising a standardised, benchtop system for the ex-situ inspection of SNM packages will have the added benefit of making inspections easier and safer. However, the key benefit to be focused on during this challenge is to provide more accurate and repeatable data collection/image capture.

Sellafield's 30,000 SNM packages are located in a number of stores. The typical throughput for ex-situ inspections is around 30 packages per year. The configuration of the stores does vary in terms of size and constraints.

Constraints

Any proposed system must:

- Be able to fit through the door to the inspection area as space is limited and it cannot remain permanently in residence
- Be reasonably mobile
- Fit onto the inspection bench (specific dimensions will be provided for organisations awarded feasibility funding to develop solutions to this challenge)
- Be straightforward to setup and dismantle as time for inspections may be limited
- Be easily operable by the inspections team
- Equipment does not need to be radiation hardened
- Power supplies are available

Functional Requirements

Any proposed system must:

- Be reusable
- Provide reproducible images of the whole of the outside of the SNM package under inspection
- Adjust for variable lighting conditions
- Be able to image reflective surfaces
- Give a reference for each image by individual package and position on that package
- Provide high enough quality images to allow the quantifiable analysis of the following characteristics of SNM packages:
 - Dimensions and depth of any dents, scratches or scuffs
 - Evidence of cracking
 - Original manufacturing defects
 - Overall expansion or other evidence of pressurisation
 - Any form of deformation
 - Evidence of corrosion/colour change

Although not essential, it would be nice to have image stitching capability that gives a 'laid flat' view of the whole of the package exterior.

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 \(gamechangers.technology\)](http://www.gamechangers.technology)

The deadline for applications for this challenge is Thursday 24th November at 12 noon.



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