Sellafield Ltd

Research and Development at Sellafield

2023

Contents

This report presents:

- Research and Development (R&D), managed by our value streams, driven by the needs of our business.
- Longer term R&D focused on opportunities for innovative technologies, tools and techniques to reduce costs, improve safety and reduce timescales.
- Collaborative R&D with a wide range of supply chain companies, organisations and universities.
- Some of the specialist staff from the research community working in and with our technical teams.

Our mission is to safely and securely remediate the Sellafield site to benefit the industry, nation and region. To create a clean and safe environment for future generations.

Introduction

As Enterprise R&D Manager I am pleased to share with you the R&D progress and successes at Sellafield Ltd in 2022-2023. R&D is crucial to achieve the goal of reducing the time that it takes to decommission our Site. We have significant challenges ahead of us but with advances in technology and digital infrastructure, innovative ways of working and bridging the gap between research and deployed innovations we can make transformational changes and bring our mission end closer.

I joined the Enterprise R&D team in February 2023 and working with the team to produce this report has made me more aware of the breadth of the research that we do across so many different areas. Our R&D isn't just about robots (although they are an important area of development for us), but we also focus our efforts on asset management, improved methods of measurement, waste treatment methods, sustainability and manufacturing.

Game Changers plays a big role in our R&D portfolio; through this innovation programme we are able to quickly put out challenges from our business and reach a wide range of innovators to help us develop solutions. You can learn more about this programme and a case study of Eadon Consulting (page 10) who started with no nuclear experience five years ago and are now delivering on our Enabling Innovation Framework.

The Spent Fuel Management value stream (page 20) have been developing a new technique which will enable new ion exchange materials to be qualified and selected much quicker than previous techniques. In Special Nuclear Materials (page 26) work has been completed looking at seismic modelling on bearings in product and residue stores. This supports ongoing technical and engineering work to justify the continued safe operation of the store and minimise the need to refurbish or replace components over its lifetime.

In Retrievals (page 35) there has been development of remote hydrogen sensing. This allows us to confirm that waste is evolving as predicted and that hydrogen levels in the stores follow the modelled values expected. Within our Remediation value stream (page 41) they are actively demonstrating using diamond wire cutting; taking learning from elsewhere in the nuclear industry to cut hot spots off pond furniture and size reduce non-uniform Intermediate Level Waste (ILW) reducing the amount of waste going to ILW stores.

Infrastructure (page 50) have been developing solutions for automated energy metering for facilities that have no energy meters. This will be implemented on site to make use of the variety of legacy equipment. This work has prompted changes to design standards and the techniques highlighted electricity being wasted in areas that weren't previously identified.

Engineering Development Solutions are based at Cleator Moor at the Engineering Centre of Excellence. They have a programme of sprints throughout the year which bring together small teams of diverse skills and knowledge to problem solve engineering challenges. By being based off-site they can trial ideas and quickly learn to find a successful solution. Examples of some of their innovative work can be found from page 62.

Throughout this report you can see the benefits of collaboration which is key to our success on many fronts. Finally, I must pass my gratitude to my predecessor Jane Cruickshank who has overseen the past 3 years of R&D at Sellafield Ltd. Her dedication and passion have left its mark and I hope to carry this forward.

Hilary Royston-Bishop
Enterprise R&D Manager

Foreword

Last year we successfully started retrievals from the Magnox Swarf Storage Silo, which is one of Europe's highest hazard facilities.

This year, the first retrievals of waste from the Pile Fuel Cladding Silo, our oldest waste store, has now commenced. This is a monumental achievement for our business and is the culmination of twenty years of work.

For every one of our operational achievements, technical teams work to understand the behaviours of the materials and waste that we're moving and storing safely. They define the technology that is required and specify how it will be used by the operators safely. It's people that make this happen.

For our people, Sellafield site and the mission is our focus; it's the environment we will remediate, and it is at the forefront of all our minds. To deliver our mission we need to be innovative and bring new technologies and techniques to site, which is why I'm so proud that we exceeded our targets on deployed innovations this year by over thirty percent. This proves we can create, develop, and deliver new solutions. This report will give you a taste of some of the deployments and the underlying work that support these successes.

As a company, we recognise the importance of investment in Research and Development, but it is also important to recognise that we don't achieve these results in isolation. We need a vibrant supply chain and strong links within academia is paramount.

We've some really strong routes to these partnerships through our commercial frameworks, with pioneering partnerships like the NNL Technical Services Agreement which received it's ISO44001 re-accreditation, rapid innovation calls through Game Changers and a new pan-NDA agreement on Robotics and Artificial Intelligence Collaboration (RAICo).

Our remit is wide and fascinating, and this report is just a taste of what we do.

Dr Robin Ibbotson
Chief Technical Officer

Nuclear Decommissioning Authority (NDA) Grand Challenges

Challenge theme	Reducing waste and reshaping the waste hierarchy	Intelligent infrastructure	Moving humans away from harm	Digital delivery – enabling data driven decisions
Challenge detail	Finding new ways to drive the waste hierarchy, increasing recycling and re-use in order to reduce volumes sent for disposal	Using autonomous technology to manage assets and buildings proactively and efficiently	Reducing the need for people to enter hazardous environments using autonomous systems, robotics and wearable technology	Adopting digital approaches for capturing and using data, to improve planning, training and aid decision making

To Find Out More Contact
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For more information about the NDA grand challenges visit:

https://www.gov.uk/government/news/nda-sets-out-its-grand-challenges

Enterprise Technical

The enterprise technical team reports to our Chief Technical Officer and is responsible for managing our technical capability and its key contract with the National Nuclear Laboratory (NNL) via the Technical Services Agreement. It also covers our technical baseline, and overseeing and managing the R&D programmes that address the needs of our business.

There are several key R&D areas that the enterprise technical team is focused on:

- Robotics and Artificial Intelligence (RAI): Coordinating deployment across the enterprise and Technology Readiness Levels (TRLs).
- Higher active waste thermal treatment: Developing pilot plants to treat plutonium contaminated material, mixed beta-gamma wastes, and pumpable wastes.
- Science programme: Coordinating the needs of the business to undertake research in key universities and research organisations.
- Our medium to long-term research focus areas managed by our Integrated Research Teams (IRTs).
- Innovation activities, including organising events and competitions, horizon scanning and our successful Game Changers programme.

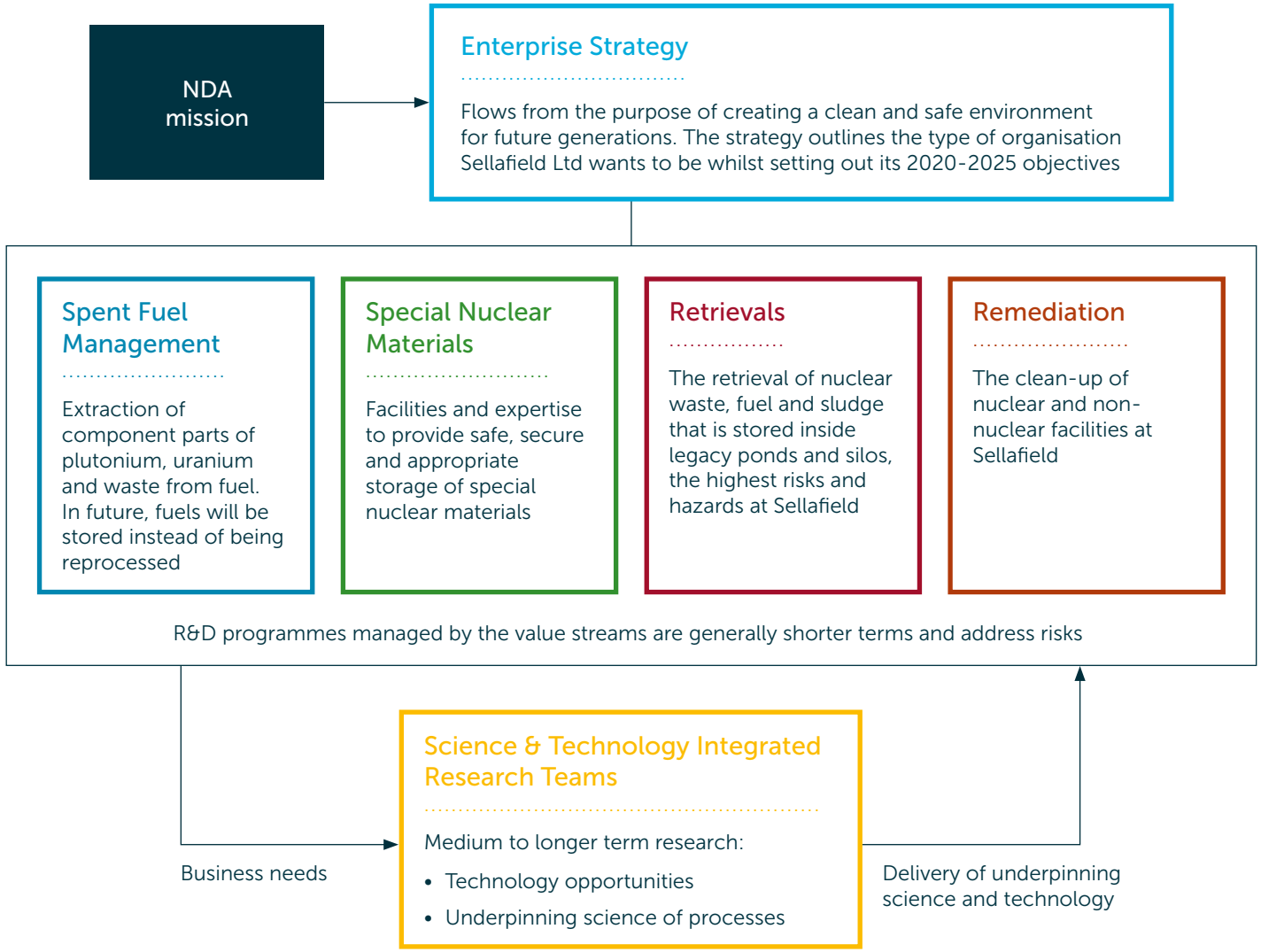
Integrated Research Teams

Enterprise R&D is focused on underpinning scientific understanding and technology development themes and is coordinated through Integrated Research Teams (IRTs). Our IRTs are defined by the needs and requirements of the business with the aims of improving safety, reducing costs and accelerating operations, and their role is to:

- Work with end users to understand challenges and coordinate R&D efforts.
- Deliver R&D which provides value across the enterprise.
- Nurture a space for more speculative longer-term, high value R&D.
- Help the value streams engage with the wider external R&D community.
- Identify technology within the supply chain that can be of use to the value streams and demonstrate its value.

Our long-term enterprise led R&D programmes complement the short-term operational based projects to deliver R&D that is beneficial to more than one area and where the science or technology is at an early stage of development.

The IRTs focus on the science and technology themes, which can be found on page 7. These themes are the key areas where R&D needs to be undertaken, in the medium to longer term, to support the fundamental delivery of our mission and to manage any potential future risks.



Link between value streams and IRTs taken from 'Future research and development requirements' document

Integrated Research Teams

Underpinning Science Themes

Materials science

Understanding of the chemical, physical and engineering properties of new materials in their relevant operational environment to facilitate decisions in support of existing operations and design of new plants

Data science

Data collection, processing and depth analysis to aid decision making

Process chemistry

Underpinning science of current infrastructure of treatment and storage facilities so that they can be adapted to manage future wastes. Development of new processes to assist in the delivery of the changing mission

Environmental science

Understanding of the long term fate of radioactivity and its impact on the environment as it changes

Particulate behaviour

Properties and behaviour of particulate materials, including sludges, slurries and suspended particulates or liquid droplets in gases to underpin design, abatement techniques, personnel protection and flowsheets

Technology Development Themes

Waste treatment conditioning and packages

Waste immobilisation strategies including thermal technologies and low temperature processes and new, cost-effective waste container options for decommissioning

Measurement and analysis

A range of measurement and deployment techniques to undertake analysis, detect signs of unexpected degradation and demonstrate control for extended storage periods

Future asset management and digital technologies

Application of Industry 4.0 (I4.0) and related technologies to asset management of aging contaminated facilities

Post operational clean-out

Techniques for characterisation, decontamination, access and deployment whilst addressing effluent and waste treatment

Manufacturing

Development of improved manufacturing processes and technologies to support our mission

Robotics and artificial intelligence

Building on existing remote handling capability to more autonomous systems. Development of a centralised route for the introduction of RAI to the site

Innovation events

Innovation events provide a great opportunity to bring together innovation specialists, technology teams and suppliers with innovative ideas. They enable people from across the business to discuss their challenges, and hear about the latest technology and how it could change their lives – and in many cases, already is.

Over the past year, Sellafield Ltd and Game Changers have held events to inspire and nurture an innovation culture across the nuclear sector.

On-site innovation festival

Hundreds of site-based colleagues took the chance to spend some time looking into the future at our first on-site innovation festival, which brought together people from different technical communities to see the innovative ideas that are being developed. The event was organised by the innovation team, led by Jake Nicholson.

Exhibits included robotics, artificial intelligence, digital, our engineering centre of excellence, special nuclear materials, remediation, legacy ponds and silos, infrastructure, business improvement, Game Changers, supply chain innovation and emerging technology.

Interest in what technology could offer was high – ranging from high-tech robotics to vital changes people can make right now.

Game Changers innovation festival

More than 200 delegates enjoyed the first Game Changers innovation festival in Whitehaven. Organisers created a relaxed, friendly and fun day with unique networking opportunities alongside an exhibition of cutting-edge technology and a diverse programme of talks.

Eighteen organisations showcased their technology, developed with Game Changers support and funding to help solve nuclear sector challenges.

Phil Marsden, of Unitive Technology, said: "The Innovation Festival gave our team the opportunity to really interact with the nuclear industry and associated businesses. Best of all for us was the direct, positive feedback and interest shown in our technology. This really motivates us".

Game Changers RAI event

An event hosted by Sellafield Ltd, Game Changers and the Robotics and Artificial Intelligence Collaboration (RAICo) offered more than 250 delegates the chance to explore the latest advancements in robotics and AI in extreme environments.

Keynote speakers discussed their experiences using robotics and AI to solve problems in wide-ranging industries from medical surgery to nuclear decommissioning. More than 30 organisations exhibited their products and services, providing a unique opportunity for attendees to get hands-on experience of the latest advancements in the sector.

The event highlighted the importance of collaboration to drive forward innovation in this field and set the stage for future partnerships working to provide robotics and AI solutions to extreme-environment challenges.

1.


2.


3.

1. On-site innovation festival

2. Game Changers innovation festival

3. Game Changers RAI event

Examples of Innovation

Innovation comes in many forms and through many routes. Last year the innovation team captured and reported 51 deployed innovations, which smashed the target of 40. By capturing our successful innovations, we can showcase the benefit from them and our ability to deploy innovation within the business.

Innovation teams within each value stream are there to enable and deliver innovation within their respective areas, focusing on their specific challenges and to explore and deploy innovative solutions to tackle them.

Underwater radiation probe

The legacy ponds innovation team developed a waterproof housing for a standard commonly used personal radiation dose meter (Radeye G10 detector), which was mounted onto a small Commercial Off The Shelf (COTS) Remotely Operated Vehicle (ROV) for initial use in the Pile Fuel Storage Pond (PFSP) for in-pond monitoring.

This solution was cheaper and easier to operate than the previous probe, and the camera and LED lights on the ROV provide clear readings to readily identify any high radiation sources.

The ponds operations teams said after its first use where dozens of readings were taken from the pond inventory in one shift "This has saved years of work". It can scan an area and help inform programmes of what to expect.

ROV for floc removal

A challenge was proposed to reduce operator dose during vacuum removal of 86 m^3 of 'Floc' from 4 tanks. Floc (short for flocculant) is a loosely clumped mass of particles, which forms in the Low Active Effluent Management Group (LAEMG) tanks due to precipitation of heavy metal compounds as a result of neutralisation of effluents.

The legacy ponds innovation team, in collaboration with NNL and Cumbria Nuclear Solutions Ltd, modified an existing ROV to enable remote floc removal. A scoop and a variety of vacuum nozzles were designed and 3D printed in 3 weeks for testing prior to fabrication.

Successful testing using inactive simulants at the contractor's facilities enabled the application for funding and incorporation of solution into the plan without impacting project timescales.

Long reach camera pole

SNM has a range of gloveboxes situated at height which require scaffolding to be erected for visual inspection. The SNM innovation team looked at alternative methods to inspect high level gloveboxes without the need for scaffolding or the risk associated with working at height.

Their simple, but effective, solution of a long reach camera pole, with camera attached to the top and viewing capability on the handle, has demonstrated that visual inspections can take place without the need for specialist scaffolding to be erected.

This innovation is currently just deployed within the SNM value stream but could benefit other areas of the business.

1. ROV mounted radiation probe

2. ROV for floc removal

3. Long reach camera pole

Game Changers – from feasibility to collaborative working

Game Changers is the UK's leading nuclear innovation programme, finding solutions and developing technologies to overcome some of the most complex challenges facing the nuclear industry. It provides a platform to connect challenge owners and solution providers across the NDA estate. For Rotherham-based Eadon Consulting, a visit to the Game Changers Waste Container Challenge Event in 2017 transformed their business.

As an engineering design consultancy, Eadon went to the 2017 event with an idea but no demonstrable experience of the nuclear industry. Game Changers provided the firm with the opportunity to introduce and develop its technology, including recommending a collaborative approach to the challenge and teaming them up with Arc Energy Resources to design and create a new, cost-effective alternative to existing nuclear waste containers. From feasibility to proof of concept to creating a joint commercial venture with Arc (Capsa Solutions), Eadon was able to learn about the nuclear industry, building its knowledge, experience, reputation and contacts.

Using the waste container design project as a case study for its innovation, Eadon was able to access new commercial avenues within the nuclear sector including:

- Becoming part of the Accord Consortium of companies and successfully applying to be part of an NDA framework that provided the opportunity to bid for any number of projects over a 4-year period.
- Working with Innovate UK and a wider advisory group to help further develop and commercialise Capsa Solutions, with a £650,000 grant over 2.5 years.
- Being awarded a place on Sellafield's Enabling Innovation Framework (EIF).

The Post Operational Clean Out (POCO) challenge presented by Game Changers, Sellafield Ltd and Dounreay Site Restoration Ltd provided Eadon with another opportunity to pitch one of its ideas to the nuclear sector. Playing to its strengths in remote handling systems and cranes, Eadon designed REACH – an innovative, remote-handling, modular system, which was recently awarded significant additional funding that is helping Eadon to grow its capability in different areas, including robotics.

Working in the nuclear industry has been fundamental to Eadon's business in recent years, with Game Changers providing an outlet for their ideas and problems to solve that would have been unavailable otherwise, and facilitating:

- Relationship and contact building.
- Networking and collaboration.
- Industry knowledge growth (technical, practical and the opportunities available).
- Supply chain access.

This journey from feasibility to collaborative working has been an inspirational one, and with so many projects ongoing, there is much more to come from Eadon Consulting.

GAMECHANGERS
DELIVERING NUCLEAR INNOVATION

1. Game Changers stages

2. Capsa waste container design

3. REACH proof of concept demonstration

1.

2.

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Our academic programme

The backbone of our academic programme are the University Links, which work closely with our Centres-of-Expertise (CoEs). These discipline specific University Links are competed contracts, typically lasting 5 years, that enable access to world-class expertise and peer review, thus ensuring that technical advice provided to programmes and projects is robust and the best available.

We currently have University Links in six technical disciplines designed to help achieve our mission:

- Waste immobilisation science: Sheffield Hallam University supported by the University of Sheffield and University of Bristol.
- Robotics and Artificial Intelligence (RAI): The University of Manchester supported by the University of Bristol and University of Oxford.
- Effluent and decontamination: Under competition.
- Uranium and reactive metals: University of Bristol supported by Imperial College London.
- Flammable gas: University of Leeds.
- Particles with fluids: University of Leeds.

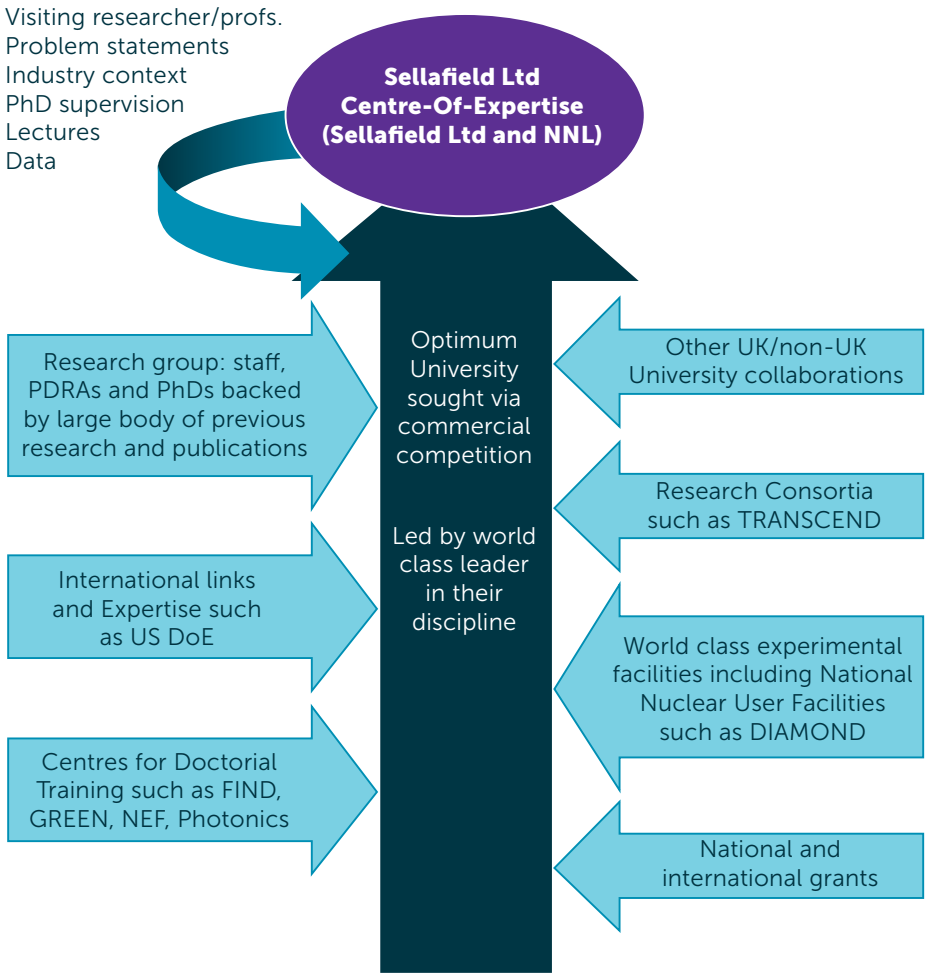
Each University Link has clearly defined objectives, research requirements and regular reviews to ensure that they deliver business benefits that support our mission.

The graphic describes the operation of a typical University Link, and the particles with fluids University Link is used to showcase our collaborative approach in more detail.

Objective of particles with fluids CoE

Many of the highest priority hazard reduction and retrieval operations across the Sellafield site require the management, mobilisation, retrieval and processing of particulate beds. As reprocessing operations move into POCO further challenges will emerge in this area.

The problem of predicting the properties and future behaviour of sludges that act as both a soil and a fluid require specialist techniques. The particles with fluids University Link aims to develop these techniques for the benefit of Sellafield Ltd and the UK. It also provides specialist consultation and peer review for work conducted both internally and by the supply chain.



Operation of a typical University Link

Particles with fluids University Link

Academic staff at the University of Leeds have many years of experience at the forefront of academic research in multiphase flow, particles and fluids, and have worked extensively with the nuclear industry since 2000. Key areas of study are:

- In-situ analysis.
- Modelling and simulation of three-phase flow.
- Mobilisation by impinging jets.
- Hydrogen retention behaviour.
- Behavioural modification.

The Centre for Doctoral Training (CDT) in Fluid Dynamics at Leeds also has a strong association with the University Link, funding MSc/PhDs and bringing researchers into the community. There are currently 8 PhD projects associated with the University Link.

The University Link takes a proactive approach in sharing its cumulative knowledge and providing us with the best possible support, which includes conducting sample analysis using a range of available instruments.

Business benefits

The particles with fluids University Link began in 2011. Our expertise in this area has significantly increased through the successful recruitment of five PhD researchers and by building our internal and external capability in multiphase Computational Fluid Dynamics (CFD) through training.

In addition, it has already delivered significant benefits to our operations:

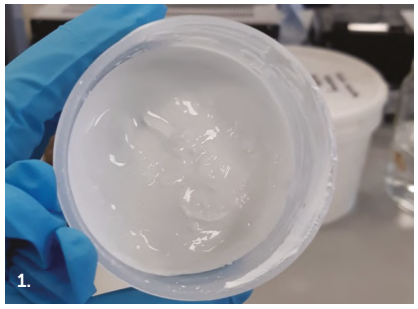
- Direct benefit to a major project through peer review of our position on long-term carbonation of Magnox sludge in 3 m^3 boxes.
- Supported experimental work to inform our skip filling strategy through analysis of the stress required to compress unsaturated sludges as an analogy to forces generated from confined expansion.
- Direct support to mobilisation test material development through the assessment of thermal crystal degradation.
- Achieved significant steps forward in our understanding of sludge-hydrogen hold-up and release mechanisms in support of several major retrieval programmes.

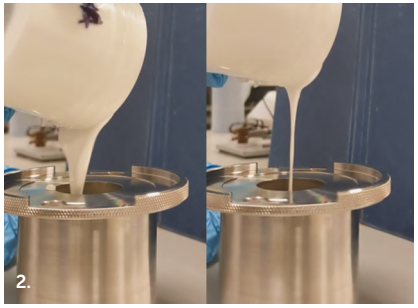
1. Pure magnesium hydroxide

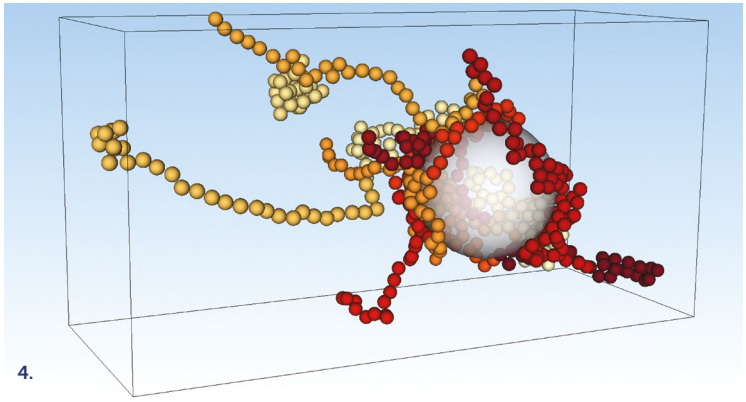
2. Magnesium hydroxide mixture pouring with reduced yield stress

3. Magnesium hydroxide mixture aged with increased yield stress after 3 days

4. First principles CFD modelling of polymer-particle interaction in a shear flow for flocculation and settling applications







Particles with fluids research value

The collaboration between our CoE and the University of Leeds brings forth a significant impact in the field of solid-liquid systems, improving our understanding of multiphase processes to make decommissioning faster, safer, and more cost-effective.

- One notable advantage is the ability to work across various length scales, allowing precise physical measurements of single particles and small samples. This data can then be seamlessly integrated with larger-scale physical modelling rigs, facilitating hydraulic flow analysis and impinging jet studies.
- The academic link provides access to world-class researchers in solid-liquid separation (dewatering), who have received a Core IChemE award for their exceptional work.
- The cross-sector collaboration, such as water treatment, oil and gas, and minerals engineering, enables us to leverage the latest advancements from various fields while tailoring these technological breakthroughs to meet our specific needs and regulatory requirements.
- The university is also actively exploring process intensification techniques like froth flotation, adsorption techniques, and agitated tubular reactors.

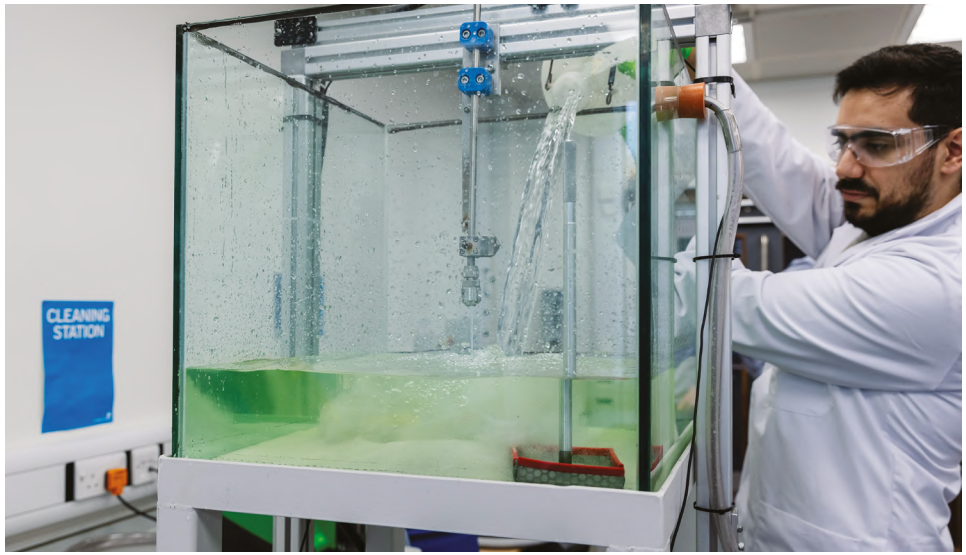
To enhance the accuracy of predictions, a wide range of numerical techniques are employed, such as CFD methods using both proprietary and freely available software packages. The particle phase within these computations is effectively modelled using Lagrangian and Eulerian approaches, as well as stochastic and particle boundary tracking methods. These advanced computational techniques allow for comprehensive analysis and optimisation of the system behaviour.

The partnership also grants access to a diverse range of specialised experimental facilities and cutting-edge measurement equipment, including:

- State-of-the-art flow and sediment measurement devices using laser and acoustic technologies.
- Analytical equipment for particle and sludge characterisation, enabling comprehensive analysis and evaluation.

An exciting development is the establishment of the ‘Multiphase Fluid Flow In Nuclear Systems’ (MultiFORM) facility, funded as part of the National Nuclear User Facility (NNUF). This facility houses water and molten salt flow loops, complemented by a wide range of measurement equipment, enabling world-class research on multiphase fluid flow, replicating real-world systems at an appropriate scale.

The cutting-edge, university-based facility empowers academic researchers to gain deep insights into complex flow systems relevant to current and future multiphase flow research. Crucially, it enables the exploration of critical aspects for the UK nuclear sector, including dispersion, settling characteristics, solid bed formation tendencies, re-suspension characteristics, and erosion by sludge wastes. These investigations play a pivotal role in ensuring safe and efficient transportation, leading to refinements in nuclear waste processing approaches. Consequently, these advancements result in reduced uncertainties in radiological impact assessments, smaller waste volumes, lower costs, and minimised worker doses.



Crater formation experiment

Sustainable concrete development

We are embarking on a programme of R&D activities aimed at environmental and sustainability improvements. Part of this development programme focuses on concrete use and the potential to re-use concrete materials following demolition activities.

Various additives are available to improve the physical characteristics (for example tensile and compressive strength) of fresh concrete pours and potentially may deliver the ability to restore some of these strength properties to mixes made from re-used demolition material. One such additive is "Concretene", a technique to add graphene to wet concrete mixes to significantly increase strength properties of structural concrete in addition to potentially reducing shrinkage and cracking.

The R&D programme will establish if, in our environment, the use of Concretene-enhanced concrete will deliver benefits in terms of reducing the quantities of concrete required for future construction given the increases in strength, recognising that some of our structures are designed to prioritise shielding over strength.

The current phase of the project is to manufacture Concretene-enhanced samples of our known concrete mixes for inspection to verify the effects on physical properties of the concrete by testing in specialised laboratory environments.

Project

Sustainable concrete ad-mix investigation, "Concretene"

Benefits

If successful, the use of ad-mixes, such as Concretene, will deliver major benefits. By using stronger concrete mixes, less concrete is required for a given construction, saving cost, schedule, complexity and of course reducing carbon footprint.

Current Status

Phase 2 (verification of technical benefits) has commenced. Future phases will include practical demonstration of the technology in the construction of small scale, non-critical infrastructure construction.

Delivery Partners

Nationwide Engineering Research & Development Ltd, Veolia Nuclear Solutions

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1. Concretene formulation testing in chemistry laboratory

2. Strength testing of Concretene-enhanced concrete in materials laboratory

Chemical & unknown material identification through windows

There are numerous gloveboxes in use on our site, but also across the wider NDA estate. Manual entry into the gloveboxes to extract components and equipment is complicated and expensive. Within these boxes there are orphan chemicals and other materials that require identification. The ability to do this without the need for entry into the glovebox will reduce cost, time and risk to operators.

Raman spectrometry is commonly used in chemistry to identify molecules using scattered light from a sample illuminated by a laser beam, and so offers the potential to determine the chemical composition of items through a glovebox window.

An initial proof of concept has been undertaken in a laboratory environment, with our delivery partners, to demonstrate whether a Raman spectrometer could be successfully used through optically transparent glovebox windows, which are typically made from thick polymethylmethacrylate or polycarbonate. The research programme also investigated the effects of scratches and other damage to the windows on the measurements.

The proof of concept study has confirmed that chemical identification through a glovebox window is possible. This will allow for faster clean-up and decommissioning as the glovebox reaches the end of its useful life.

The next step is to move to a real glovebox to demonstrate the technique in a truly representative environment.

Project
Measurement and analysis IRT

Benefits
Chemical identification of unknown chemicals in gloveboxes allows for faster clean-up and lower dose rates to those performing the work. Moving the human away from harm.

Current Status
A proof of concept has been completed and we are looking forward to commencing the next phase this year with deployment onto a real glovebox.

Delivery Partners
Jacobs Clean Energy Ltd,
IS-Instruments Ltd.

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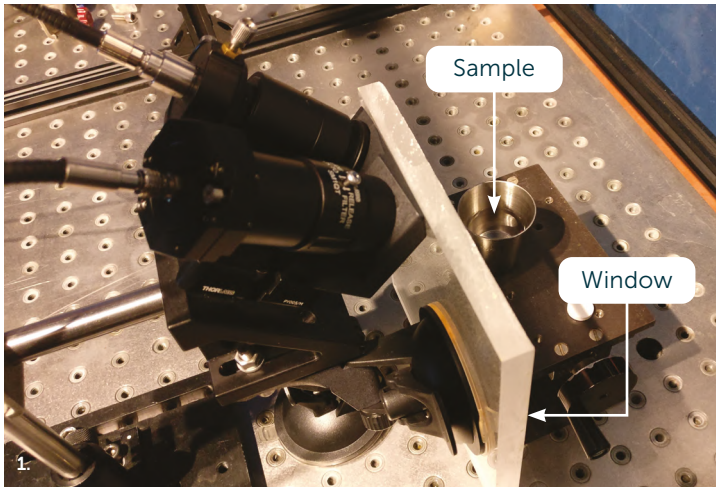
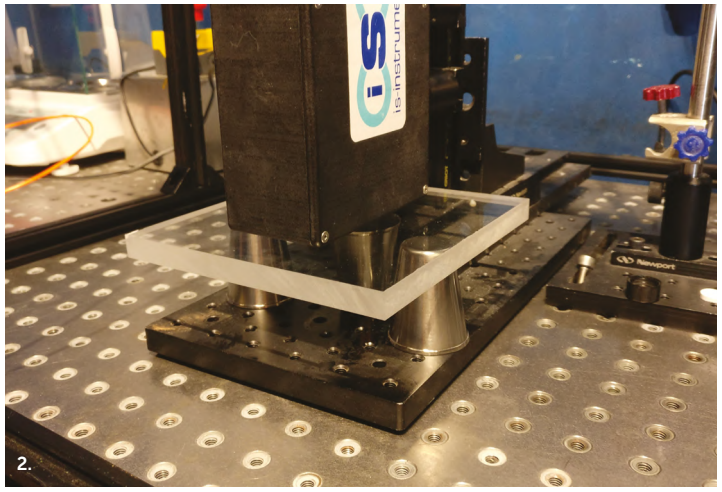




1. Raman spectrometry through test window (DECEIF01-0094-LT-RPT-0001 © Copyright 2022 Jacobs Clean Energy Ltd)

2. Raman spectrometry through test window (DECEIF01-0094-LT-RPT-0001 © Copyright 2022 Jacobs Clean Energy Ltd)

Real-time Gamma Optical Video Imaging (GOVI)

POCO involves the identification, reduction and/or removal of radiological and chemotoxic hazards in a facility in order to make decommissioning safer, faster and cheaper.

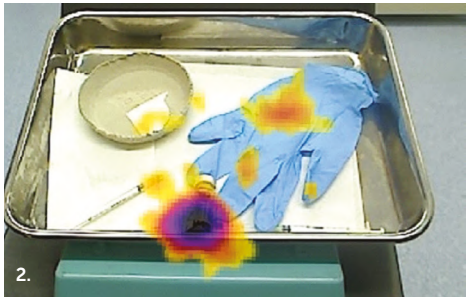
As part of the POCO challenge supported by Game Changers, we wanted to investigate innovative technologies, processes and characterisation techniques that could deliver significant improvements compared to the current POCO methodologies. Applications would need to offer cost savings and improved efficiencies in the areas of access and deployment, characterisation, decontamination, and/or waste transfer and treatment. Particular areas of interest included:

- Remote deployment and navigation techniques for characterisation and decontamination.
- In-situ chemical and physical analysis techniques.
- The use of chemical and physical methods to mobilise contamination.
- In-situ storage and grouting applications.

Addressing the characterisation aspect of the challenge, Gamma Optical Video Imaging (GOVI) delivers simultaneous, co-aligned optical and gamma imaging to produce a real-time display of an area being scanned. The GOVI camera:

- Fits through a standard 6-inch glove port.
- Offers relative activity quantification.
- Provides real-time imaging (i.e. a video feed with no reconstruction time needed).
- Delivers high spatial resolution (shapes of distributed sources can be seen or close sources separated).
- Offers efficiencies when monitoring POCO activities.
- Allows for non-intrusive characterisation methodologies.

Originally developed for use on the Mars Rover, and subsequently for medical imaging by the University of Leicester and University of Nottingham, researchers at Loughborough University have been working with Game Changers and Sellafield Ltd to identify and implement the adaptations needed for the nuclear industry. In a milestone for the project, the technology is now ready for active demonstration.



1. GOVI handheld gamma-optical video camera

2. Gamma and optical image

Project

Game Changers POCO challenge

Benefits

The GOVI camera is portable and can be operated while handheld or mounted on an arm for imaging at a distance. During manual cleaning (for example, in congested gloveboxes) the camera can identify areas of focus and monitor when a suitable endpoint for cleaning has been reached.

This device will reduce operating time, risk to operators, number of samples to be analysed, and secondary waste generation.

Current Status

The GOVI device is due to be deployed in an active glovebox at the Sellafield site, demonstrating its use in a real facility and benchmarking its performance against other tools, such as AmCam.

Delivery Partners

Game Changers, Loughborough University

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Drones through ports

There is a challenge to monitor and characterise the content of active cells that have been closed for many years. These cells have thick walls and limited access, generally through 150 mm ports.

Sellafield has used drones extensively in unconstrained environments due to their manoeuvrability and flexibility, but the problem is how to deliver, communicate and recover them in active cells with constrained access. In 2022, Game Changers set out the 'UAVs in confined spaces' challenge and we received some very exciting and quite diverse proposals. Working with our subject matter experts and pilots, three projects were selected to take through to a feasibility study.

In an impressive display of innovation, three pioneering Small and Medium-sized Enterprises (SMEs) recently showcased ground-breaking Unmanned Aerial Vehicle (UAV) technology: heliguy™, Headlight AI and ICE9 Robotics responded to our call for cutting-edge drone technology to help characterise difficult to access areas. After receiving Game Changers feasibility funding, the three SMEs customised existing drone technology to develop bespoke solutions capable of deployment through extremely small access ports.

Designing drones this small that retain the ability to maintain stable flight, and provide high-quality inspection footage, is a major challenge. Therefore, reaching a stage where the technology can be demonstrated after only a 12-week project was excellent. Click here to watch a video showcasing the UAV demonstration.

The next phase of work will involve a limited demonstration of these solutions to decide what to take to proof of concept and active demonstration phases.

Project
UAVs in confined spaces

Benefits
Benefits of flying the drones in cells are numerous, reduce cost base of inspections, to enable us to better monitor plant, direct more costly intervention, and plan for decommissioning. This will benefit cost, safety and accelerate our programme.

Current Status
Ongoing work with further stages keenly anticipated.

Delivery Partners
FIS360 Ltd, Colena Ltd t/a heliguy, ICE9 Robotics and Headlight AI Ltd.

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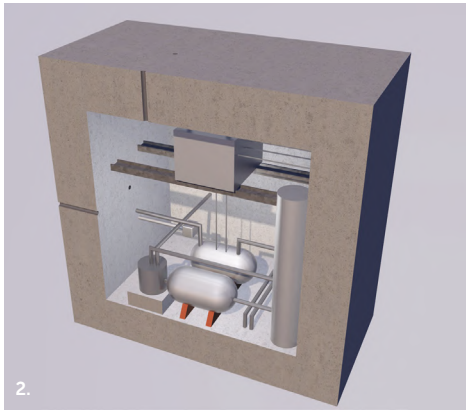
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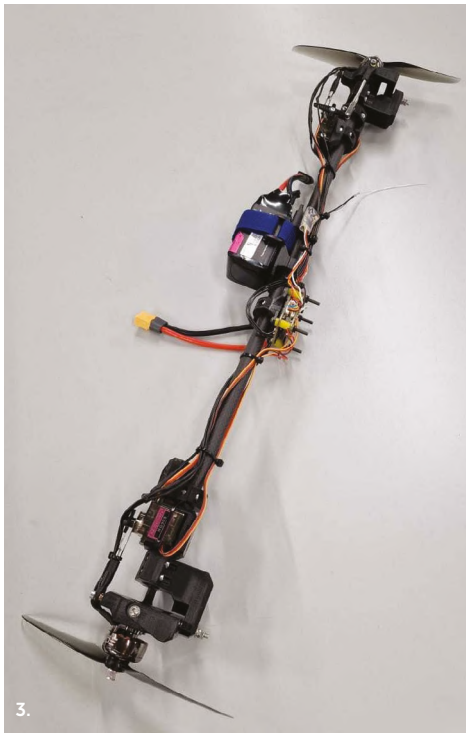
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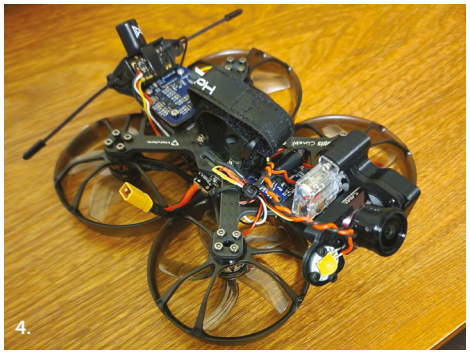
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1. Drones through ports

2. Cluttered cell image

3. Headlight AI drone

4. ICE9 Robotics drone

5. Heliguy drone

Jill Dunn

Senior technical advisor

Senior technical advisor Jill Dunn is passionate about technology, innovation and the adoption of artificial Intelligence within the nuclear industry. She is committed to finding new ways to report, detect anomalies and keep our work force safe through the research and innovation she oversees.

Her professional career began when she joined Sellafield Ltd in 2012 as a laundry operative and she has always sought to introduce improvements through innovation and processes to improve the working environment.

Jill then joined cyber security in 2014 where she was the information systems accreditor for the Site, and used her technical skills to approve suppliers, manage their networks and ensure that they complied with the Office for Nuclear Regulation (ONR) standards. She also worked with Information Services Organisation (ISO) closely when they were bringing in new technology and ensuring that they had the correct security policies such as the digital kiosks that are located across the site and the Mobile Device Management (MDM) policy that underpins the mobile phones for Sellafield.

Jill moved into the central technical team in August 2021 as a senior technical advisor where she supports AI capability for central robotics, new technology developments, such as Concretene and mechanochemistry, for the waste IRT, and innovative methods to support our mission to become carbon neutral for the sustainability IRT.

Jills current role allows her to harness her fascination with artificial intelligence as she seeks to introduce novel technologies and ways of working that adopts artificial intelligence into its practices.

"I love being able to improve and innovate the way that we do things."

Katy Spencer

Future asset management IRT lead

As IRT lead, Katy Spencer is responsible for engaging with stakeholders around the business and externally to determine what R&D in asset management would be most useful to explore over the next few years.

Katy graduated from Newcastle University in 2009 with a BSc in Mathematics and Statistics. Her first job was a 3-year Knowledge Transfer Partnership (KTP) through Newcastle University, Sellafield Ltd and NNL looking at the application of multivariate statistical predictive modelling techniques, and completed an MPhil using Neural Networks to model glass viscosity and analysing dust scrubber and melter neck blockages.

Fascinated by the work at Sellafield Ltd, Katy joined the two-year Graduate Scheme in 2012 within the Waste Vitrification Plant (WVP) technical team with a secondment to analytical services. As a member of the SFM technical & strategy team, she continued to look at how data was recorded and trended across various plants.

Her expertise and interest in understanding how data science could be combined with process/condition monitoring data to determine the condition of an asset led her to focus on enterprise asset management in 2021, before becoming future asset management IRT lead in 2023. Her current role investigates what enterprise R&D challenges there are within this theme, what research would be most useful to explore and then plan what R&D the IRT will focus on over the next few years.

"I am passionate about the value of data and showing others the power of turning data into information and the knowledge it can provide."

Jake Nicholson

Central innovation lead

Enabling innovation throughout the business is led by Jake Nicholson within the central R&D area, which involves organising events and creating an innovative environment.

Jake graduated from the University of Cumbria with a degree in Plant Engineering before joining the WVP team in 2013 as a system engineer. During this time, he worked on the in-cell cranes.

He moved to the central innovation team in 2017, where he ran the Engineering Education Scheme (EES), which is a nationwide scheme in which 4 to 6 sixth-form students complete a challenge set by a company over 6 months. His commitment to the scheme and voluntary effort put in by Jake and the rest of the team won them a Sellafield Excellence Award in 2018.

Jake's current role involves coordinating and enabling innovation by organising innovation events, managing the Dragons Den style competition and innovation community of practice. He has recently captured and reported our deployed innovation for the NDA, which has involved connecting and collaborating with different areas of the business and seeing all of the innovative work that is being done.

Building on the first site-wide innovation event, Jake is keen to create an innovative environment and culture that allows people to change the business and develop more innovation teams and routes to innovation within Sellafield Ltd, so that more individuals can get involved to progress their ideas.

"It's great to enable people in Sellafield to innovate."

Andres Alfaro

Horizon scanning lead

As part of the central emerging technology and innovation team, Andres Alfaro explores the changes, trends and technologies being developed around the world and looking at how they could help our projects.

Andres joined the project management graduate scheme at Sellafield Ltd in 2016 after completing his degree in Marketing Management at Manchester Metropolitan University. This involved rotating through several teams in the business, primarily focusing on enterprise technology and change programmes.

After completing the graduate scheme, Andres joined the innovation team to improve our technology horizon scanning capabilities. This can range from procuring and embedding new tools into the business to help projects in the short-term, to constructing scenarios that explore different potential futures to test our resilience and inform future workstreams.

Over the past year, he has supported the NDA horizon scanning framework, led by Frazer-Nash Consultancy, to identify several emerging technologies that could benefit our mission in the future. This collaborative approach has yielded outputs, analysis and data to inform our future decision making, and determine which areas of R&D we should be investing in and could yield significant benefit.

The increasing pace of change and levels of uncertainty in the world today mean that horizon scanning of the external environment is becoming increasingly important. Andres consciously monitors these developments to understand the potential impact and how to benefit from them.

"I have enjoyed learning this discipline and helping to prepare our business for the future."

Spent Fuel Management

The Spent Fuel Management (SFM) value stream is responsible for the safe, secure and cost effective lifecycle management of spent nuclear fuel and associated waste, including:

- The receipt and long-term storage of Advanced Gas-cooled Reactor (AGR) fuels which enables continued electricity generation and efficient reactor defueling. Storage and lifecycle management of remaining Magnox fuel and consolidation of irradiated fuel from Dounreay.
- The evaporation and vitrification of high-level waste and long-term storage prior to disposal along with completing the return of vitrified product to overseas reprocessing customers.
- Operation of complex suite of effluent facilities along with establishing new capabilities to ensure effective treatment of aqueous waste. Effluent treatment enables reprocessing POCO effluent and high hazard risk reduction.
- Implement arrangements to transition facilities post operations in a timely manner to enable effective lifecycle asset and waste management.

Faster ion exchange testing

The Site Ion Exchange Effluent Plant (SIXEP) uses a naturally occurring zeolite, clinoptilolite, to remove caesium and strontium from effluent prior to discharge. The current stock of clinoptilolite was purchased at the start of SIXEP operations in the early 1980s following an extensive testing programme. It is forecast that stock will be exhausted in the mid to late 2030s and a new supply of material will need to be sourced to support SIXEP operations until 2060.

A new approach to qualify future ion exchange materials is required as the original testing programme is no longer considered viable due to modern radiological protection standards. Development of a rapid ion exchange technique will enable the most suitable material to be identified and qualified much quicker, saving time and cost to the programme.

Rapid ion exchange experiments by NNL measure the uptake of radionuclides onto the ion exchange material, rather than the breakthrough of radionuclides once the ion exchange bed becomes saturated. This technique provides the ability to quickly screen many conditions prior to undertaking a few specific time-consuming column trials.

During the initial phase of development work, several experimental configurations were investigated and refined until competing ion effects could be observed and measured. The technique has been proven to detect elevated competing ion concentrations as low as 2.5 to 10 µg/ml. Further development of the rapid ion exchange technique is ongoing to provide information on radionuclide desorption and transfer rates.

A complementary modelling programme supports and underpins the experimental setup and design. Simulations, completed prior to the experiments, predict the likely performance and conditions required, such as ion concentration and flow rate. The experimental data is then used to continually improve and enhance the model. The next phase of modelling work includes fitting the exchange kinetics of the competing ions and scaling the model to plant scale.

Project

SIXEP-NNL R&D programme

Benefits

Successful development of the rapid ion exchange technique to test the performance of ion exchange materials will deliver significant time and cost savings to the future ion exchange qualification programme.

Current Status

Development of the rapid ion exchange technique and associated modelling support is ongoing. Experimental work to date indicates the technique can be used to test the effect of competing ions on ion exchange performance and provide useful data for development of the ion exchange model. Future work will focus on validation of the technique by applying it to a range of ion exchange materials.

Delivery Partners

NNL

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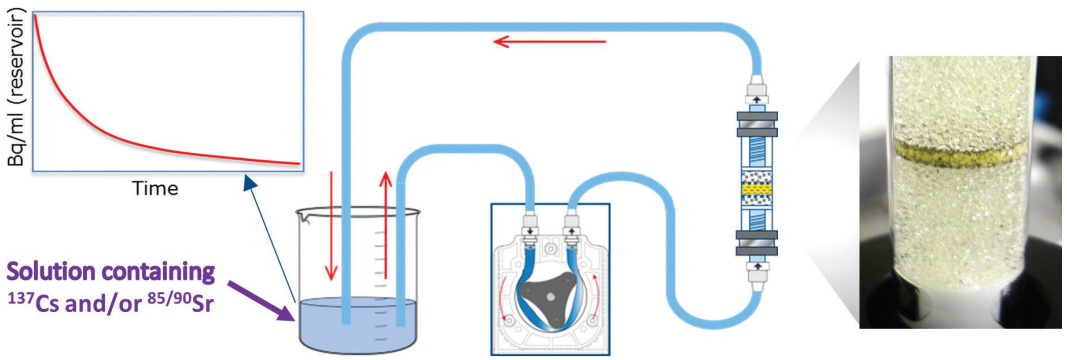

Schematic of rapid ion exchange technique

Radiolysis of high pH aqueous solutions

Spent nuclear fuel from the UK's fleet of Advanced Gas cooled Reactors (AGRs) will be held in long-term storage at the THORP Receipt and Storage (TR&S) pond before eventual disposal in a future Geological Disposal Facility (GDF). TR&S is an alkaline-dosed (high pH) pond, with high doses of gamma radiation from the (stainless-steel clad) spent fuel pins which are due to be transferred to a new 63-can rack.

Data on the radiolysis of solutions at high pH values was sparse, and radiolytic generation/recombination reactions are highly environment-specific, and therefore trials were initiated in two phases to:

1. Understand the effect of changes in pH.
2. Assess the impact of stainless-steel substrates on the radiolytic generation of hydrogen gas.

Using the Cobalt-60 gamma irradiator at the Dalton Cumbrian Facility, NNL conducted a series of trials measuring the radiolytic generation of hydrogen gas with a gas chromatograph; across a series of dose rates, irradiation times, and solution chemistry; using glass and stainless-steel substrates to test the effect of this surface.

The Dalton Cumbrian Facility is a state-of-the-art experimental facility for The University of Manchester's Dalton Nuclear Institute, which is part of the National Nuclear User Facility (NNUF), where academia and industry carry out world-leading research.

A degree apprentice within our team was fortunately able to take part in conducting the trials, using this truly experimental research as the basis for his undergraduate dissertation.

Project
Long-term storage of spent nuclear fuel

Benefits
Improved understanding of radiolysis of aqueous solutions.

Current Status
Experimental work completed with results reported, and NNL are in the process of submitting this for journal publication. Additional work is planned to undertake radiolysis of failed fuel.

Delivery Partners
NNL, The University of Manchester

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1.


2.

1. Dalton Cumbrian Facility, The University of Manchester (image courtesy of Dalton Cumbrian Facility)

2. Cobalt-60 gamma irradiator (image courtesy of Dalton Cumbrian Facility)

Characterisation & processing of solids

As we approach POCO and decommissioning activities, each facility will be required to remove and dispose of process solids and cruds that have collected throughout their operational lifetime. Operation of the Plutonium Uranium Redox Extraction (PUREX) solvent extraction process is no exception. Sampling and characterising these solids is extremely challenging due to their complex chemical nature, activity and restricted access.

Consequently, research is needed to understand how to characterise these complex solids and determine whether they can be processed via existing techniques, require pre-treatment before using existing processes, or require new processes entirely.

This work is required to support the upcoming POCO operations, advise on credible waste routes and feed into strategic decisions. The effort has been initially prioritised on the solids in the Salt Evaporator Feed Storage Tanks (FSTs).

The characterisation requirements have been reviewed against the techniques and the analytical capabilities available and an array of tools (shear vane, sonar, turbidity probe, cameras, solid sample tools, gamma probe and jet wash) have been proposed to characterise the Salt Evaporator FST solids. Working with Game Changers, two new Raman and near infrared probes have been successfully trialled for some organic mixtures.

Active surrogates, taken from laboratory scale PUREX trials at NNL, have been identified to develop characterisation protocols for use on actual waste samples and assess their behaviour during back-washing.

In addition, several methods to process test materials have been investigated:

- Processing some solids via the Enhanced Actinide Recovery Plant (EARP) would require significant dilution of feeds and hence buffer storage.
- Although encapsulation is challenging, preliminary trials using geopolymers, rather than conventional grouts, looks promising.

1. Solids inside salt evaporator FST

2. Sonar probe for solid characterisation

Project

LAEMG solids study

Benefits

Characterisation of complex solids within multiple facilities across the Sellafield site is vital to identify the optimal POCO solutions, disposal routes and avoid costly delays to the upcoming POCO operations.

Current Status

The project is ongoing with the intent to deploy an array of tools into the Salt Evaporator FST to characterise the solid chemistry and understand their behaviour.

The solids that have arisen from small scale PUREX trials in NNL represent a subset of the waste that are likely to be present. These solids will be used to develop characterisation protocols and assess back-washing processes that could be adopted on plant during POCO operations.

Delivery Partners

Clifton Photonics, Fortis Remote Technology, Game Changers, Imperial College London, NNL

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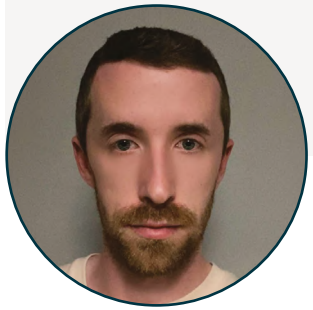
Stephen Kirvan

Technical and strategy team lead

Within technical and strategy, Steve Kirvan oversees the R&D portfolio for the Low Active Effluent Management Group (LAEMG), covering a number of effluent treatment facilities. He is also a Chartered Chemist (CChem) with the RSC.



Stephen's career began at Sellafield Ltd in 2016 after obtaining a Master's degree in Chemistry with Industrial Training from Newcastle University. Since joining, Stephen has always focused on technical and strategy development, initially in analytical services with a secondment to SIXEP in 2018.

He's been in his current LAEMG technical and strategy role, since 2020 and finds the diversity of challenges within his area satisfying. Over the past year, Stephen has been supporting the disposal of high activity wastes through a period of significant change. Our effluent plants have seen a drastic change in the feed as a result of the cessation of reprocessing.

As part of this work, the sites effluent flowsheet is transitioning from reprocessing dominated feeds to POCO effluents, which affect the chemistry at the abatement plants. Going into next year, Stephen will continue to develop the LAEMG R&D plan to support the effluent strategy.

Stephen enjoys problem solving and finding out new information, two critical aspects of his role. He works collaboratively with his team, made up of chemists, physicists and engineers, but also interacts with colleagues in operations, system engineering and safety case.

"I am driven by contributing to work that will make a real-world impact in the nuclear sector and support the remediation of the Sellafield site."

Richard Veazey

Senior technical advisor

As a senior technical advisor in the spent fuel services strategy & technical team, Dr Richard Veazey is responsible for leading and supporting the development of strategies for spent fuels.

Richard has a Master's degree in Physics and Astrophysics, and a PhD in Nuclear Materials, both from the University of Sheffield and is a member of the Institute of Materials, Minerals and Mining (IOM3), working towards chartership. He joined Sellafield Ltd in 2019 on the graduate scheme which involved 18 months in the SFM ponds technical and 6-month secondment to the independent performance and assurance group.

In his current role, Richard advises programmes on strategies and supports prioritisation of different activities so that the strategies are implementable at the right time. The strategies could be implemented for many years into the future, and in some cases require developing fast to resolve issues that are happening on plant today.

His work involves regularly engaging with different programmes and external bodies, such as the NDA and EDF Energy. For example, Richard has recently been supporting the AGR operating programme, engaging with EDF Energy, and helping keep the fuel we are due to receive safe until final disposal.

Richard enjoys being able to set the strategic direction of the company within spent fuel services and then seeing the business move towards that direction. This will continue into next year with Richard writing a strategy that is determining the optimised use of assets in the Thorp Receipt and Storage (TR&S) pond to provide storage capacity and value for money.

"It's exciting to be supporting a national programme and helping 'keep the lights on'. I get a lot of satisfaction from seeing the strategies I develop being implemented in the business."

Trent Bell

SIXEP technical

Trent Bell joined Sellafield Ltd in 2016 on the Degree Apprenticeship scheme. Over the next 5 years he earned a Bachelor's degree in Plant Engineering with Nuclear Technologies, accredited by the University of Cumbria, alongside working in SIXEP.

Whilst on the Degree Apprenticeship scheme, Trent studied 1 day per week at Energus, whilst spending the remaining 4 days per week working in SIXEP technical. Having earned his degree in December 2020, he is continuing his professional development as a Member of Nuclear Institute working towards becoming an Incorporated Engineer.

Trent analyses and investigates trends in the sample results and pressure data from the plant. His technical skills are continually developing by undertaking technical investigations into multiple areas, identifying potential issues and plant improvements that could be made, as well as performing ad hoc investigations and problem solving.

Over the past year, Trent has improved the value of the log system by moving sand bed weights from the previous paper-based system to a digital system. He is also helping with the development of the new PowerBI dashboard, which has saved multiple hours of work by automating data processing and visualisation.

Working for SIXEP has provided Trent with a good overview of site operations as he routinely interacts with operations managers and technical teams from a variety of facilities, and also interfaces with NNL regarding some of their research and experiments.

"I enjoy working through issues and finding a resolution."

Matthew Haigh

Inspection and characterisation manager

Within the Highly Active Liquor (HAL) facilities, Matthew Haigh oversees the development and deployment of inspection and characterisation technology, which requires specialist equipment due to very high radiation.

Matthew joined Sellafield Ltd in 2013 through the degree apprenticeship scheme and graduated with a BEng in Plant Engineering (nuclear technology) from the University of Cumbria. This 5-year scheme involves 1 day per week study, while working on the Highly Active Liquor Evaporation and Storage (HALES) inspection programme.

His part-time degree allowed him to develop his knowledge and expertise in characterising highly active liquor, which enabled him to move into a characterisation specialist role after graduating, and he became the inspection and characterisation manager for the HAL programme in 2021.

Due to the Sellafield site transitioning towards remediation the priorities and processes have changed, Matthew's focus is now on supporting washout and preparing for POCO. This includes developing and deploying ROVs to inspect the buffer storage facility and identifying methods the improve the efficiency of the wash out programme to simplify decommissioning and reduce cost.

Matthew is a member of the Society of Operational Engineers and associate member of the Nuclear Institute and manages a team of current apprentices and experienced professionals to solve a wide variety of challenges.

"It's satisfying to solve problems and see projects through from issue identification through to deployment."

Special Nuclear Materials

The Special Nuclear Materials (SNM) value stream is responsible for the safe, secure and appropriate storage of plutonium and other special nuclear materials, with the R&D programme focusing on:

- Understanding the chemical and physical behaviour of plutonium-bearing materials to ensure long-term safe management and storage, focusing on aspects including radiolysis, evolution of sealed packages, corrosion, behaviour of impurities such as chlorides and the requirements for future conditioning.
- Innovative approaches to the safe operation of facilities handling and storing plutonium, possibly including technologies such as robotics, automation and digital applications for alpha environments.
- Continued technical underpinning of POCO and decommissioning plans for alpha facilities.
- Techniques for the monitoring, retrieval and processing of residual product in gloveboxes, plant, equipment and facilities during POCO and decommissioning.
- Techniques for improving the capability of package and asset inspections.
- Direct support to the special nuclear materials consolidation programme.

Blast testing of transport containers

Sellafield Ltd is responsible for the movement of high security materials between facilities on the Sellafield site. Our security operations are designed to manage all relevant threats to the materials, but we have limited real world data on the performance of our transport containers.

We believe that we can improve our current processes with further data. The transport containers, commercially known as Safkegs, are required for radiological safety protection and are not designed with security threats in mind.

Working with the wider NDA group, we identified the specialist capabilities of Det Norske Veritas (DNV) at RAF Spadeadam to safely manage the explosive testing work. They worked with us to design the data capture and effective management of the tests. A series of blast tests of increasing complexity and power were performed as we gained confidence in the novel testing programme. Alongside this, colleagues at Nuclear Transport Solutions (part of the NDA group) used Light Detection and Ranging (LiDAR) scanning to validate explosives modelling.

Ultimately, we showed certain containers could perform well in the relevant situation and others were justified in our current security arrangements. The modelling has been validated and is now being used to help plan larger tests and to extrapolate the existing data without performing difficult physical tests.

This work has helped increase confidence in our threat assessments and allowed us to take credit for the engineering assets more than we previously could. It has also provided confidence to our stakeholders that we can get real world data on the performance of our equipment during security threats.

Project

Support to plutonium disposition

Benefits

We have created a relationship with a unique supplier who can now be used for more complicated testing across the wider NDA group. We have also simplified some of our arrangements, making the best use of our limited resources.

Current Status

The first phase is complete. We are now developing larger blasts and more complicated testing to further improve our understanding.

Delivery Partners

DNV, Magnox Ltd, NDA, Nuclear Transport Solutions (NTS)

Contact Details

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1. Safkeg explosion test

2. 3D scan of test component

Ensuring functionality of storage facility

The Sellafield Product and Residue Store (SPRS) is a modern storage facility for SNM packages, with a planned life of 100 years. It is passively cooled by unfiltered air, which has led to corrosion of store structures due to the coastal location of the building.

The storage cells are supported by tie bars that are held by rose bearings that must be able to move during a seismic event to minimise stresses on store components. Advanced corrosion has been observed on bearing test coupons in the store ventilation system. Corrosion of the in-service bearings does not appear to be as severe, but it is important to understand the possible impact of bearing corrosion on the operation of the seismic system.

The aim of this research project was to measure the force required to actuate corroded rose bearings, and quantify the resistance to movement that they may have during a seismic event. This will inform engineering assessments of how long the store will continue to meet its safety requirements and guide the potential need for refurbishment or replacement of components in the future. The SPRS is not easily accessible for manned entry to inspect or maintain, so this lab-based research reduces potential risk and dose uptake to maintainers.

A range of corrosion levels were induced in a corrosion chamber using salt sprays in a controlled environment for different lengths of time (53 to 441 days). The bearings were then mounted into a custom jig that allowed their movement to be tested. Forces were measured using a load frame over many cycles of movement before and after corrosion.

The results showed that significantly more force was required to initially move the most heavily corroded bearings, compared to new bearings. Forces generally decreased after the first movement cycle.

This result can be compared to existing modelling of the forces acting in the store during a seismic event with one or more seized bearings. It is considered that even severe build-up of corrosion products on seismic bearings is likely to spall off in a seismic event to allow sufficient movement of the seismic ties.


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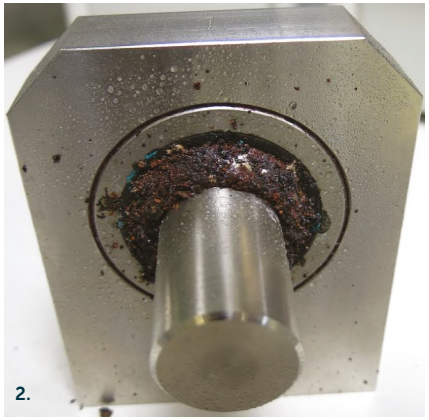
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Project

SPRS corrosion mitigation programme

Benefits

Improved understanding of the operation of SPRS seismic bearings under a range of levels of corrosion. This supports ongoing technical and engineering work to justify the continued safe operation of the store and minimise the need to refurbish or replace the components over its lifetime.

Current Status

The condition of in-service bearings appears to be less deteriorated than many of those tested at NNL, which were all able to move under applied forces. If bearings in the store show signs of advanced corrosion or build-up of corrosion products, additional modelling work may be required.

Delivery Partners

NNL

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1. Corroded seismic bearing test coupon from SPRS ventilation system

2. Seismic bearing after exposure to a controlled corrosive environment

3. SPRS seismic bearing test rig at NNL

SNM inspections capability development

We inspect our packages and store infrastructure to better underpin business decisions and ensure better compliance with our regulatory requirements.

To determine if an SNM package remains safe for storage it is necessary to quantify the following characteristics of a package:

a. Internal pressurisation (flammable and/or non-flammable within safety limits).

b. Physical damage (scratches, dents and corrosion to a standard).

c. Seal quality (lid weld quality and integrity to demonstrate pressure withstand capability).

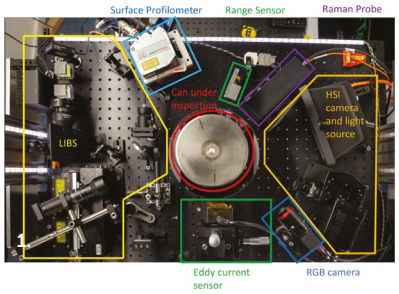
d. Presence of loose contamination on the outside of packages (indicating a loss of containment failure which may also be indicated by weight-gain).

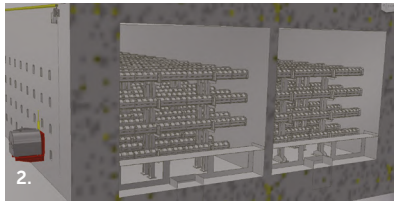
Packages are currently assessed using visual inspection and digital cameras, but there is a drive to move away from the subjective nature of this assessment to more objective examination and inspection methods. In addition, we cannot be certain of all four attributes from an external examination. An informal consortium of delivery partners has been created to develop these new inspection methods.

Test rig facilities have been created that replicate the constraints of inspecting packages in a storage environment, and R&D programmes have been created and delivered using a mixture of PhDs, postdoctoral and contract research, Game Changers and LINC (Liaise, Innovate, Network, Collaborate) framework opportunities.

This research has demonstrated the following developments to enable a complete, objective inspection of all package characteristics:

- A laboratory based acoustic technique to measure internal pressure in SNM welded packages.
- A prototype rapid inspection rig where multiple sensors are incorporated to enable a multi-sensor approach to characterising SNM packages.
- A laboratory based ultrasonic technique to detect for weld abnormalities of a resistance seam weld.
- The use of thermal imaging to identify surface features on SNM packages.





1. Multi-sensor arrangement in prototype rapid inspection rig

2. 3D model of the interior of a typical SNM store

3. Charge face wall within the charge corridor of a typical SNM store

4. Typical welded SNM package

Project

SNM inspections capability improvements

Benefits

Improving the inspections capability, to obtain more objective inspection and examination data, will enable the business to make better, more informed decisions on our current SNM packages thereby enabling more quantitative risk reduction.

Current Status

Construction and operation of a test rig facility replicating the constraints of the SNM stores. Programmes of work are underway to convert the prototypes, and/or laboratory-based demonstrations, to on-plant demonstrators whilst maintaining a pipeline of PhD research.

Delivery Partners

Fraunhofer Centre for Applied Photonics, FIS360 Ltd, NNL, National Physical Laboratory (NPL), The University of Manchester, University of Strathclyde, University of Warwick

Contact Details

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Smart sensors for the 100 year can

SNM packages need to be inspected on a regular basis to identify any possible issues that may affect the package integrity. The inspections can be performed in-situ or ex-situ and can be difficult to carry out and result in a radiation dose to operators.

Package pressure and temperature have been identified as the most important measurements to indicate any possible issues with the package. By installing smart sensors onto the packages before they go into the store, we can wirelessly monitor the packages through a central hub which will be notified if any of the packages show an abnormal reading in terms of pressure and temperature. This will reduce the need for human intervention within the stores, saving dose uptake.

Sensor Driven, selected through the Game Changers framework, have proven that communication is possible from the sensors inside of a channel to a central hub, providing detailed cannister data for decades without sensor maintenance. Sensors are now being prepared for trials in an active SNM store.

Project

Long-term storage of SNM packages

Benefits

The implementation of smart sensors will reduce the number of inspections required over the lifetime of the packages, in turn reducing the dose to operators as they will be performing manual inspections less often.

There will be increased confidence in the condition of packages without the need for manual inspection and allow for any potential issues to be identified earlier, enabling swifter responses. Combined, these benefits will assist in maintaining the integrity and safe storage of the packages.

Current Status

The project has been approved to move into the final delivery stage and trials. The next steps are to refine the design against specific handling, measurement and environmental requirements for the 100 year can.

Delivery Partners

Sensor Driven Ltd, Game Changers, FIS360 Ltd

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Smart sensor on can

Duct monitoring within stores

We have numerous stores across the Sellafield site that contain SNM packages. The environment within the stores is carefully monitored and each building is equipped with a ventilation system to provide cooling as well as a second containment barrier through a series of High-Efficiency Particulate Absorbing (HEPA) filters.

There is up to 2 km of ductwork within and around each store, which are currently inspected visually via an endoscope inserted through circular openings at regular intervals along the duct. This gives the operators limited information and is time consuming to inspect the whole duct. Long-term sensor solutions would allow remote monitoring of conditions within the ducts to give an indication of duct degradation or corrosion.

A remote monitoring capability would detect any change in condition within the ducts and make it easier to obtain and store any data received. This will reduce the need to perform manual inspections, replacing them with a leave and forget alternative. The benefit of this method will be increased safety of the operators, reduced maintenance cost and increased confidence of the regulator and store manager in the state of ductwork system.

The Game Changers framework was used to identify potential innovative solutions by providing multiple companies / universities with a £10,000 grant and 3 months to deliver a business plan for their proposed solution. After 3 months, the stakeholders will review the proposals and down-select which projects should be taken forward.

Project

Maintaining and ensuring the safe, long-term storage of SNM packages

Benefits

This work will increase the amount of information available to operators in order to give them a more in-depth overview of the condition of the ducts. By introducing a leave and forget capability, the dose to operators is reduced due to less manual intervention. Overall this will increase confidence in the state the duct is in.

Current Status

We are coming to the end of the 3-month window for companies / universities given the £10,000 grant to feedback with their proposals of possible solutions and project plans. Once these are received, we will then decide which solutions to further fund to a feasibility state.

Delivery Partners

Game Changers, FIS360 Ltd

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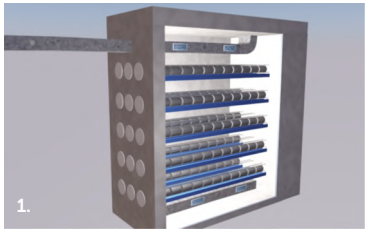
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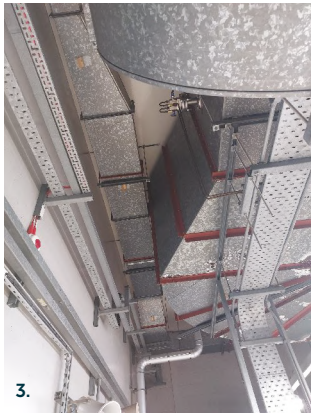
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1. Typical store and associated ductwork

2. Examples of ductwork

3. Examples of ductwork

Virtual training environment

Glovebox operators need to be properly trained and familiarised with the processes that they need to undertake in a safe, inactive environment. A Virtual Reality (VR) simulation of generic glovebox operations provide an immersive virtual environment to allow operators to safely learn and test different processes and emergency procedures.

PixelMill was contracted through the LINC framework, which encourages SMEs to collaborate with Sellafield. This has produced a capability that gives operators the ability to practice glovebox operations that they will likely encounter during active glovebox work. It also gives them the ability to practice for 'off-norm' situations, such as alarms that may happen in an active operation.

The VR simulation provides an immersive experience to assist in training and familiarisation of the operators. The virtual environment allows operators to get fully familiarised and accustomed to generic glovebox operations, such as picking up, moving, and positioning articulated objects using the VR controllers. Some examples of operations that are simulated are cleaning a glovebox and changing a hose.

Another benefit of the VR environment is to identify the most ergonomic and efficient process for each task. Operators can then be trained on the finalised process to minimise the risk of potential accidents in an active environment. In addition, ad hoc operations can be tested before they are actioned in an active environment.

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Project

Safer glovebox working

Benefits

This work allows operators to train in a safe, inactive virtual environment before they are actioned in an active environment. This allows them to understand and practice the correct emergency response in worst case scenarios, allowing them to be better equipped to deal with challenges they may face.

Current Status

Second scheme of work completed with PixelMill to develop the first emergency scenario. This has been trialled with operators and feedback received. Two further emergency scenarios have been successfully developed and will be rolled out in July 2023.

Delivery Partners

PixelMill Ltd

Contact Details

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1. Glovebox training toolbox

2. VR headset

3. VR Room set up

Improved glovebox inspection

Glovebox inspections can often be difficult to carry out due to poor visibility through older glovebox windows and/or poor lighting levels. In addition to inspecting glovebox internals and furniture, operators also need to look inside some vessels within gloveboxes.

Inspections are important because they help confirm the condition of gloveboxes and their contents on a regular basis. They can also be used to plan and carry out specific glovebox tasks therefore helping to make the work safer.

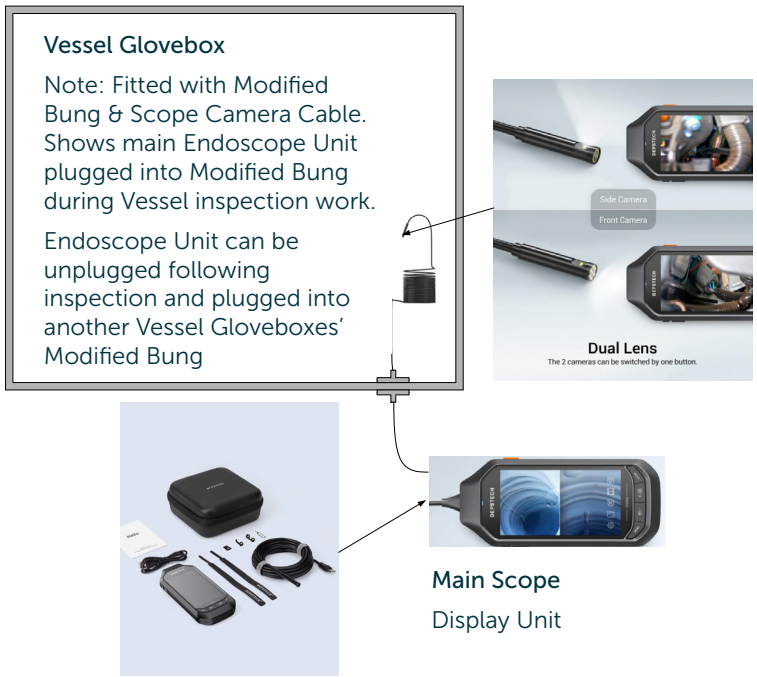
The SNM innovation team answered a need from plant to provide a means of viewing inside a vessel in a glovebox. The team purchased a COTS endoscope (less than £100) and following successful off-site testing with a modified bung handed it over to plant, so that it could be used to improve their glovebox inspections.

The endoscope camera cable is connected to a USB type through-connector on the glovebox side of the modified bung and then the rechargeable monitor/control unit is connected to the modified bung on the outside of the glovebox. This hard-wired connection is reliable and doesn't require any battery powered components inside the glovebox which can be difficult to post out as waste.

The endoscope monitor unit can capture both video and still photos on a removeable memory card, ensuring that the inspection is recorded and available for further review. The endoscope camera inside the glovebox has two cameras, so the footage captures images both to the side and in front of the endoscope camera as it is lowered down a vessel. Video footage can be taken from both camera views at the same time and the monitor has a split screen option to show both images if required. The cameras also have integral LED lights with variable brightness that can be adjusted using the monitor unit.

The endoscope camera cable can be left inside the glovebox ready for a future inspection as it is relatively low cost (~£30) and can be easily replaced in the future if required.

The monitor/control unit can be simply unplugged from the modified bung, stored and recharged as required in a safe place on plant ready for the next inspection. Therefore, one monitor/control unit can be used for multiple gloveboxes as long as an endoscope camera cable has been installed within them.



Schematic of glovebox endoscope

Project
Glovebox improvement

Benefits
This work improves glovebox inspections by allowing operators to view areas that can't be seen through the glovebox window and inspect inside items within gloveboxes, such as vessels. This would be suitable for all gloveboxes across site with modified bungs, allowing the benefit to be realised in multiple plants around site.

Current Status
The endoscope and display screen have been bought and trialled inactively to demonstrate proof of concept. We are now waiting for the deployment of the modified bungs on site to allow a USB connection into the glovebox.

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Jon Squire

Strategy and disposition manager

As strategy and disposition manager, Dr Jon Squire applies the knowledge gained from his doctorate and 10 years' experience at Sellafield to solve issues relating to the disposition of plutonium. He also plays a key role in the development of the people and skills necessary to meet this objective.

After gaining a Master's degree in Chemical Engineering from the University of Manchester, Jon completed an Engineering Doctorate (EngD) at the University of Sheffield. This involved industrial research at NNL in Workington and was focused on the manufacture of plutonium materials for disposal. Jon is also a member of the IChemE.

Jon joined the SNM team at Sellafield Ltd in 2013 to deliver projects that involved the application of research to make a real difference. His first role did just this, applying the knowledge gained from his EngD to use Hot Isostatic Pressing (HIP) for plutonium residue management. This led to work looking at package lifetime assessments before he moved to an operational role in 2017 as a business change manager, where he was involved in the technical and strategic implementation of ideas and processes.

In 2021 he started his current role, coordinating a number of studies and research on disposition and coordinating Sellafield's response to the NDA's requirements. He enjoys the sense of purpose, complex challenges, and the role that he has in developing strategies and options to handle plutonium.

Next year, Jon will be developing the long-term processing strategy for plutonium and building the capability and skills within Sellafield Ltd to deliver NDA's disposition requirements.

"It's great to have the opportunity to solve big problems and ensure that the UK's disposition strategy is delivered in the right way."

Rob Stephen

Assets management team manager

Dr Rob Stephen, assets management team manager in SNM strategy and technical, ensures that his team establishes the condition of all our assets, both the product and residue packages, and the storage facilities.

Rob's extensive 26-year career in the nuclear sector began in 1997 when he joined BNFL in research and technology, developing potential future Mixed OXide (MOX) fuels. Before this he completed a BSc in Materials Technology, a PhD in Engineering Ceramics and a 2-year postdoctoral role at the Flemish Institute for Technical Research.

His role at BNFL involved carrying out small scale MOX trials, later developing into full scale trials to support the recycling of rejected fuels in the Sellafield MOX Plant. Rob then went on to manage the Sellafield MOX Plant development work carried out by NNL at their Preston Laboratory before joining the Plutonium Operating Unit. There, his work mainly involved supporting the Dounreay unirradiated shipments to Sellafield.

Rob started his current role as assets management team leader in 2022. His team is responsible for managing technical issues associated with the SNM value stream assets. These are primarily the product and residue packages and the storage facilities.

Over the past year Rob has been getting up to speed with his new role. There has been a steep learning curve and he has focused on understanding the scope of work and what his team members' roles are and how he can support them.

"The assets team members are mainly in the early stages of their career, and it is exciting to see them develop and progress as they will be the future of the company."

Retrievals

The Retrievals value stream mission is to reduce the hazard and risk posed by nuclear waste stored in legacy facilities (ponds and silos) by retrieving and transferring it to safe modern containment.

The waste is highly heterogenous and has been stored for many decades in non-ideal conditions, making it difficult to characterise and retrieve. The R&D programme is focused on:

- Characterising the waste and assessing risks in order to develop and implement waste routes.
- Continued development of innovative techniques for waste retrieval based on Learning from Experience of early waste retrieval activities.
- Managing the impact of waste retrieval activities on the continued safe operation of the legacy facilities and on downstream waste conditioning and effluent treatment facilities.
- Assessing treatment and finishing requirements for unconditioned waste together with Letter of Compliance (LoC) requirements.
- Developing Condition Monitoring and Inspection (CM&I) capabilities to demonstrate that retrieved waste behaviour is consistent with predicted behaviour during the storage period.
- Conditioning, storage and disposal solutions for metallic uranic fuel and uranium bearing material.

Remote hydrogen detection

Condition, Monitoring, and Inspection (CM&I) aims to ensure waste is evolving as predicted through modelling. One method of determining this is by using the rate of hydrogen being produced. Hydrogen generation rates are a good indicator of how the waste is behaving and how fast it is reacting. Therefore, the validity of waste evolution models can be confirmed by monitoring hydrogen production rates.

Hydrogen produced by waste is safely vented out through filters on the waste containers. The potential risk that some waste containers produce excessive hydrogen compared to the expected behaviour requires a system that can monitor hydrogen without having to move the waste containers to a monitoring station. Ideally this system would use a stand-off system, requiring long-range detection. Therefore, a project was launched to build a system that can remotely detect and measure hydrogen at low concentrations.

Initial research was undertaken to choose a suitable method to detect hydrogen that doesn't pose any risk to the waste containers or store. Raman spectroscopy was selected as it is a well-established technique that fulfils these criteria. However, it is not commonly used at long range which created a unique challenge during development.

Research into laser systems, power requirements, and how to separate Raman signals was conducted through collaboration between Retrievals, Central Technical and the Fraunhofer Centre for Applied Photonics (CAP). This collaborative project, managed by FIS360 Ltd, has allowed the fast development of this cutting-edge technology.

A full-scale working system was successfully trialled in October 2022 that met the long-range requirement. Further trials in March 2023 demonstrated that the system could detect hydrogen concentrations as low as 0.0025%.

The project supports the safe storage of waste containers and has provided value through the benefit it can provide to safely monitor hydrogen within Sellafield and other estates, such as Dounreay and Magnox. The technology has also proven valuable to the ever-growing hydrogen economy and wider industry, such as BP, who have asked Fraunhofer CAP to develop a hand-held system for forecourt hydrogen monitoring.

Project

Condition, Monitoring & Inspection technology development

Benefits

The system ensures that waste is evolving as predicted and that hydrogen levels in the stores follow the modelled values expected. Hydrogen monitoring of nuclear waste has the potential to promote continuous safety and reliability. The collaborative approach brings great value and stronger business and interpersonal relationships within the industry and throughout the team.

Current Status

The next phase is underway with the aim to improve and refine the capability of the system and determine the final deployment route into stores.

Delivery Partners

Fraunhofer Centre for Applied Photonics, FIS360 Ltd

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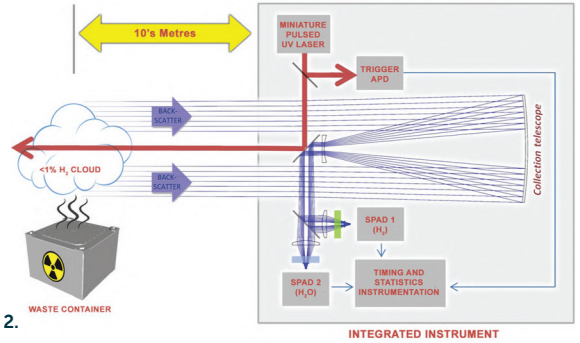

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1. Long range Raman spectrometer developed by Fraunhofer CAP

2. Remote hydrogen detection method

Inspecting encapsulated waste

The Box Encapsulation Plant (BEP) will process legacy wastes prior to interim storage until a final disposal option is available. CM&I is required to understand the waste container performance and condition that can be used to inform the finishing requirements and ultimate disposal.

CM&I within the Box Encapsulation Plant and Stores (BEPS) will either be performed in-situ, where the waste containers are not moved from the store, or ex-situ, where waste containers are returned from the store to the BEP for enhanced monitoring.

Ex-situ monitoring will be used to provide reassurance that the waste is evolving as expected and assure the internal integrity of waste containers. The only viable options that can see through such large and robust waste containers are muon tomography and high energy X-ray radiography. A decision of which technology to use was needed to allow for further development and ultimately timely implementation of a technology.

- Muon tomography is a passive detection system, using the scattering of naturally occurring muons to produce an image of a waste container and its contents. NNL and Lynkeos have developed muon technology to test the capabilities for the imaging nuclear waste containers.
- High energy X-ray radiography would use an X-ray fan beam to scan the waste containers. A turntable and bogie design has been developed by Jacobs and Rapiscan Systems that would allow for waste container rotation to produce the required image.

Both technologies were developed to a roughly equal stage to enable a fair comparison. A Technology Readiness Assessment, Technology Roadmap and NDA Value Framework Assessment was conducted to assess each option, alongside a 3rd option of developing neither technology. This identified the maturity, risks and remaining development required, as well as the safety, risks, enablers and ability to implement each technology.

The outcome from the assessment process is that muon tomography should be taken forward for further development and implementation. Muon tomography is a passive technology with fewer safety concerns and has the potential to obtain more valuable information about the waste containers than X-ray.

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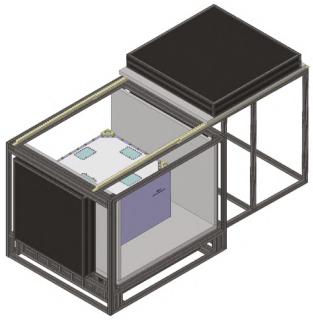

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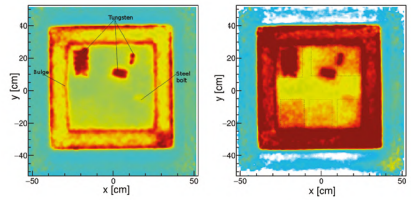

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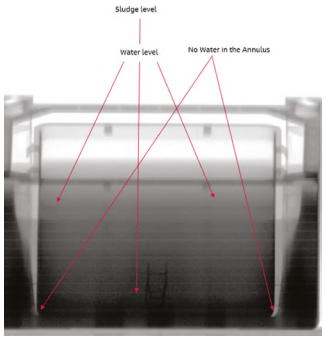

1. Proposed Muon Imaging System (MIS) design with retractable top detector

2. Test waste container layout

3. MIS results showing differing densities across test waste container

4. X-ray of a full-scale test waste container

Project

CM&I Technology development and selection

Benefits

Muon tomography will help understand waste evolution within stored waste containers to confirm evolution models. This gives regulators and stakeholders confidence in our ability to manage wastes for interim storage and identifies potential issues with waste containers in sufficient time to allow an appropriate and timely response.

Current Status

The work is currently scheduled to undergo decision governance in June 2023, following this a project will be initiated to develop the chosen technology and eventually implement it within the BEP.

Delivery Partners

Jacobs, Lynkeos Technology Ltd, NNL, Rapiscan Systems, REACT Engineering Ltd

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MSSS thermal modelling

Magnox swarf is stored in the Magnox Swarf Storage Silos (MSSS) within large silos under a volume of cover water. The waste generates heat through ongoing radiogenic decay and reaction with the cover water.

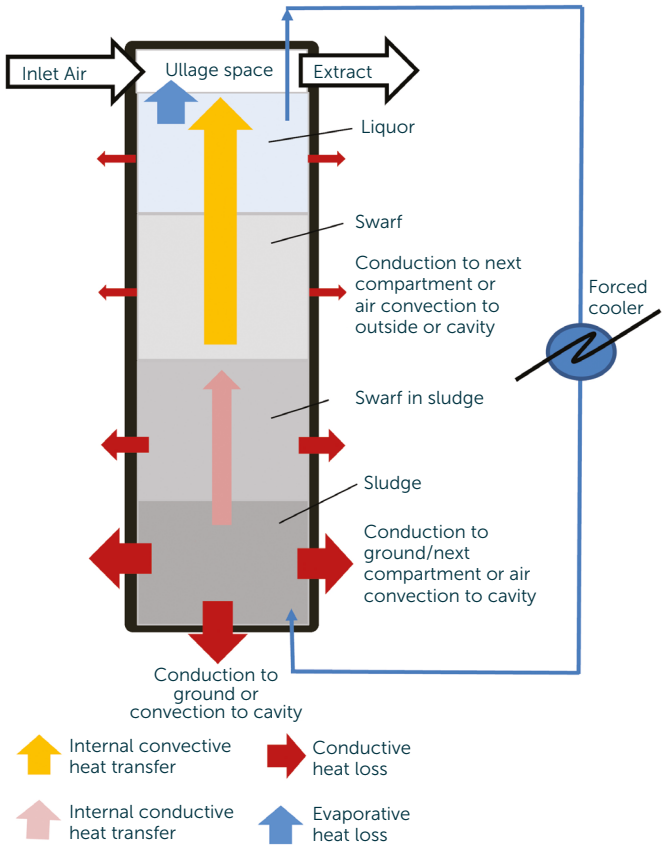
It is possible that excessively high waste temperature could accelerate the Magnox water reaction to the point of a run-away reaction, known in MSSS as an excursion. An excursion results in the generation of large amounts of heat and hydrogen. Previous understanding of the margin to excursion was based on analysis of data from historical excursion events (1968 to 1980) and not on a fundamental understanding of the silo heat balance.

In December 2019 the recorded temperature of the waste in 3rd extension compartments C16, C17 & C18 rose above the expected normal trend by a few degrees. This triggered work to explore the heat balance with the aim of confirming our understanding of the margin to excursion.

Working in conjunction with NNL, a thermal model of C18 was developed to simulate the mechanisms for heat loss and heat generation to produce a waste temperature profile within the compartment. The model predictions correlated well with plant data from 2015 to 2020, and supported the MSSS team's working theory that the change in behaviour may have been caused by a decision to reduce the silo ventilation flow in 2017.

The margin to excursion has been explored through sensitivity analysis, which demonstrated that the model did not become unstable until the heat load was approximately double the current value.

The model has improved our technical understanding of the MSSS heat balance, provides confidence that the margin to excursion remains large and moves predictions on margin to excursion away from reliance on analysis of historical plant data. This learning will be taken forwards and used to expand its capability and apply it to other silos.



Heat loss mechanisms within an MSSS compartment

Project

MSSS technical

Benefits

The model has expanded our understanding of the MSSS compartment heat balance, improving confidence in the theory of the causes of the 2019 change in waste behaviour. It also provides confidence that the margin to thermal runaway in C18 is likely to be large and moves predictions on margin to excursion away from reliance on analysis of historical plant data.

Current Status

The current phase of model development is complete including a functioning model of C18 and a sensitivity analysis. Future work is planned to improve the current model, expand it to cover the entire 3rd extension and use it as a basis to develop future silo heat models.

Delivery Partners

NNL

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Elizabeth Sumner

Graduate chemist

As a graduate chemist in the MSSS plant-facing technical team, Elizabeth Sumner is responsible for tracking and trending the MSSS compartment data, helping make retrievals more efficient and getting us closer to our goal of removing all the waste from the MSSS.

Elizabeth studied Chemistry at the University of Reading, where she obtained a First-Class MChem degree and a prize for best dissertation research project. She is working towards membership of the Royal Society of Chemistry and is a member of Women in Nuclear and the Nuclear Institute.

Since joining Sellafield Ltd in September 2022, she has been working on the characterisation of waste from the compartments, and how this can be optimised to improve the packing of waste into skips and meet disposability requirements. This role is very different to her past experiences, and she's had a challenging but rewarding time learning about the history of the plant and how this impacts current and future operations.

Elizabeth has enjoyed having a hands-on role, seeing the 350-tonne Silo Emptying Plant (SEP2) operate on compartment 10 and using the silo contents to learn about the conditions of the compartments. Going forwards, Elizabeth will be re-evaluating what we want to learn about the different Miscellaneous Beta-Gamma Waste (MBGW) and assess the potential hazard associated with it.

"I enjoy the fact that I can make a real difference and contribute to improving retrieving the waste out of the MSSS, troubleshooting storage issues here that might be faced at downstream plants."

Matthew Jackson

Technical manager

Since joining Sellafield Ltd in the Retrievals value stream strategy and technical area in October 2022, technical manager Dr Matthew Jackson utilises his strong research-focused background to play an important role undertaking studies to benefit various aspects of retrievals.

Matthew earned his Chemistry degree from the University of Manchester before spending four years at NNL as a research scientist. He then returned to academia and completed his PhD on vacuum drying corroded Magnox cladding for interim dry storage at the University of Leeds. Following this, he joined Sellafield Ltd in his current role through the postdoctoral recruitment scheme.

As part of his role, Matthew responds to a range of RVS project challenges, such as anticipating material behaviours in a radioactive environment, or in conditions that can't be easily accessed for measuring. In particular, he was part of the team that delivered the MSSS retrievals Skip Fill Optimisation (SFO) study, which was a huge task for everyone involved.

Although it has been a steep learning curve, the support from the rest of the team and broadening his network has really helped him make a positive start. Going forwards, Matthew will continue to be involved in the SFO project as it moves into the implementation phase, as well as contributing to the Self-Shielded Box (SSB) supporting work.

"Joining Sellafield has moved me closer to the implementation side of research, and I like seeing the value of R&D in overcoming real-world challenges."

Alex Allen

CM&I technology development lead

Having joined Sellafield Ltd in 2001 as a graduate process engineer, Alex Allen has developed a wealth of experience working his way up to technical lead, responsible for managing a team that develops novel techniques to monitor the condition of waste containers.

Alex began his career in the aerospace sector developing heat exchangers on jet engines. He then shifted to the nuclear sector by joining Sellafield Ltd, where he worked as a chemical engineer for 21 years across a variety of waste processing systems. Over the years, he has led several large projects, such as Sellafield's aerial effluent strategy, integrated waste strategy, fuel drying contingency, and BEP impact assessment.

For the past 3 years, Alex has been responsible for delivering cutting edge technologies, to solve first-of-a-kind engineering problems, to improve the CM&I of waste containers and undertaking studies to better characterise ILW, such as the remote detection of hydrogen. A key part of his job is to support and develop his team to deliver innovative technologies that are demonstrated and subsequently deployed on plant. One such development was the vision system to trend hydrogen releases from the surface of MSSS skips, "Bubble Counting", that won the 2020/21 WAVE award for Technical Innovation.

Beyond his technical role, Alex is a mentor and fellow of the IChemE, who encourages the next generation of engineers through his role as a STEM ambassador and Chair of Governors for a local primary school.

"I want to drive more rapid delivery of projects and technology solutions, and improve our knowledge of waste containers."

James Hawco

Technical specialist

Technical specialist James Hawco studied Applied Chemistry with Chemical Engineering at the University of Strathclyde before joining the Nucleargraduates programme sponsored by Sellafield Ltd. Completing five secondments at four companies over the two-year programme gave James the opportunity to experience multiple different roles in the nuclear industry.

After completing the Nucleargraduates programme, James joined Sellafield Ltd in 2020 in his current role, providing technical support to enable solid and effluent waste retrievals from legacy facilities. His work has been split between supporting the solids studies team on the SSB programme and providing effluents technical support to the MSSS effluents modelling and flowsheeting team. This has focused on delivering the MSSS Effluent Modelling Environment (MEME) project in collaboration with NNL.

This year has seen a growing focus on developing the CM&I strategy for fuel bearing materials in SSBs. James has been involved in multiple stages of this process, including residual risk scoring workshops, measurement technique optioneering and R&D studies into novel CM&I technologies.

Collaboration is a key part of James' role, working with both internal and external colleagues, to carry out technical work and make recommendations based on that work to support retrievals from our legacy facilities. For example, he was customer lead for the Game Changers study that investigated muon tomography for imaging SSBs.

James is also an Associate Member of IChemE and is looking to become charted by the end of the year.

"It is really satisfying to work with colleagues to come up with solutions to unexpected challenges."

Remediation

The Remediation value stream is responsible for the clean-up of nuclear and non-nuclear facilities across the Sellafield site with the R&D programme focusing on:

- Characterisation, POCO and decontamination of facilities.
- Forecasting and modelling to support decommissioning planning.
- Enablers such as access to facilities, deployment platforms, containment systems and operator working conditions.
- Tools and techniques for the removal of plant and equipment.
- Surveillance and maintenance and care and maintenance tools and techniques.
- A range of waste processing technologies for waste treatment and conditioning.
- Waste transfer, handling, storage and export.
- Size reduction of Intermediate Level Waste.
- Developments in demolition techniques.
- Land remediation technologies.
- Waste disposal and records.

The remediation capability development team is responsible for identifying new technologies, supporting innovation in the supply chain, developing and industrialising technologies and techniques and delivering active demonstrations of technology, systems and facilities. This is achieved through a structured R&D strategy for each programme area (Alpha, Beta Gamma and Waste).

REACH Deployment Platform

The facilities on the Sellafield site need to be characterised to understand the radiochemical, physical and chemotoxic conditions of the facilities and wastes to reduce uncertainties, develop decommissioning strategies and forecast waste arisings. However, using sensors in areas of interest that are constrained, congested and/or hazardous remains a big challenge and an area requiring further investment.

Radioactive reprocessing cells are particularly challenging to characterise due to their high radiation levels, contamination (radiological and chemical), space and access constraints. Therefore, there is a need for a platform that provides 'through wall' capability, which can be deployed at a range of heights with extensive reach and the capability to navigate a cluttered environment.

Recognising this challenge, the POCO capability development team launched a challenge statement through the Game Changers programme for 'long reach deployment solutions in hazardous environments'. One of the potential solutions is Eadon Consulting's Remote Extendable Access, Characterisation and Handling (REACH) arm.

REACH has been developed as a high payload capacity, modular system for long-range mapping, data collection and tool deployment in hazardous environments. It offers a reusable and configurable toolkit that can be adapted to suit different instruments, tools and environments. REACH improves efficiency and safety whilst reducing deployment preparation time and cost.

The design is modular to aid deployment and not directly linked to or associated with the device being deployed. This means that there is a possibility for multiple different devices to be used, with a range of different applications beyond characterisation. REACH carries all the workings such as cabling internally. These internals are protected from the external environment, and it can be deployed horizontally or vertically.

The REACH proof of concept project will be completed over the course of 18 months with the aim of an active demonstration in a reprocessing cell late 2024.

Project

Game Changers

Benefits

There is a reduced risk to workers through reduced dose uptake as REACH would remove the need for workers to access hazardous areas. An increased range of decommissioning activities would also be possible as it allows for characterisation of congested and hazardous areas. REACH provides a simpler solution to accessing and operating in complex environments, reducing the need for costly solutions to be engineered.

Current Status

Proof of concept project for REACH began in May 2023. This will develop REACH from the initial prototype into a fully designed, UKCA marked and actively tested item.

Delivery Partners

Game Changers (FIS360 Ltd and NNL), Eadon Consulting Ltd.

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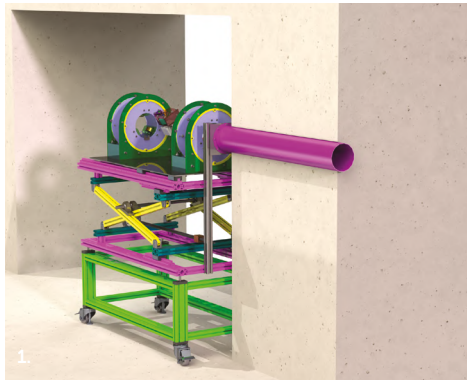


1. Adjustable height platform modular arm

2. Prototype REACH arm from initial feasibility study

3. Prototype REACH arm from initial feasibility study

Skip Size Reduction Facility (SSRF)

The Sellafield site is constrained by its limited options for handling and storage of large ILW items. Therefore, size reduction of ILW contaminated items, such as legacy Magnox skips, is required to maximise the packing efficiency of the waste sent to higher activity storage facilities, these activities support the high hazard risk reduction or the removal of the skips from the first-generation Magnox storage ponds.

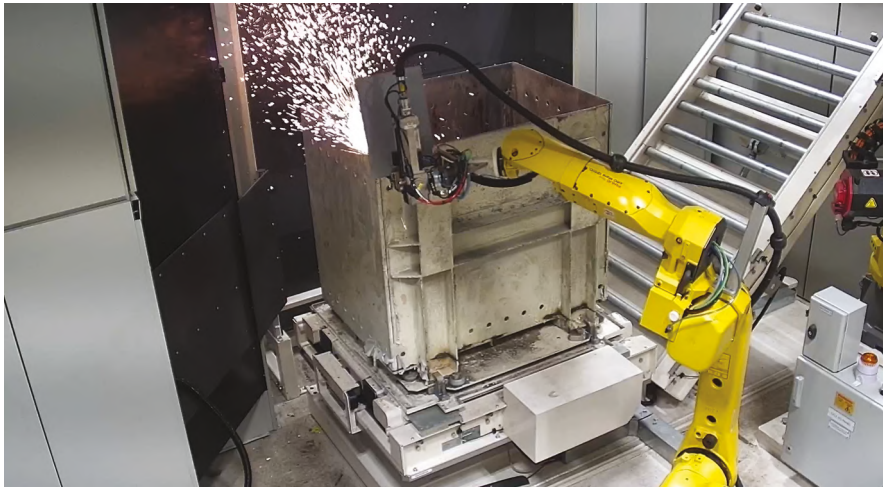
The SSRF active demonstrator utilises COTS industrial robot systems to automatically reduce and re-pack legacy Magnox skips. This is all done in what is known as the laser cutting module located within an existing building on the Sellafield site, utilising otherwise redundant real estate and removing the requirement to build a new facility.

This project has continued to build on experience gained throughout the inactive commissioning, has forged a new way of thinking in decommissioning and how things can be done differently proving that these technologies can be deployed successfully within a nuclear environment.

The facility has now processed several skips, size reducing two and placing them into a third skip all remotely, reducing the storage requirements by two thirds.

The SSRF has been commissioned on the Sellafield site and includes two "six-degrees of freedom" robots for automatic laser cutting and remote handling. Active commissioning has been successfully completed and the facility is in the process of being incorporated into normal operations.

A major part of the project was to collect data & learning to allow future decisions to be made on how to handle larger ILW in the future and how new technologies can play a part in this.



Size reduction of active skip

Project

Skip size reduction

Benefits

The SSRF removes human operators as much as possible from the nuclear and conventional hazards associated with size reducing and packing intermediate level contaminated skips. Size reduction and packing of skips in this way reduces the potential storage requirements by 2/3, benefiting interim storage arrangements, creating room for further retrievals to take place. The learning gained throughout the process has been invaluable informing future active demonstrators.

Current Status

This project has successfully processed multiple active skips and gathered vast amounts of useful learning.

Delivery Partners

Cyan Tec Systems Ltd, Integrated Decommissioning Solutions (IDS), Lasermet Ltd, Taylor Kightley Engineering Ltd

Contact Details

Lester Wilkinson
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Decommissioning Waste Services Partnership (DWSP)

The Decommissioning Waste Services Partnership (DWSP) has designed, installed, commissioned and commenced operation of a Contact Handleable Intermediate Level Waste (CHILW) processing facility. Its goal is to deal with 18 problematic waste items retrieved from the First-Generation Magnox Storage Pond (FGMSP). Such items often require improved characterisation and/or size reduction to fit into the existing waste routes. Without this capability there was a serious risk that such waste would keep accumulating, severely impacting risk reduction and potentially preventing legacy ponds retrieval operations.

The DWSP active demonstrator represents a collaboration with Integrated Decommissioning Services (IDS), testing a novel commercial model, with IDS running the facility under supervision from Sellafield Ltd. The key component of the facility is a remote diamond wire cutting system called Stealth II, with similar systems deployed elsewhere across the nuclear industry.

DWSP was introduced as a lead and learn initiative to apply operational experience gathered from other UK nuclear licensed sites and establish a waste processing capability on site to deal with non-uniform ILW waste.

The objectives of the active demonstrator are to:

- Process 18 previously retrieved ILW waste items from FGMSP.
- Capture data and learning to inform future strategic decisions on how to deal with ILW items of this nature and what the ideal future capability should look like.
- Demonstrate that ILW contaminated waste items of varying geometries and sizes can be dealt with in a semi-remote manner.
- Investigate improved characterisation techniques.

The DWSP programme has already successfully reduced the volume of waste going to ILW stores and has processed 8 out of the available 18 items. These items originally occupied approximately 61.5 m^3 of space within the Windscale's Advanced Gas-cooled Reactor (WAGR) store and another storage compound on site. After processing, the same waste occupies approximately 3.4 m^3 of space in the Miscellaneous Beta Gamma Waste Store (MBGWS) and 0.8 m^3 in the Low Level Waste Repository (LLWR), which represents a 93% reduction in volume occupied.

Project

Active demonstrator programme

Benefits

The main benefit of the DWSP program is to reduce the amount of waste going to ILW stores, and the associated cost savings. More importantly, DWSP is gathering invaluable learning and data which will allow the business to make an informed decision on what capability is required for the treatment of future large quantities of bulky Low Level Waste (LLW) and CHILW items.

Current Status

The current phase is scheduled to finish in November 2023. In the next phase DWSP is looking to gather additional learning and optimise the process further. As part of this, the facility is looking to allow a broader feedstock to be processed from other consignors.

Delivery Partners

Integrated Decommissioning Solutions (IDS)

Contact Details

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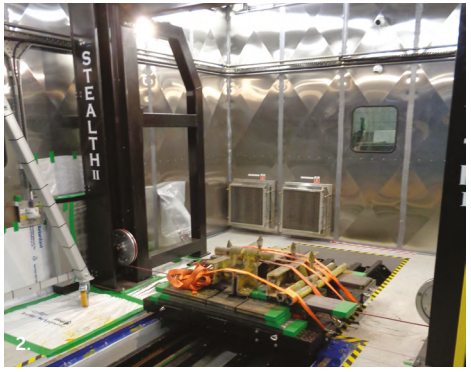

1. Overview of the DWSP facility

2. Wire cutter in operation

3. DWSP facility operator

AmCam: Safer, faster and better value decommissioning

Our site has over 650 alpha contaminated gloveboxes requiring characterisation for POCO and decommissioning. There are difficulties with characterising the gloveboxes: swab samples are random and inefficient for confirming hotspots, surface scraping involves time consuming laboratory analysis and self-shielding in surface contamination can limit data gathered by probe.

Sellafield Ltd and Cavendish Nuclear have developed AmCam, a handheld radiometric inspection device. The device has a matched field of view that produces a live video and a real-time count rate from a gamma detector. Therefore, it gives a real-time indication of radiation levels in the area shown and can indicate levels of activity and shielding present.

The small size and real-time functionality of the device makes it ideal for deploying in a glovebox and quickly identifying areas of high-count rate. The recording provides evidence of the survey coverage and radiological information which can be analysed offline.

A collaborative delivery team was formed to undertake an active demonstration on gloveboxes suspected to be above LLW thresholds. AmCam was deployed via a modified PVC sleeve attached to an existing glove port in seven gloveboxes. The clear view and good range of motion allowed operators to clearly identify and decontaminate hotspots in real time, whilst maintaining containment.

Once the survey indicated no remaining hotspots, In-Situ Object Counting System (ISOCS) measurements were taken, which allowed 5 gloveboxes to be reclassified as LLW. Storing gloveboxes as LLW instead of Plutonium Contaminated Material (PCM) saves around £30,000 per glovebox. Appropriate segregation of waste to the appropriate waste route may mean that additional PCM storage facilities are not required.

Going forward, AmCam is now a business-as-usual tool that is being used daily to reclassify gloveboxes. This will enable laboratories to be repurposed or decommissioned sooner than expected. AmCam can also act as a springboard to support wider alpha decommissioning activities within the NDA group and UK nuclear industry.

Project

Comprehensive characterisation toolkit

Benefits

Identification of contamination hotspots, which when removed can allow relevant gloveboxes to be reclassified as LLW, saving approximately £30,000 per glovebox. AmCam also provides an indirect safety benefit as operators can find and highlight areas of high contamination in real time. Operators upskilled with use of characterisation tools and reviewing footage offline aids planning and learning capture on effectiveness of decontamination techniques

Current Status

AmCam is now routinely used to aid in the decontamination of glovebox internals. It is also being used in other areas to support wider characterisation activities and is expected to be deployed in additional environments, including other NDA Group sites (Dounreay). It won both the 2023 Sellafield Wave and NDA Group Employee Awards in the innovation categories.

Delivery Partners

Cavendish Nuclear Ltd

Contact Details

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1.


2.

1. AmCam device

2. AmCam in operation in glovebox

Alpha Sort & Segregation (αSAS) active demonstrator

Managing PCM on the Sellafield site is expected to cost ~£2billion over the lifetime of the Site. Therefore, there is a drive to explore opportunities to maximise the appropriate segregation of PCM and LLW. LLW is typically 10-15 times less expensive than PCM, so effective decontamination and characterisation of alpha-contaminated material can very quickly add up to significant cost savings.

In addition, we have approximately 650 legacy crates containing large items of PCM that need processing into a suitable form for long-term disposal.

The Alpha Sort & Segregation (αSAS) active demonstrator will provide a new capability that will transport a crate to a containment structure where operators can safely characterise, dismantle, and then sort and segregate it into PCM and LLW. These can then be disposed of through our existing waste processing routes.

The purpose of the active demonstrator is to process a small number of legacy crates to gather learning and test improvements to:

1. Understand the typical challenges associated with decommissioning legacy crates. This will inform a future major project called the Crate Breakdown Facility, which will breakdown all 650 legacy crates.
2. Provide a test bed for new handheld radiometric equipment and decontamination approaches to optimise our segregation of PCM and LLW.
3. Implement the learning from this programme across the rest of alpha remediation, with the potential to greatly reduce the volume of PCM generated in the future.

The demonstrator programme, which began in 2019, involved working collaboratively with Cumbria Nuclear Solutions Ltd on the design, build, and commissioning of this new capability. Installation works are ongoing and inactive commissioning is expected to begin in Summer 2023 with a view to starting active operations in Spring 2024.

Project

Remediation capability development

Benefits

Significant cost savings in storing reduced quantities of PCM. In addition, decommissioning legacy crates has multiple benefits by:

- Freeing up space in our PCM drum stores.
- Reducing high hazard risk.
- Providing contingency space within our stores.

Current Status

Inactive commissioning is expected to begin in Summer 2023 with a view to starting active operations in Spring 2024.

Delivery Partners

Cavendish Nuclear Ltd, Cumbria Nuclear Solutions Ltd

Contact Details

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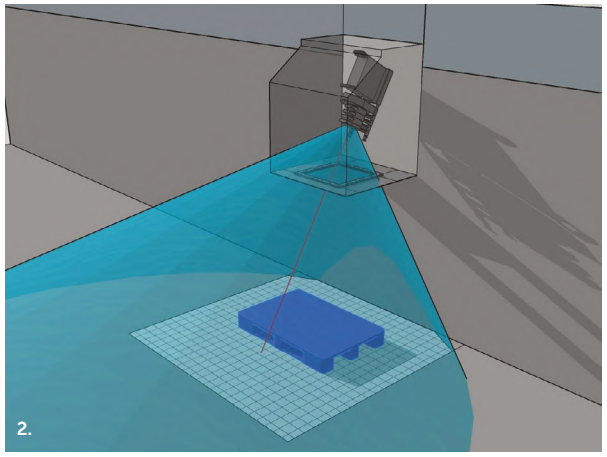
1.



2.

1. Containment structure where the crates will be dismantled

2. High-resolution gamma spectrometer to sentence waste

Automatic, remote waste monitoring

The Continuous Autonomous Radiation-Monitoring Assistant 2 (CARMA 2) is a ground-based autonomous robotic platform that has the capability to characterise and monitor large areas of floor space for fixed or migrating contamination.

CARMA 2 uses a proven and robust ClearPath jackal as the base robot with a custom body that houses COTS sensors. The COTS sensors facilitate onboard 2D mapping, autonomous navigation and radiation measurement and the full system is CE marked. The platform is capable of autonomously navigating the accessible areas of a given floor space to ensure that the entire area is covered.

Any areas of contamination are located, quantified, and recorded using associated software, that outputs location tagged radiation measurements both as raw data and as a radiation heatmap that is overlaid on the physical map. This enables us to gain an understanding of the environment, take action and / or monitor change over time. CARMA 2 can also be operated manually utilising a WiFi signal with live visual feeds to the operator via the LiDAR, cameras and radiation sensors.

By performing standard floor monitoring, CARMA 2 frees up health physics resource to complete higher priority tasks. It also reduces the time spent in an active area for the nuclear operator by highlighting the areas that are required to be monitored.

The CARMA 2 demonstration in the Mixed Oxide Demonstration Facility (MDF) realised some of the required benefits, but the one-off deployment was insufficient to conclusively assess the platform's efficiencies and longer-term benefits. Therefore, the next step was to procure a CE marked CARMA 2 platform and undertake further trials to understand the system potential and evaluate how this equipment could become 'Business as Usual' (BAU).

The CARMA 2 deployment will be conducted in the Engineered Drum Store (EDS) to provide confidence that it can identify contamination in an area with known contamination hotspots. CARMA 2 will be trialled with both manual and autonomous driving during this demonstration phase to assess its full potential and benefits as a characterisation aid.

Project

Robotics and Artificial Intelligence IRT

Benefits

CARMA 2 frees up resource by autonomously carrying out standard floor monitoring overnight on a pre-planned path, providing information to health physics when their shift begins. It also reduces the time spent in active areas by operators.

Current Status

Work is ongoing for the CARMA 2 active demonstration in the EDS facility. It is expected that the CARMA 2 capability will be demonstrated in an active area and progress to BAU within the next financial year. If modifications are required after the demonstrations, the platform will be reworked to suit the needs of the plant to allow the continuous use of CARMA 2 going forwards.

Delivery Partners

ICE9 Robotics, The University of Manchester

Contact Details

Jay Todd
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1. CARMA 2 automatic monitoring platform

2. CARMA 2 control system and pre-planned path

Nicholas Clarke

Technology demonstration manager

After spending ten years in the Radiometric Systems Group (RSG) at Sellafield Ltd, Nic Clarke joined the Remediation technical team in 2021 as a senior technical manager to take on a new challenge. Nic graduated from the University of Manchester with a Master of Physics degree before completing an MSc in Nuclear Science and Technology through the Nuclear Technology Education Consortium (NTEC).

Nic joined Sellafield Ltd in 2008, drawn in by the natural beauty in Cumbria and intrigued by the opportunities offered on the Technical Graduate Programme, which started in PCM technical with a 6-month secondment with RSG. He enjoyed his secondment so much that he spent a decade working in RSG as a technology manager, developing a deep understanding of radiation detection & characterisation.

Seeking a new challenge with a focus on innovation, Nic joined remediation in 2021, initially providing technical management to projects and studies before moving to the new capability team in 2022. In his current role, Nic leads the technology demonstration team and is responsible for a portfolio of about 30 new capability projects and enjoys helping to develop the next generation by bringing in new talent and growing their capabilities.

His team is focused on changing the business; developing and proving new technologies through active demonstration to allow them to become business-as-usual tools. Recent successes include the being part of the AmCam demonstration team that won a 2023 Wave Award and NDA Group Employee Award in the innovation category.

"Learning is the golden thread that runs through the work we do in new capability; not every project will succeed but by leading and learning, we capture key knowledge which will inform future decisions."

Lester Wilkinson

Active demonstrator lead

As active demonstrator lead within technical remediation, Lester Wilkinson is responsible for delivering innovation projects to speed up decommissioning, including the first-of-a-kind SSRF.

Lester joined the graduate scheme at Sellafield Ltd in 2013 after completing his Mechanical Engineering degree at Northumbria University. He was based in the High-Level Waste Plant (HLWP) systems engineering team, and remained there after completing the scheme.

His main focus was keeping the HLWP running on a day-to-day basis, combined with longer term continuous improvement projects. After seven years, Lester applied for a remediation role that involved technical innovation and technology development, joining as active demonstrator lead in 2022.

In his new role, Lester looks for COTS equipment that can be applied in radioactive environments to speed up the decommissioning process. He is currently focused on the SSRF, developing clever solutions to challenges that arise during its use, which has included adaptions for different skip types, software improvements and air supply modifications.

Lester is working towards becoming chartered with the IMechE, and has completed a post-graduate certificate in Reliability, Engineering and Asset Management at the University of Manchester. This was funded by Sellafield Ltd and was completed on top of his day job. He is also a STEM ambassador and leads workshops promoting STEM.

"Although challenging, the work is immensely enjoyable deploying one-of-a-kind technologies in extrema environments."

Jonathan Norman

Technical team member

Jonathan Norman joined remediation capability development in 2021. He plays an important role in developing technologies to make a difference in the nuclear industry, reducing time, cost and improving safety.

Jonathan's career began on the Sellafield site in 2014 working for Morgan Sindall on the Technical Specialist Trainee Scheme (now known as Degree Apprenticeship). Whilst working there, he earned his BEng in Plant Engineering at the University of Cumbria, studying 1 day per week over the course of 5 years.

After 6 years, his interest in technical work and developing new technology led him to join Sellafield Ltd in his current role. As a Technical team member, Jonathan is responsible for leading technology development projects, ensuring learning and innovation are at the forefront. He is now delivering larger packages of work and is currently leading the definition phase of the laser decontamination active demonstration.

Jonathan also leads several smaller technology development projects, working with internal stakeholders and suppliers to enable development and active demonstration. No two projects are the same, and there is always something different to get involved in, enabling him to develop technical knowledge and experience. This is combined with the benefit of seeing that technology put into use and making a real difference to operators.

"I enjoy making a change through innovation, and it's great to see my projects making a difference on the Sellafield site."

Jay Todd

Technical degree apprentice

Jay Todd joined the Technology Capability Development team in 2022 as part of the degree apprenticeship scheme and will graduate with a degree in Plant & Process Engineering from the University of Cumbria in 2026.

The five-year apprenticeship scheme has enabled Jay to gain real-world experience working at Sellafield Ltd while studying for his degree, with a day-release each week for courses and tuition.

Being part of the Technical & New Capability team in Remediation has given Jay the opportunity to work on new and exciting technologies. He has recently completed his active demonstration work on Boston Dynamic's Spot. Seeing the technology be proven to work on site has been Jay's most satisfying part of the role so far.

Jay is the delivery lead for two first-of-a-kind technologies, CARMA 2 and VIDARR (Verification Instrument for Direct Assay of Reactors at Range) for Strontium-90 detection. VIDARR in an anti-neutrino monitor used to measure strontium within waste, and eventually within the ground.

He has been given real responsibility early into his career. There has been a steep learning curve and a large but exciting workload. However, Jay enjoys the challenge, responsibility, and busy nature of the job. It has provided him with a great learning experience. He has also found the support from his team brilliant and really helpful.

"I am driven by the challenge of the job, being able to work with brand new stuff, and finding ways to drive change."

Infrastructure

The Infrastructure portfolio and its support functions provide a range of varied and essential services to the NDA suite which includes:

- Analytical Services, which provides central analytical support including activity, elemental, isotopic, speciation and physical properties of samples.
- Provision of utilities to support welfare, operations and site processes including steam generation and distribution, water, electricity and chemicals.
- Operation and management of the sewage treatment plant and separation area ventilation plant
- Active area services, including welfare facilities.
- Laundry services.
- Estates management both on and off site.
- Consignment management of Site, national and international movement of dangerous goods.
- Safe road and rail transportation of dangerous goods (including radioactive materials) across the site, the country and the world.
- Land allocation and management including roads, bridges and car parks.
- Package management and rail services.
- Site logistics management including on-site buses, commuter service provision and vehicle access.
- Strategy and portfolio management.
- Programme management.

These services are critical to the ongoing operation of the site and our off-site locations. Without these services, delivery of the Sellafield mission would not be possible.

Infrastructure

70+
More than 70 substations on site

100km
100km of pipework for water supplies, on/off site

120km
120km of high voltage cable

19km
19km of steam mains

40km
40km of road and tracks on site

1,750m³
1,750m³ of sewage effluent processed every day

1,000
1,000 shipments in/ out of site each year

2,000m³
2,000m³ domestic water supplied per day

Improved sample screening process

Analytical Services analyse plutonium rich samples using a variety of analytical protocols. Whist much of the analysis is performed in glovebox containment, some is performed in fumehoods on highly diluted samples. However, there is always the possibility of human error whereby an undiluted very high alpha sample is mistakenly sent to a fumehood. The consequence of this could be significant contamination of people and plant.

FIDLER (Field Instrument for the Detection of Low Energy Radiation) probes are very thin gamma scintillation detectors. Typically, they are set to measure Am241 gamma levels, which is indicative of Plutonium presence. Analytical Services performed experimental work to determine a methodology to screen samples for plutonium activity.

The test confirmed that at a 10cm distance (gap between sample and detector), the probe could distinguish between samples bound for fumehoods and gloveboxes, thus significantly reducing the possibility of sample mis-routing.

The screening process takes a few seconds per sample and is robust to differences in sample shape/size and attenuation of gammas. The probe is low cost and does not require specialist training to operate.

The use of the FIDLER probe to screen samples has been technically reviewed and will be implemented this year following final approval. Further work is planned to improve screening of other samples, but it is anticipated that an additional gamma detector will be required as fission product levels, and associated gamma levels, will be much higher in these samples.

Project

Analytical services operations

Benefits

This low cost, rapid screening process helps prevent significant alpha contamination to people and plant thus protecting people and analytical operations.

Current Status

Sample screening will be implemented this year after final approval.

Contact Details

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FIDLER probes

Enabling sample transfer to the supply chain

Analytical Services has provided a chemical and radiochemical analytical capability to the Sellafield site for over 70 years from the Analytical Services laboratory. Over its lifetime the facility has provided on-site analysis supporting reprocessing operations, waste processing and hazard/risk reduction to enable our mission.

An analytical capability is essential to support our mission until at least 2070. However, due to the age and condition of the existing building, alternative arrangements are needed to secure the capability.

In the future, analysis of samples will be split between two different streams:

- Low Active and Very Low Active (LA/VLA) analysis will be sent off site from 2026.
- Medium Active, High Active and SNM analysis will be processed on site in the new facility delivered by the Replacement Analytical Project (RAP) from 2030.

There is a need for a facility to process, screen, package and dispatch LA/VLA samples which will be delivered through the Sample Management Capability (SMC). This facility will deliver the above requirements alongside a limited on-site analytical capability to ensure compliance with our site license conditions. This facility is anticipated to process up to 25,000 samples per year which will then be sent out to our supply chain partners for analysis.

At present the facility is currently undergoing the siting process with two options being explored. The considerations about location are not just where there is space, but also the ease of operation. For example, whether straddling the radiological boundary is preferable and access to other infrastructure on the site. The final location decision will be made by 2024.

Project

Delivery of the Sample Management Capability (SMC)

Benefits

The SMC will secure the LA/VLA analytical capability required to support our mission. This will also allow the company to be more agile in its approach to analytical capability in the future.

Current Status

Ongoing. Expected date of completion and transition to the SMC is 2026.

Delivery Partners

AXIOM (Assystem, Jacobs, Mott MacDonald Group Ltd)

Contact Details

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Utility metering and monitoring

Measuring utility consumption across the Sellafield site is not a new activity, and we have fiscal meters to ensure that we pay the bills correctly. These meters aggregate data at the top level, which is great for financial transactions, but it does not help at a lower level where we might look to introduce energy reduction measures.

At the Fellside plant, an energy sprint made some substantial gains in gross energy reductions, mainly through implementing operational changes. To implement continuous improvements in energy reduction, a more granular approach to metering (how much we consume) and monitoring (how efficiently we consume) is needed. The challenge is to implement this on-site in a way that makes use of the variety of legacy equipment to reduce costs.

Metering has been reported at a building level for some time on some buildings, but not all. This has been accomplished by physical readings of meters, which is labour intensive and problematic. In some cases, there are no building meters, so estimates are common.

Ada Mode was engaged to help develop a hardware and software solution for automated electricity metering. They developed a strategy and conducted a small trial to demonstrate available technology for automated meter readings that covered a variety of use cases on the Sellafield site. This has prompted changes to design standards and the techniques highlighted electricity being wasted where it wasn't previously thought.

The outcome will be a method to collect data at a low enough (equipment) level to effectively collect the use and efficiency data, which will inform energy reduction measures. A future project to deploy this learning across site has been identified through the land and infrastructure programme which will bring sitewide improvements.

Project
Energy sprint

Benefits
Delivery of automated metering for site utilities and a single method for utility monitoring. This will include updated standards and design guidance.

Current Status
Ongoing. Expected to complete 90% of site metering by 2028.

Delivery Partners
Ada Mode

Contact Details
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Conor Kelly

Analyst

After gaining a DPhil in Biochemistry from the University of Oxford and a short post-doctoral position in a laboratory using biophysical and structural biology techniques, Dr Conor Kelly joined Sellafield in April 2022 as an analyst. He now utilises his expertise in biochemistry to help develop novel solutions.

Before completing his DPhil, Conor obtained a Master's degree in Biochemistry from the University of Glasgow, including a year abroad at the University of Tampere in Finland as part of the Erasmus exchange programme.

He is a Member of the Royal Society of Chemistry, providing reliable and accurate analysis of samples to support operations across the Site. This is a vital role as the results of the analysis can be responsible for the safety of several plants, as well as ensuring environmental requirements are met.

Since joining, Conor has been busy learning new analytical techniques and how they can be exploited to solve interesting challenges. In addition, he has been using his expertise and knowledge of biochemistry to support waste retrieval, such as contributing to a novel biological approach to removing legacy waste.

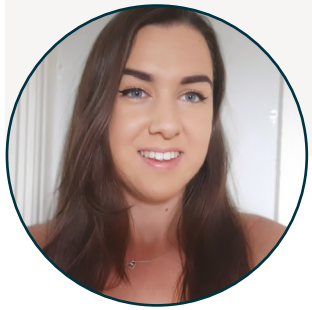
Conor's role enables him to try out novel approaches to solve the problems whilst also learning about new techniques or processes, working in a team of analysts ranging from degree apprentices to highly experienced members. He is passionate about helping the next generation of scientists and has started evaluating the need for enhanced mentoring of the degree students undertaking their projects at Sellafield Ltd.

"It's great to have the opportunity to solve challenges where the answer isn't obvious."

Sally Charlton

Liaison support officer

After spending four years teaching science at a secondary school, liaison support officer Sally Charlton is using her problem solving and communication skills to resolve issues and organise analyses.



Sally's career began as a science teacher after obtaining a degree in Forensic Science and Criminology from Northumbria University and a Postgraduate Certificate in Education (PGCE) from the University of Cumbria.

Sally joined Sellafield Ltd in May 2022 as an analyst, inspired by an advert she saw on LinkedIn, after deciding to change careers and the positive feedback from her partner, who also works at Sellafield Ltd. The support from both her colleagues and clients have helped her through this transitional period and she has never looked back.

She is now on secondment as a liaison support office, actively using the skills she developed as a teacher. In her role she communicates with customers to organise analyses, provide results, and solve any issues or queries they may have.

Since joining Sally has been broadening her knowledge of the different analyses performed in the laboratories, the unique processes and terminology at Sellafield Ltd and business improvements that could be made. She has also started a business improvement course to learn tools to organise, standardise and communicate better.

"Talking to different people each day to resolve issues is very rewarding."

Robotics and Artificial Intelligence

Robotics and Artificial Intelligence (RAI) are being embraced across the NDA estate, with Sellafield Ltd at the forefront. They provide us with the means to remove people from extreme hazardous environments and assist in its mission to decommission and clean up the site in a safer, faster and cheaper way.

Using RAI effectively can have a positive impact on both nuclear and conventional safety. They can be used to perform repetitive, difficult and time-consuming jobs remotely while freeing up employees to take on roles that are more fulfilling and rewarding, ultimately helping to deliver our mission.

The RAI capability team has been set up to focus on the long-term uses of these technologies as they continue to develop and evolve, covering four domains:

- Water: robots are needed to scour ponds, pick up and cut material and then sort the nuclear inventory sitting underneath the surface.
- Land: robots are needed to be lowered into hard-to-reach areas, such as the silos and compartments and then to operate in what can be extremely toxic environments for significant periods of time.
- Air: drones have been identified as ideal to carry out detailed infrastructure inspections quickly and safely, at a reduced cost. The inclusion of Artificial Intelligence (AI) means that they can operate independently and spot degradation much sooner.
- AI centre of excellence: working collaboratively to identify opportunities and to take full advantage of what robotics can offer across the site and the NDA estate.

Each of these domains is being managed across Sellafield Ltd within the remediation and retrievals value streams, as well as in engineering and maintenance and technology groups.

The use of robots has already proven to keep our people safe but there is still potential for them to help speed up the mission, making our site safer, sooner, whilst also contributing towards delivering some of the NDA's grand challenges.

Collaborative Robot Autonomy and Localisation (CORAL)

Wet and dry storage facilities must be routinely monitored to ensure that corrosion, leaks, or degradation of facilities is identified rapidly. Unfortunately, this is not an easy task for human operators due to the presence of active materials. The CORAL project aims to automate these inspection tasks that would otherwise be performed by humans, minimising the risk of humans receiving a radiation dose.

Two robot teams that can perform repeatable autonomous inspections of wet and dry facilities without the need for additional infrastructure are being developed. The two robot teams comprise:

1. An aquatic surface vehicle and an underwater vehicle.
2. A ground vehicle that can deploy an Unmanned Aerial Vehicle (UAV).

A requirement for mobile robot autonomy is a positioning system. The complex arrangement of most nuclear facilities, and the fact that coverage is limited by the placement of the sensors, means that installing positioning system infrastructure is often infeasible.

The CORAL project solves this issue by using a multi robot team. One of the robots is used as a movable base to position from i.e. the aquatic surface vehicle and ground vehicle. These robots self-localise using LiDAR and Simultaneous Localisation and Mapping technology. The base robots also compute the real time position of the partner robots (i.e., the UAV and underwater vehicle) by tracking active markers placed directly on the partner robot.

Using more than one robot allows for fast and accurate robot positioning in environments where Global Positioning System (GPS) is not available, without the need for any additional infrastructure. The accurate tracking of the robot's position will also enable them to revisit exact positions to repeat measurements. This collaborative approach also enables consistent, long-term monitoring so that potential problems can be identified early and rectified in the safest and most cost-effective way.

Project

Heterogeneous multi-agent robotic inspection missions

Benefits

Reduced risk to humans and improved repeatability, accuracy and availability of monitoring.

Current Status

The project is ongoing and currently focusing on the underwater vehicle.

Delivery Partners

The University of Manchester

Contact Details

Mel Willis
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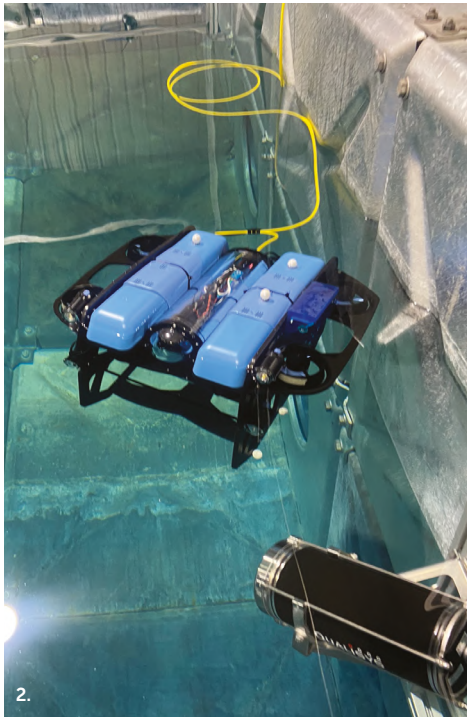
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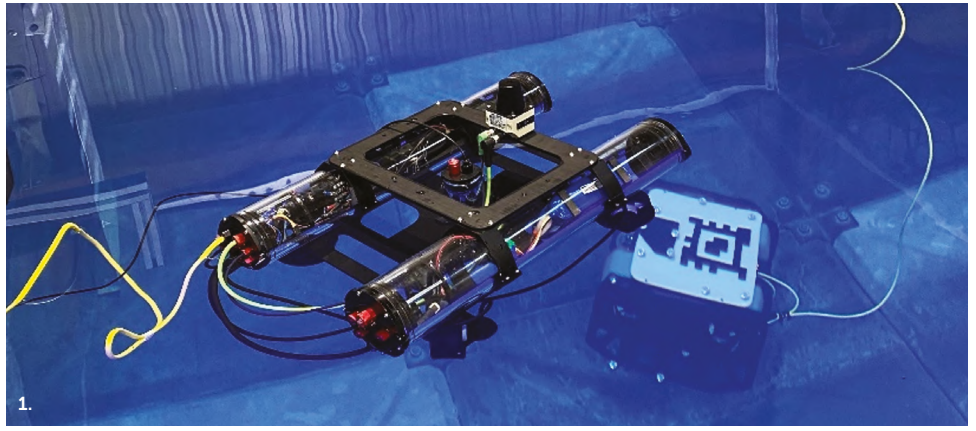
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1. Base surface vehicle with underwater vehicle below

2. Underwater vehicle before submerging

Spark & Excite AI Strategy

Adopting AI on the Sellafield site will ensure risk is As Low As Reasonably Practicable (ALARP). The implementation of our AI strategy (published March 2023) is an essential part of making sure this is done in an efficient, structured way, ensuring people remain at the heart of AI adoption.

The Spark & Excite projects are the beginning of a new way of working that are focused on stoking enthusiasm and building momentum on AI adoption in the immediate term.

AI will be a fundamental technology in accelerating our clean-up mission and the benefit it can bring over the next decade is substantial. We have lots of data, a long future and many technical challenges. AI can help to distance our people from harm, assess risk and health to direct our work prioritisations. This will ensure our plant reliability, maximise safety and bolster the way we operate as a business.

AI deployment at Sellafield can be broadly categorised into three themes:

1. **AI for asset management** - Help manage and maintain our complex asset base through initiatives including long-term condition monitoring, optimisation and risk analysis. This applies to both existing assets and new developments.
2. **AI for live plant optimisation** - Support operators and engineers with decision making on operational facilities and reduce the risk associated with manual inspections and sampling. This also includes AI for robotic applications.
3. **AI for business functions** - Enhance our business support functions and increase the efficiency of projects, recruiting, financial management, inventory management and commercial activities.

We are currently at the beginning of our AI adoption journey and are embarking on a number of Spark & Excite projects to demonstrate value from AI in the short term. These projects also allow us to explore and develop key enabling initiatives and technologies that are essential for longer term, sustainable adoption of AI.

Project
Artificial Intelligence Strategy

Benefits
Improvements to asset management, plant optimisation and enhancement of business functions.

Current Status
Working with Ada Mode and our THORP pond team to develop a health map of the THORP pond to improve lifetime monitoring. Future work will include incorporating live sensing data from the ponds. We've also been working with NNL to look at our safety event data, and using AI to make better predictions about future events and how to prevent them before they occur.

Delivery Partners
Ada Mode, NNL

Contact Details
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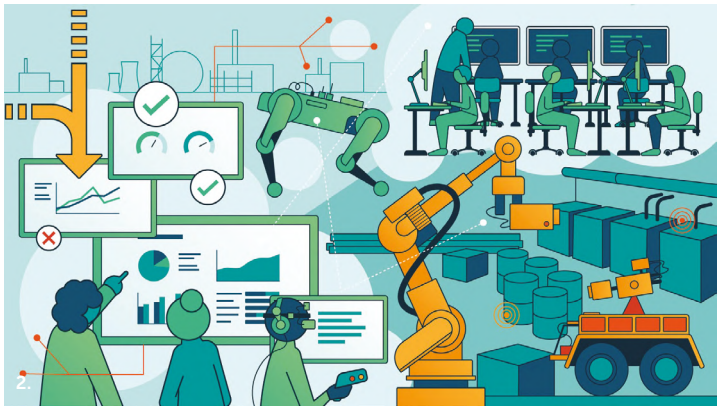


1. Vision of AI for asset management (image courtesy of Ada Mode)

2. Vision of AI for plant optimisation (image courtesy of Ada Mode)

Robotic Glovebox and AI Sandbox

Gloveboxes are used to contain and conduct tasks with nuclear materials. The Risk Reduction of Glovebox Operations (RrOBO) project aims to reduce the number of manual operations that occur inside gloveboxes by developing a robotic system capable of performing these tasks.

This project aims to reduce the risk to operators and is based at the RAICo1 facility, which is a collaborative R&D facility located in Whitehaven.

Robotic Glovebox

Phase 1 of the project discovered the "art of the possible" by understanding how robotic solutions may be applied to manual glovebox operations and demonstrated a systemised assembly of Commercial Off The Shelf (COTS) and Modified Off The Shelf (MOTS) equipment carrying out typical tasks within a clean glovebox.

Phase 2 is further developing the technology and reducing the technical risk in preparation for the active demonstration.

Robot Arm Containment Sleeve System

The RrOBO containment sleeve operation involves taking a double sleeved containment system through a variety of different scenarios, such as deployment, withdrawal, recovery, fault states and operations. Testing is required to verify there is no breach of containment and the polymer sleeve does not affect the robot arm's performance.

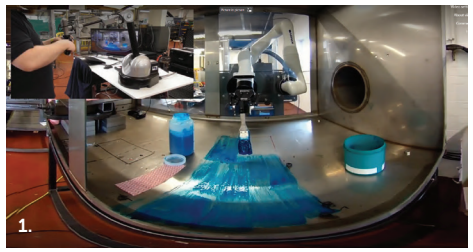
Testing of a PVC sleeve took place in the RAICo1 facility earlier this year. The glovebox was run under depression using a vacuum pump and tests were completed successfully.

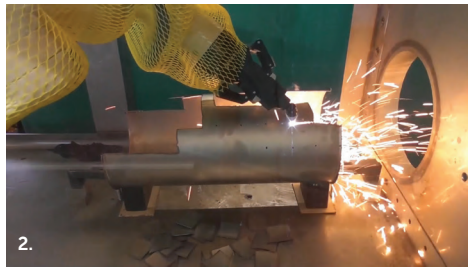
AI Sandbox

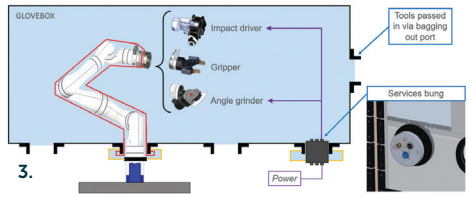
About a year ago, there was no way of regulating AI in place. We were ready with the technology, but the ONR needed to establish what good AI regulation looked like. RrOBO is one of two projects selected by the ONR to take this forward in a Sandbox environment, which offers a safe space for all parties to work together in advance of permissioning.

Adelard – part of NCC Group have been engaged by the ONR to develop a Claims-Argument-Evidence (CAE) framework for mock safety cases. A sprint has been executed to agree an overall structure for the CAE framework, identify key claims for the use cases, determine significant challenges for claims or argument steps, and establish deep dive focus topics, with two sessions planned based on a typical safety case.

This inactive testing approach will provide an opportunity for developing the basis of AI regulation.







Project

Risk Reduction of GloveBox Operations (RrOBO)

Benefits

Risk reduction and protection of glovebox operators with a strong focus on collaboration and openness between the regulator and nuclear site licensees.

Current Status

Development of RrOBO Phase 2, investigating improvements to the polymer containment sleeve and deep dive safety case sessions for the AI Sandbox.

Delivery Partners

Adelard – part of NCC Group, Atkins, Cavendish Nuclear Ltd, Taylor Kightley Engineering Ltd, UKAEA RACE

Contact Details

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1. POCO operations with two-finger gripper

2. POCO operations with angle grinder

3. Automatic glovebox tasks and operations

4. Containment sleeve

Automated stores

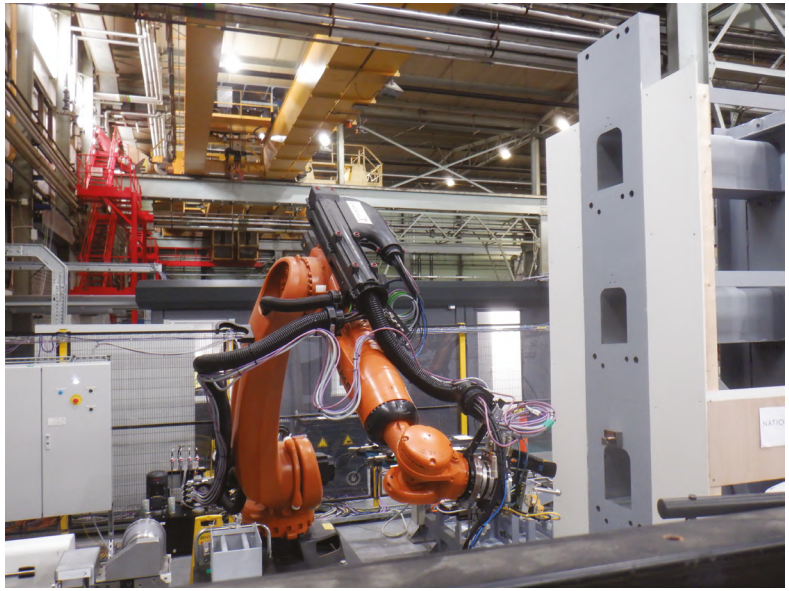
On the Sellafield site there are several ageing storage facilities housing product cans. Each of the product cans require inspection and sorting before being moved to a new, safer facility to await further processing in the future.

Currently, product can inspections and movements are performed manually by operators. The task is highly hazardous to the operators and requires various Personal Protective Equipment (PPE) and regulated processes to perform.

Automated robotic systems have been adopted across the wider industry and, with today's advancements in technology, we have decided to collaborate with the supply chain to design an innovative solution to the safe management of our stores. The aim is to develop and install a fully automated robotic module to retrieve, inspect, shuffle, package, and transport product cans without the need for human intervention.

Not only would this remove the risks of working with radioactive material, working at height and manual handling, it is expected to increase annual can retrievals by 200%. The only modifications to the store will be a line on the floor for an Automated Guided Vehicle (AGV) to follow and a charging station for the robots.

A mock-up store has been built at NNL's Workington laboratory. This test facility has been used to develop and demonstrate the port plug, shield plug and package removal tools and the datuming tool. These tools enable the robot to locate itself against a given extrusion, remove the port plug, remove the shield plug and remove packages from an extrusion.



Mock-up store with AGV and tooling demonstrator (image courtesy of NNL)

Project
SNM innovation and RAI

Benefits
Automated stores will significantly reduce the overall risk to operators, as it reduces the need for them to enter the stores. The successful implementation of the automated module will increase store productivity by speeding up the processing and manoeuvring of packages. Moving the product cans to a newer facility is a big step towards creating a clean and safe environment for future generations.

Current Status
The project is still ongoing, and a demonstration of the combined AGV and tooling is scheduled for later this year.

Delivery Partners
NNL

Contact Details
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UAV capability development

Manual inspections can be dangerous and put workers at risk, especially in restricted areas such as confined spaces, active areas, high areas or areas with no access. Current inspection techniques that allow access, such as scaffolding for working at height, require manpower, equipment shutdowns and increased risk.

The use of Unmanned Aerial Vehicles (UAVs) for asset inspection, once a foreign concept, is now commonplace across the Sellafield site. The remote technologies group that sits within Special Equipment Services (SES) and Engineering & Maintenance (E&M) has built stakeholder confidence to such an extent that the benefits and uses of UAVs is constantly expanding.

Ensuring our capability

The UAV equipment programme has developed an extensive, industry-leading maintenance regime that mitigates likely failure modes. This approach ensures that a reliable and professional service is readily available across the Sellafield site by prioritising safety, accountability and asset availability.

Beyond Visual Line of Sight (BVLOS)

Normal permissions for flying UAVs restrict operations to ensure that the UAV remains within visual line of sight, which due to the congested nature of the Sellafield site requires missions to be split. The equipment programme is applying for BVLOS permission, which would allow pilots to fly UAVs across site from a central operating base at an offsite facility. This involves procurement of a BVLOS-capable craft, appropriate risk mitigations and appropriate procedures to ensure safe operation.

Shared learning across NDA group

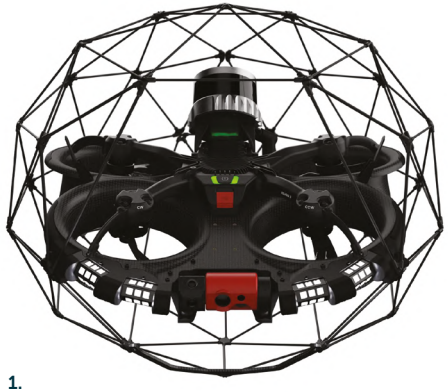
The UAV equipment programme chairs a forum of SMEs and others involved in UAV operations from across the NDA estate and wider industry. This shared learning strengthens the industry in general, whist demonstrating our role as a source of best practice for UAV operations in national critical infrastructure. In addition, BVLOS permission means that NDA-wide asset inspection tasks could be flown from a centralised control centre, enabling a OneNDA approach to UAV operations in the future.

1. Elios 3 UAV with LiDAR payload

2. Elios 3 UAV and collected data

3. Internal UAV inspection

4. UAV inspection of Pipebridge



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Project

UAVs engineering and maintenance programme

Benefits

If the programme delivers its stretch target of 200 remote inspections a year, it could save 274,000 working at height hours and £7.9 million each year across the enterprise.

As well as reduced risks to workers, UAV inspection also reduces cost, improves decision making and provides better visual data that aids future programme planning.

Current Status

The UAV equipment programme provides a reliable and professional service that is readily available across the Sellafield site.

A 10-year roadmap has been developed to exploit more autonomous and tactile UAV solutions, whilst simultaneously considering more advanced applications.

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Karl Fearon

Robotics and AI programme manager

As RAI programme manager, Karl and the RAI team are tasked with Leading and Managing RAI across the NDA estate and aim to deliver projects that turn innovative ideas into technology that is deployable on a nuclear facility.

Karl began working at Sellafield Ltd over 10 years ago in the HLWP technical team before moving into the HLWP process engineering team. He joined on the Technical Specialist Trainee (TST) scheme, which is now known as the Degree Apprenticeship scheme. As part of the TST scheme he studied at GEN2 one day a week, earning a BEng honours degree in Plant Engineering (Nuclear Technology) from the University of Cumbria.

Previously working in HLWP, where he managed a shift team, has given Karl a good understanding of the scale of the clean-up task being completed at Sellafield and an appreciation of the challenges. HLWP was mostly based in high radiation cells, so any intervention work required the use of Master Slave Manipulator (MSM) arms in highly congested operating cells with restricted visibility. These are the types of environments that robots will need to work in to make the operator's job easier.

Since recently joining RAI, Karl has seen a number of demonstrations of innovative new technology for a range of uses that will have a huge impact on the way we work. Seeing the cutting-edge technology that is being developed has been the most satisfying part of his job so far. This includes working with suppliers and stakeholders who are genuinely enthusiastic about the RAI developments that are underway at Sellafield.

"I enjoy seeing the innovation that is taking place in Robotics and AI helping to remove humans from hazardous environments and deliver faster decommissioning."

Rebecca Roulson

Senior technical advisor

As part of the Sellafield Robotics & AI team, Rebecca Roulson is responsible for the oversight and planning of major projects. In addition to her role, she also promotes STEM in schools, work experience placements and is aiming to develop a robotics apprenticeship scheme.

Rebecca joined Sellafield on a Scientific Apprenticeship in 2014, which she successfully completed in 2017, achieving a level 3 NVQ in laboratory techniques with an HNC & HND in Applied Chemistry from Lakes College West Cumbria. Following this, she obtained a BSc Honours degree in Applied Chemistry from the University of Cumbria in 2021 and is a member of the Royal Society of Chemistry (MRSC) and Registered Science Technician (RSciTech).

Prior to her current role, Rebecca was a laboratory analyst in Analytical Services for 8 years, starting in radiometry, then moving to radiochemistry and spent the last 5 years in the standards department producing certified reference materials.

Since starting her new role in March, Rebecca has been busy integrating into the RAICo team, building up her network and engaging with stakeholders. Her role involves organising events, presentations and demonstrations to showcase the innovation projects, both implemented and in development, across Sellafield and the NDA group.

The RAI area is expanding, and new facilities have opened throughout West Cumbria as the nuclear industry looks to take advantage of developing technology. In the coming year, Rebecca is excited to be involved in the automated stores project and complete her project management training & development.

"I'm enjoying getting involved with innovation projects across the Sellafield site and learning about new technologies available."

Engineering Development Solutions

Engineering Development Solutions (EDS) was established to take real time problems, from the Sellafield site and wider NDA estate, and develop underpinned proof of concept solutions. This process is achieved through sprint projects that are delivered within just 6 weeks – turning problems into solutions.

EDS are based at the Engineering Centre of Excellence in Cleator Moor, which provides the opportunity to test solutions off-site, engage with supply chain companies to find solutions to industry challenges, and implement proven innovations back on site.

The Engineering Centre of Excellence core team provide guidance and coaching to support the teams through their sprint projects, which:

- Achieve success across a wide range of projects, saving time and money, improving safety and upskilling team members.
- Provide an opportunity to develop capability and skills, introduce different processes, and solve a real-time challenge at the same time.
- Engage local supply chain organisations to provide development support throughout the project.

The Engineering Centre of Excellence runs 10 sprint projects per year. That is 10 real time problems taken from site and solutions developed. It also means 60 people benefit from the development opportunities associated with the sprint process.

Sprint project teams

When the concept of sprints was first introduced, they were seen as a development opportunity for graduates on the Sellafield graduate programme with the focus on developing teamwork, leadership, creative thinking, and ideation.

In 2022, thanks to the programme run at the Engineering Centre of Excellence, the focus shifted to finding solutions to real-life challenges on the Sellafield site. This has been achieved by creating the right environment and developing a shared mindset for compliance, agility and creative problem solving.

The teams are now made up of people from a diverse selection of backgrounds with varying knowledge, skills and experience. This includes graduates, industrial placement students, maintenance craft personnel, engineers, operational roles, administrative and support roles and engineers from our supply chain partners. The more diverse the team composition, the more diverse and wider ranging the initial concepts for analysis.

The teams gain development in areas such as team building, leadership, practical problem solving and root cause analysis, cost benefit mapping, commercial awareness and procurement overview, ideation and creative thinking, technical report writing and presentation skills.

We also work with each participant to produce an individual development plan that aligns to their personal objectives and that will support meeting competencies and criteria required to progress their professional accreditation through the various bodies such as IET, IMechE etc.

Why the Centre of Excellence?

The Engineering Centre of Excellence provides the perfect venue - with its off-site accessibility we can be reactive by quickly solving site challenges with our supply chain colleagues through making the right connections.

It's important that this work takes place off the Sellafield site because we need to give our workforce a place which is safe and they can express themselves, utilising their full potential and capability.

By being away from site, we can emphasise that the consequences of actions do not have the same impact as they would on the nuclear facility, so we have been able to create a culture where it's okay for solutions to fail. That way we can learn and find a successful solution. Then we can be right first time when we take that solution onto site which is the most safe, cost-effective, and time-efficient way of achieving progress.

All the development advantages of the previous on-site sprint programmes remain, but the Centre of Excellence has built on that foundation to deliver a more dynamic and collaborative programme to deliver results for the wider organisation.

Engineering Centre of Excellence

Recovery of stuck hoses

A 5-week rapid prototyping project was completed as part of the engineering skills development training at the offsite Centre of Excellence to identify a method of recovering a stuck hose from the vitrification cell of Line 1 in the Waste Vitrification Plant (WVP). This project was necessary to avoid a pipe re-route and extensive shutdown.

Concept generation and optioneering in the early stages of the project required a visit to the WVP to understand the issue currently faced on plant. The team investigated COTS products that could be used to develop a concept that would remove the stuck connection.

The prototype tool was manufactured from COTS products by Forth Engineering and consisted of a clamp to press the button on the stuck connection and a screw jack to remove it from the back plate. A mock back plate was manufactured by PAR Systems with the same fault replicated on the connections. The prototype was tested within PAR Systems mock cell using MSMs, similar to those on plant. From testing it was found that the prototype effectively removed the stuck connection without damage to the back plate.

Testing demonstrated that the combination of button press and screw jack effectively removed the stuck connection from the back plate. A bespoke design will be developed for use in an active cell based on our research, prototyping and testing.

Project

Recovery of stuck hoses from HLWP cells

Benefits

The prototype tool developed during this project will enable stuck hoses to be removed quickly and safely without re-routing pipework and extensive shutdowns.

Potential cost savings by using the removal tool is lifetime costs of £3.69millon.

Current Status

Complete - Concept manufactured and tested, design approved, handed over to plant to be used when required.

Delivery Partners

Forth Engineering Ltd, PAR Systems Ltd

Contact Details

Lorna Devine
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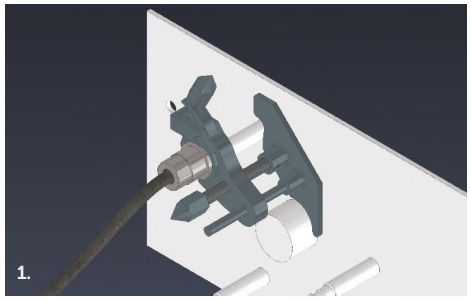
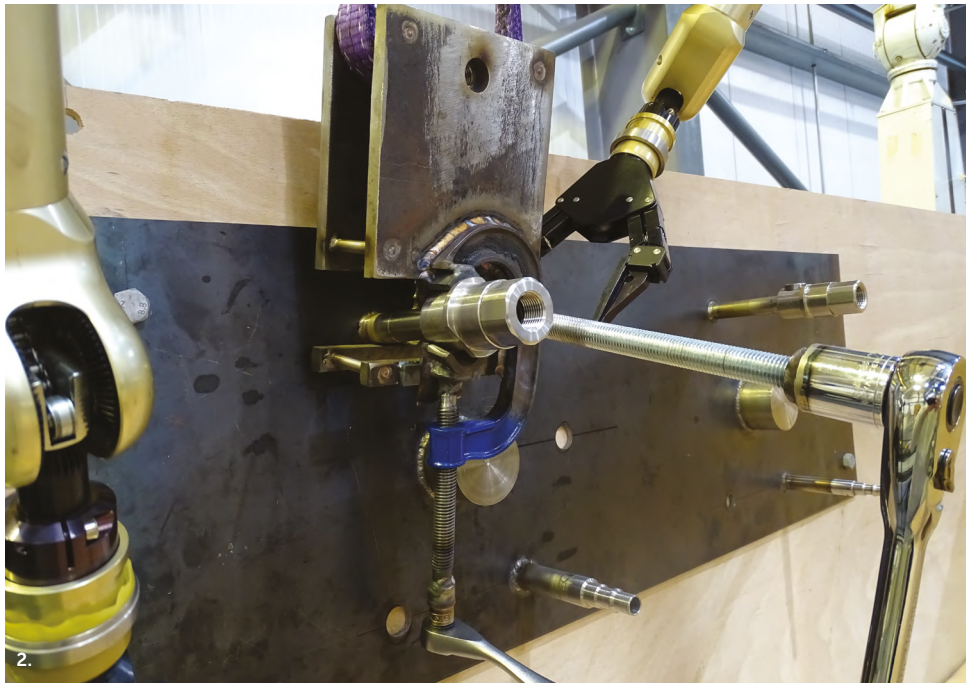
1. Concept CAD geometry

2. Prototype tool being tested

3. Hoses in vitrification cell





Repair damaged storage extrusion

Aluminium extrusions are used to store SNM canisters within the SPRS facility. An extrusion had been damaged and the plant is unable to use it until a solution has been sought to deburr the aluminium seats to a smooth finish and clear all debris.

The damaged extrusion means that the store will not be able to achieve full capacity until it has been repaired. EDS completed a 6-week rapid prototyping project to design and produce a complete working system that can be used on the plant to refinish the damaged surfaces and retrieve the existing and new swarf/debris present within the extrusion.

The objective was to get the damaged extrusion back into a condition where the SNM technical department are satisfied, the extrusion is safe to house SNM canisters and it can be used by the plant.

Following a plant walkdown, a problem statement was created by the team, outlining the problems communicated by the systems engineers. Multiple concepts were then devised, and these were ranked using a Pugh Matrix.

The extrusion deburring and cleaning concepts selected in the optioneering study were developed into solutions by Forth Engineering and 3D printed. A test rig was created using a new extrusion that had been deliberately damaged to test which concept would be most effective.

The tests confirmed that the concept should be manufactured from high heat resistance material with nylon wheels to travel along the extrusion, which is consistent with the existing charge trolley.

LED lights and cameras are installed on each side to monitor the surface before and after deburring, which is achieved using coarse grit paper to remove large gouges and fine grit paper to give a smooth finish.


1.


2.


3.

1. Damage within extrusion

2. Concept for cleaning

3. Concept for deburring

Project

SPRS damaged extrusion repair

Benefits

The repair of the damaged extrusion will enable further storage of 15 SNM packages, remove the current constraints on package storage within the SPRS and provide additional space to store SNM packages during routine inspection and removal.

Current Status

The debris cleaning tool is being manufactured with factory acceptance testing planned at the end of 2023 and deployment planned for 2024.

Delivery Partners

Forth Engineering Ltd

Contact Details

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Increasing reliability of dismantling process

The AGR fuel dismantling process requires the fuel pins to be impacted with an air ram to release them from containment. They are then fully extracted by jaw collets, which provide uniform pressure that holds the fuel pin in place. However, reliability issues during the current procedure have caused the jaw collets to fail causing significant delays and cost implications.

EDS completed a 6-week rapid prototyping project to improve the method of improving/re-designing the jaw collets within the AGR facility. The main area for improvement is increasing the Mean Time Between Failure (MTBF) of the equipment associated with the dismantling process.

Concept generation, research and optioneering in the early stage of the project highlighted six suitable concepts, the concepts were then ranked using a criteria-based decision (Pugh) matrix. The three highest ranking concepts were taken through to initial design, and then down-selected to a final concept.

The pneumatic chuck design was chosen to prototype and intrinsically test due to its quick release feasibility and ability to fit in a can for posting in and out the cell. This removes the need to take the cell down and send fitters into the maintenance cell.

A test rig was then designed and engineered to test an 'off the shelf' pneumatic chuck under conditions that represent the plant environment as far as reasonably practicable.

PAR Systems Ltd has trialled this tool under the appropriate plant environment and conditions, and it is now being taken forward into a proof of concept design.

Project

Jaw collet improvement

Benefits

The most significant cost to the AGR facility is downtime. Based on existing data, approximately 88 hours are lost due to jaw collet failure annually. The new collet design will significantly reduce plant downtime and therefore allow more processing time.

Current Status

Pulling force of the new jaw collet design has been proven, and in cell test has been carried out with the MSMs to prove feasibility within the cell under plant conditions.

Manufacture of the final quick release jaw collet concept ongoing, testing within plant conditions is then required to complete the package of work.

Delivery Partners

PAR Systems Ltd

Contact Details

Lorna Devine
technical.innovation@sellafieldsites.com

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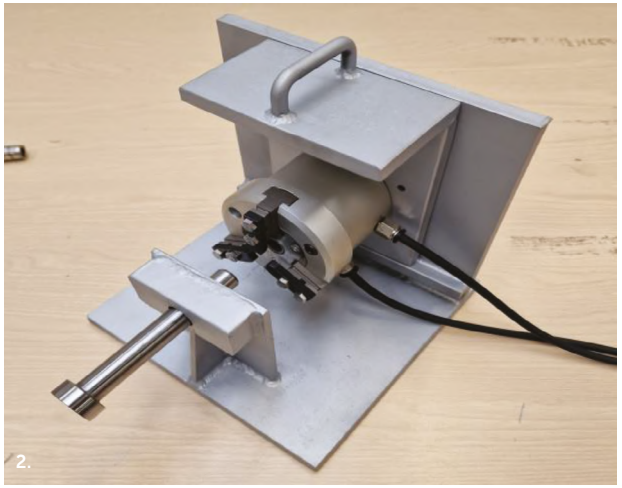

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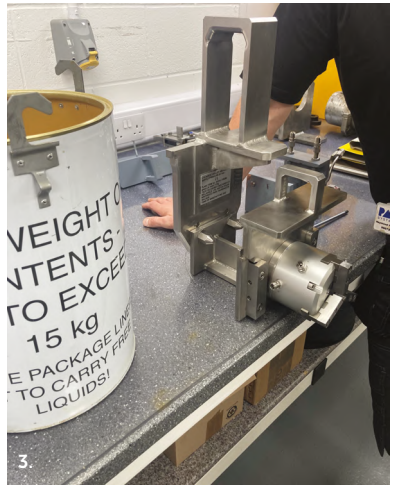

3.

1. Concept designs

2. Pneumatic chuck design

3. Jaw collets and tin

VR upskilling solution

VR technology has revolutionised training and skill development across many industries. Using an innovative VR solution to upskill our electrical community allows users to practice their own electrical isolations and follow the Isolation Test Certificate (ITC) process, ultimately enhancing their expertise in electrical safety protocols.

Electrical isolation plays a critical role in ensuring the safety of personnel working with electrical equipment. Errors in isolation procedures can have severe consequences, ranging from accidents to equipment damage and even loss of life. Recognising the significance of robust training, we have invested in a cutting-edge VR module that improves the skills and knowledge of our electrical community.

The VR module provides an immersive learning experience, placing users in realistic scenarios where they can engage with interactive challenges. By practicing these electrical processes, participants gain hands-on experience in following proper procedures. The module offers a safe environment for them to hone their skills, actively engage with realistic scenarios, develop their problem-solving abilities, and build confidence in their isolation practices.

To enhance the effectiveness of the training, intentional errors have been strategically placed to test the users' ability to catch and rectify mistakes. By encountering and correcting these errors, participants develop a heightened sense of awareness, critical thinking, and attention to detail. Moreover, the module emphasises the importance of using and adhering to human performance tools, promoting a culture of safety and best practices.

The VR module is designed to be part of a comprehensive coaching session led by highly skilled electrical professionals. These coaches provide personalised feedback and guidance, allowing participants to learn from their mistakes and further improve their knowledge and confidence.

This collaborative approach fosters a supportive learning environment, where experienced individuals mentor and guide learners, ensuring continuous growth and development.

Through this VR project, our electrical community will be empowered with the necessary skills and knowledge to perform electrical isolations effectively.

Project
Emerging technology programme

Benefits
The VR module will create a safe and available environment for trainees to practice and test their isolation skills, whilst being coached by an SME. This improves the knowledge and experience of the electrical community, which will reduce risk during electrical isolation and improve safety.

Current Status
This project is expected to be completed in September 2023.

Delivery Partners
HU-Media Ltd, V360 Energy Ltd

Contact Details
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technical.innovation@sellafieldsites.com

1. Voltage testing

2. VR training environment

1.


2.

Lorna Devine

EDS lead at the Engineering Centre of Excellence

As EDS lead, Lorna Devine takes challenges off site and leads teams to identify and develop solutions to issues through 6-week sprint projects at the Engineering Centre of Excellence.

Lorna began her career at Sellafield Ltd after joining the Degree Apprenticeship Scheme in 2011, which involved working as a system engineer in the LAEMG with 1-day a week study leave. This enabled her to achieve her BEng degree in Plant Engineering from the University of Cumbria, while gaining industrial experience.

As a system engineer in LAEMG, Lorna worked on numerous facilities, learning a wide range of engineering principles across a diverse range of engineering tasks that supported operational plant. This breadth of experience was invaluable when she joined the Centre of Excellence in January 2023 to lead EDS.

Lorna coordinates the 6-week sprint projects at the Centre of Excellence to ensure that the project scope is suitable and has created a more structured approach to the sprint projects and subsequent deployment tasks to allow the teams to work more efficiently. She then guides the teams through the sprint process, asking challenging questions to allow them to think differently about the problem.

She also works with the local supply chain to develop the solutions from initial proof of concept to plant deployment, as well as enabling the individual team members to expand their capabilities, tools and techniques to problem solve.

"It's great to see what the teams achieve in such a short space of time."

Dan Haughin

Emerging technology engineer

As part of the emerging technology team at Leconfield, Dan Haughin researches and develops new technologies that would improve safety, reduce risk and maximise the efficiency of the workforce.

Dan joined Sellafield Ltd in 2013 as an Electrical & Instrumentation (E&I) craft apprentice. After completing his apprenticeship, Dan studied 1-day per week at the National College for Nuclear in Lillyhall to obtain a BEng in Electrical Engineering whilst continuing to work in E&I. He is currently completing an MSc in Reliability Engineering and Asset Management from the University of Manchester.

Working in the E&I craft, security and resilience maintenance and then central reliability teams has given Dan a broad understanding of the operational requirements across the Sellafield site, which provides an essential background to his current role in the emerging technology team.

This year, Dan has enjoyed pushing the boundaries on what's been done and is possible within VR modules by upskilling the existing and upcoming electrical community, but more importantly showing them what can go wrong and developing their error trap awareness.

Moving into a role where nothing is clearly defined has been challenging has helped him develop the skills and processes required to implement new technologies and processes, especially through the support from the rest of the team.

"I want to make changes for the better and not accept 'this is the way that we have always done it'."

Appendix

Supply chain companies and organisations

Ada Mode	Fraunhofer Centre for Applied Photonics	National Physical Laboratory (NPL)
Adelard – part of NCC Group	Headlight AI Ltd.	Nuclear Transport Solutions
Atkins	HU-Media Ltd	PAR Systems Ltd.
AXIOM (Assystem, Jacobs, Mott MacDonald Group Ltd.)	ICE9 Robotics	PixelMill Ltd.
Cavendish Nuclear Ltd.	Integrated Decommissioning Solutions	Rapiscan Systems
Clifton Photonics Ltd.	Imperial College London	REACT Engineering Ltd.
Colena Ltd t/a heliguy	IS-Instruments Ltd.	Sensor Driven Ltd.
Cumbria Nuclear Solutions Ltd.	Jacobs	Taylor Kightley Engineering Ltd.
Cyan Tec Systems Ltd.	Jacobs Clean Energy Ltd.	The University of Manchester
DNV	Lasermet Ltd.	UKAEA RACE
Dounreay Site Restoration Ltd.	Loughborough University	University of Leeds
Eadon Consulting Ltd.	Lynkeos Technology Ltd.	University of Strathclyde
FIS360 Ltd.	Magnox Ltd.	University of Warwick
Flyability Ltd.	Nationwide Engineering Research & Development Ltd.	V360 Energy Ltd.
Forth Engineering Ltd.	National Nuclear Laboratory	Veolia Nuclear Solutions
Fortis Remote Technology Ltd.		

Abbreviations and acronyms

AGR	Advanced Gas-cooled Reactor
AI	Artificial Intelligence
BEP	Box Encapsulation Plant
CFD	Computational Fluid Dynamics
CM&I	Condition Monitoring and Inspection
CoE	Centre-of-Expertise
COTS	Commercial Off The Shelf
EDS	Engineering Development Solutions
HLWP	High-Level Waste Plant
ILW	Intermediate Level Waste
IRT	Integrated Research Team
LAEMG	Low Active Effluent Management Group
LiDAR	Light Detection and Ranging
LINC	Liaise, Innovate, Network, Collaborate
MSSS	Magnox Swarf Storage Silos
NDA	Nuclear Decommissioning Authority
NNL	National Nuclear Laboratory
ONR	Office for Nuclear Regulation
PCM	Plutonium Contaminated Material
R&D	Research and Development
RAI	Robotics and Artificial Intelligence
RAICo	Robotics and Artificial Intelligence Collaboration
ROV	Remotely Operated Vehicle
SFM	Spent Fuel Management
SIXEP	Site Ion Exchange Effluent Plant
SNM	Special Nuclear Materials
SPRS	Sellafield Product and Residue Store
SSB	Self-Shielded Box
SSRF	Skip Size Reduction Facility
UAV	Unmanned Aerial Vehicle
VR	Virtual Reality
WVP	Waste Vitrification Plant

Sellafield Ltd

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This document was edited and produced by Frazer-Nash Consultancy Ltd