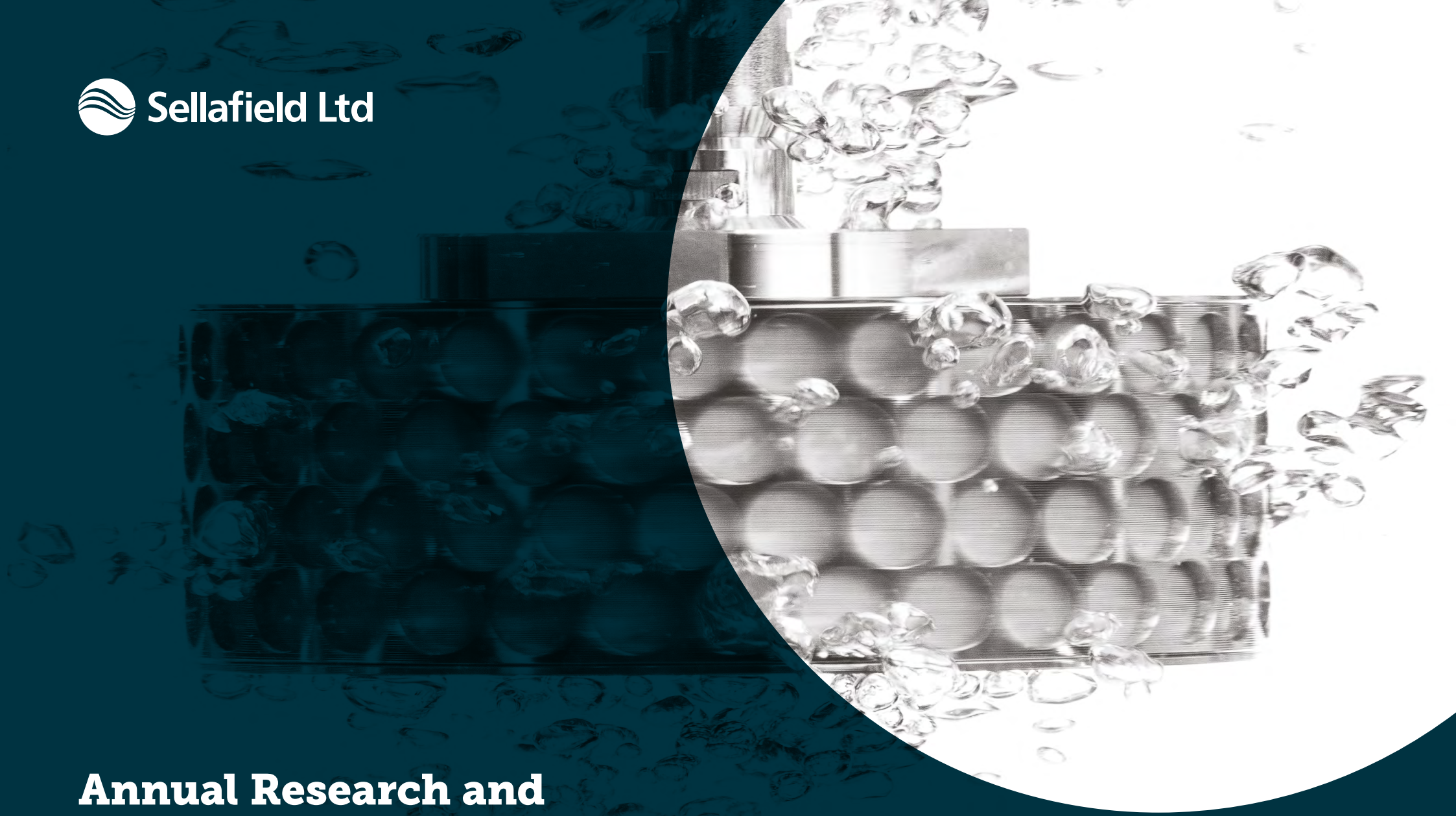
Sellafield Ltd



Annual Research and Development Review

2023/24

Contents

This report presents:

- Research and Development (R&D) 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 create a clean and safe environment for future generations.

Introduction

In the previous edition of our Annual R&D Review [1] we highlighted the fantastic work of our 'Smart Can' R&D project, which was due to start inactive demonstrations with the aim of providing accurate, real time monitoring of Special Nuclear Materials (SNM) packages in long-term storage. Since then, those trials have been a resounding success and the technology is now scheduled to enter active demonstration in our SNM value stream this year. In addition, the success of these demonstrations has prompted new ideas about other use cases the sensors could be applied to within Sellafield Ltd.

This is just one example of how the benefits of R&D can multiply if we are bold enough to take those first steps of investing and developing a technology.

I am thrilled to report another year of excellent progress in R&D at Sellafield Ltd. Whether it's our thermal treatment programme making strides forward in demonstrating fit-for-purpose solutions for our waste inventories, developing cutting edge modelling capabilities for our nuclear plants, our Robotics and AI workstreams being deployed onto our site in collaboration with our supply chain and earning national attention, or many of the other exciting programmes and projects detailed in this review; we are developing and delivering technologies that are altering the trajectory of Sellafield Ltd's mission.

We have recently undertaken a major review of our R&D needs across the site, which are now reflected in this year's Annual R&D Review. We have also included more information on the many innovations – not just from R&D - which were deployed into operations across the business over the last year (page 79). Finally, we have also introduced an R&D conveyor to show how our R&D is helping move our technology from the lab through to deployment on site (page 10).

As ever, the next year promises more important and exciting milestones in decommissioning the Sellafield site. Please follow us to see how R&D will continue to enable these milestones, and learn how to be part of this nationally significant work in future.

Hilary Royston-Bishop
Research, Development and Innovation Manager

1. Sellafield Ltd Annual Research and Development Review 2022/23, October 2023. Available at: https://assets.publishing.service.gov.uk/media/6516976d6a423b0014f4c5ed/SEL_22_23_BCC_final-WEB.pdf

Foreword

In March 24, the business landed a significant achievement: Successfully removing the first ever zeolite skip from the First Generation Magnox Storage Pond.

Two years ago, the Annual R&D Review featured the underpinning work which we had undertaken to revisit historic conservative assumptions, meaning that this skip – and many others in the future - can be safely processed in the Box Encapsulation Plant without the need for any plant modifications or additional treatment steps.

Stories like this show the contribution that research and development makes to our nationally significant mission.

For our people, working on unique challenges and cutting-edge technology isn't an anomaly, it is what we are here to do. Time and again, they prove that we can deliver transformational technologies and redefine techniques into the business where they can start delivering real benefits, whether that be improving the safety of our workers and communities, building internationally recognised capabilities, or reducing the cost of Sellafield Ltd's mission to the UK taxpayer.

And it is not just the people working at Sellafield Ltd who make this possible. We also work with a vast network of talented suppliers, academics, and partners to support us, and this collective of brilliant minds all contribute to the various successes outlined in this annual review.

I hope that by reading this you get an insight into just some of the R&D which is taking place at Sellafield Ltd. All of which, are tied into significant operational and business improvements.

As extensive as this list is, there is more to come, and I look forward to sharing more progress with you soon as we continue towards achieving our mission of creating a clean and safe environment for future generations.

It is an exciting time to be here.

Dr Robin Ibbotson
Chief Technical Officer

Benefits of R&D

The R&D science and innovation work delivered by Sellafield Ltd through our Technical and Technology teams is supported by our supply chain and specialist academic partners. It provides a wide-ranging benefit for the site and its key programmes by underpinning current operations, enabling plant and process improvements, mitigating risks, discovering new opportunities and investigating fundamentally new or game changing technologies with potential to accelerate the site's mission.

Often R&D will not only be enabling Sellafield site programmes, it will also be valuable to the wider NDA estate and UK/International organisations programmes and forums. The R&D teams across the Sellafield site work to meet NDA grand challenges and the articles throughout this document link back to these estate-wide goals.

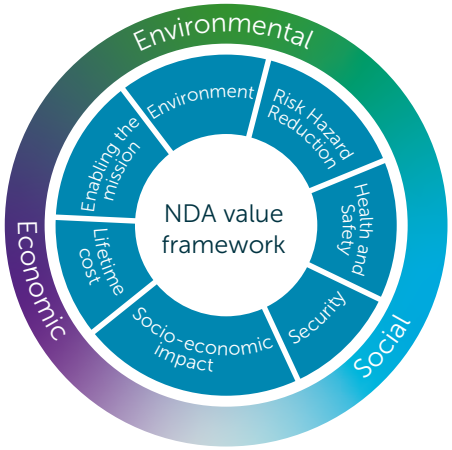
R&D work supports risk and hazard reduction, nuclear and conventional safety improvements, lifetime cost savings benefits, enables the business and can deliver social value, sustainability, and socio-economic benefits too. Collectively these categories reflect the NDA's Value Framework - and at Sellafield Ltd we are working closely with NDA and other stakeholders to demonstrate how, and to what extent, our work enables these estate wide value principles.

This Annual R&D Review provides a summary of some of the exciting and ground breaking R&D that is being conducted by Sellafield Ltd, all of which delivers wide ranging value and benefits to programme customers, the NDA and ultimately the tax payer. As we move forward we will continually improve the process and methodologies to capture, estimate and share the wide ranging benefits being realised.

For further information on R&D benefits please contact Richard Smith at technical.pmo@sellafieldsites.com.

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

innovation.team@sellafieldsites.com

For more information about the NDA grand challenges visit:

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

The table below provides a summary of the key technical challenges by area, and examples of the innovative activities that we are carrying out at the Sellafield site and their associated benefits.

AREA	KEY TECHNICAL CHALLENGES	UNDERPINNING TECHNICAL EXAMPLES
Technology	Thermal Science Robotics Integrated Research Teams Sellafield Advanced Business Analytics	Thermal (page 17) – Potential for £5+ billion cost reduction. Robotics – RrOBO (page 26) – Increasing operational efficiency through automation.
Spent Fuel Management	Spent fuel services Magnox operating plan Highly Active Liquor (HAL) Programme Effluents programme Site Ion Exchange Effluent Plant (SIXEP)	Effluent flow sheet - £3.4 million/year savings due to revised effluent treatment philosophy. Spent Fuel Services – £200 million saving associated with enabling a single pond storage strategy for Advanced Gas-cooled Reactors (AGRs).
Special Nuclear Materials	Package integrity and surveillance Sellafield Product and Residue Store Retreatment Plant (SRP) corrosion Innovation programme	Corrosion science – underpins Sellafield Product and Residue Store (SPRS) lifetime substantiation, avoiding the need to build a new store (estimated cost of £1.7 billion). Destructive examination – Estimated cost avoidance of £100+ million for the SRP programme.
Retrievals	Effluent management Condition monitoring and inspection Encapsulation Optimisation of Retrievals options	Alternative encapsulants – reduced CO_2 footprint. Skip fill optimisation - £150 million cost reduction by reducing storage demands.
Remediation	In-situ dismantling and decommissioning Characterisation Ex-situ waste treatment Sorting and segregation Decontamination	Real time characterisation (e.g. AmCam) – Better characterisation enables waste to be diverted in line with the waste management hierarchy. Decommissioning Waste Services Partnership Active Demonstrator – Enables 'hot spots' to be removed from waste, allowing the majority to be diverted to cheaper, lower streams.
Site Management	Analytical Services programme Sellafield energy strategy	New Fellside operating model – resulted in £17 million/year savings and 41% carbon emissions reduction.

The technical baseline team

The technical baseline provides a structured forecast of the technical activities required to deliver the Sellafield lifetime plan. It is managed by the technical baseline team, part of the Portfolio Management Office (PMO), within the technical directorate.

The technical baseline provides confidence that the lifetime plan is sufficiently underpinned by identifying key activities such as R&D, technical support activities and studies. By capturing the forecast cost and schedule data, it provides Enterprise-wide oversight of the shape and balance of the technical portfolio, enabling opportunities to be identified for collaboration, and avoidance of duplication where similar R&D is taking place elsewhere in the business.

The technical baseline is managed using a powerful roadmapping database program called Accolade, which was initially implemented to aid delivery of the annual Technical Baseline underpinning Research & Development (TBuRD) report deliverable to the NDA. Since implementation, Accolade has been developed to manage additional key business capabilities including Strategy, Corporate Planning, and Assurance.

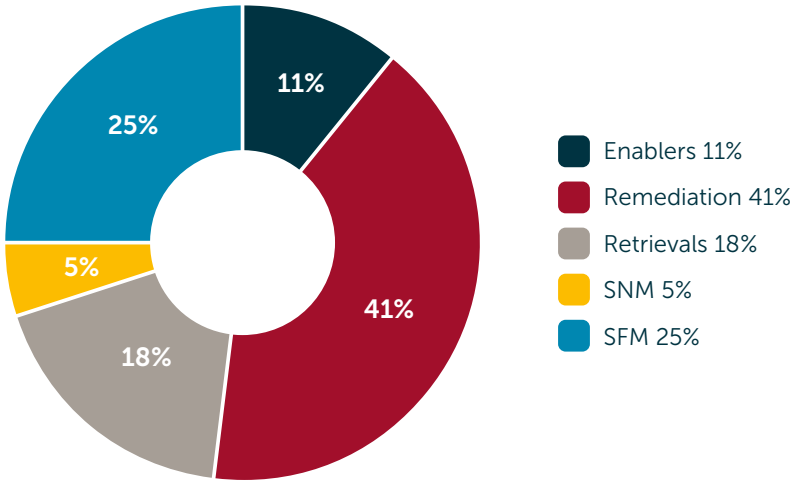
The technical baseline team hold an annual workshop where representatives across the Enterprise present their technical roadmaps to each other and to key stakeholders, for example, the NDA and Office for Nuclear Regulation (ONR). This helps to build, and improve upon, a consistent understanding of the Enterprise technical baseline and helps to identify potential dependencies or common themes of R&D across the business.

Throughout the 2023/2024 financial year, we worked in collaboration with the NDA estate to manage, maintain and improve the TBuRD process. Working together, updates were identified and delivered on the operation and performance improvement document, which governs the TBuRD process. In addition, the development of Power BI reporting to utilise data taken directly from Accolade and the TBuRD submission have been explored. This financial year Accolade was introduced to the NDA Group members to identify opportunities to support technical baseline management in these organisations with trials at Nuclear Restoration Services Dounreay and Nuclear Waste Services (NWS).

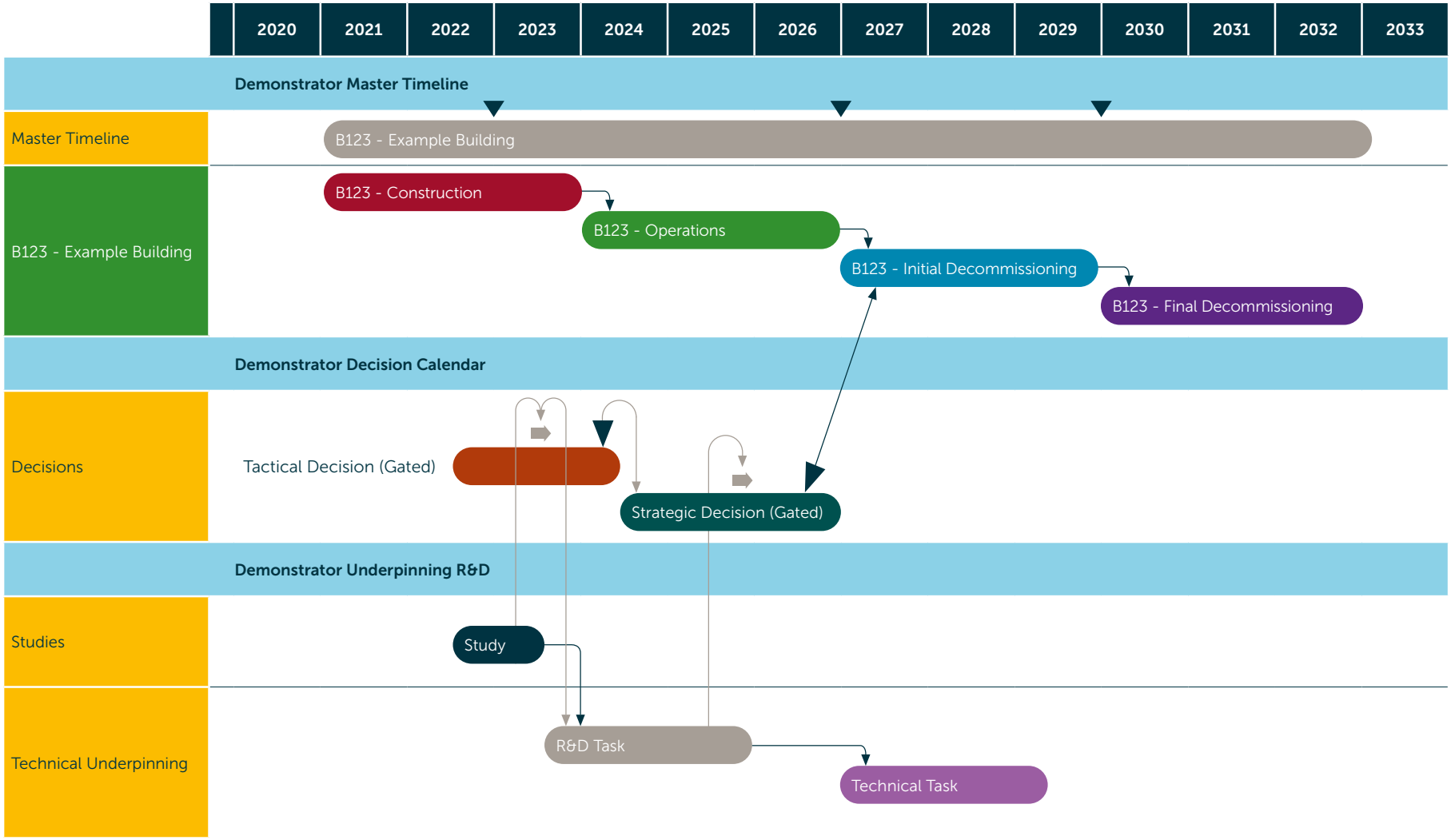
The Sellafield site's technical baseline indicates that over £75m has been spent on R&D in the 2023/24 fiscal year across value streams and enabler areas (see pie chart). Work is ongoing to improve the completeness and quality of the R&D investment data Enterprise-wide to incorporate into future annual updates of the Sellafield Ltd TBuRD deliverable.

Technical baseline team, left to right:
Marcus Johnston, Marcus Swift, Josh Cavaghan.

R&D Investment: FY 23/24



Demonstration model of the site master timeline in Accolade



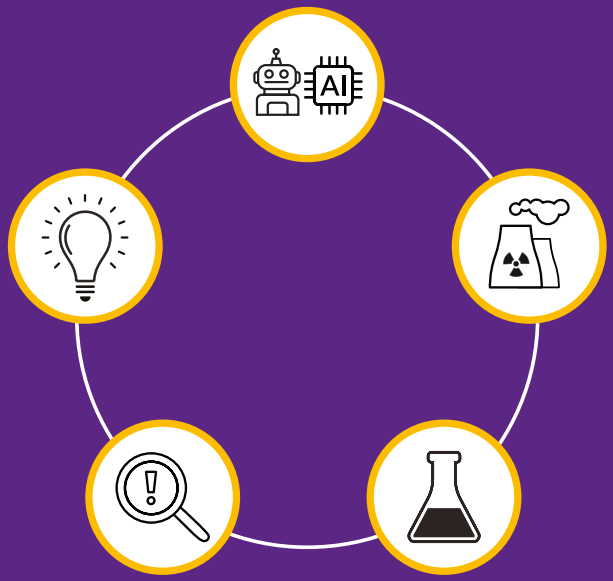
Enterprise Technical

The Enterprise technical team reports to our Chief Technical Officer (CTO) and is responsible for managing our technical capability and its key contract with the National Nuclear Laboratory (NNL) via the Technical Services Agreement (TSA). 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:

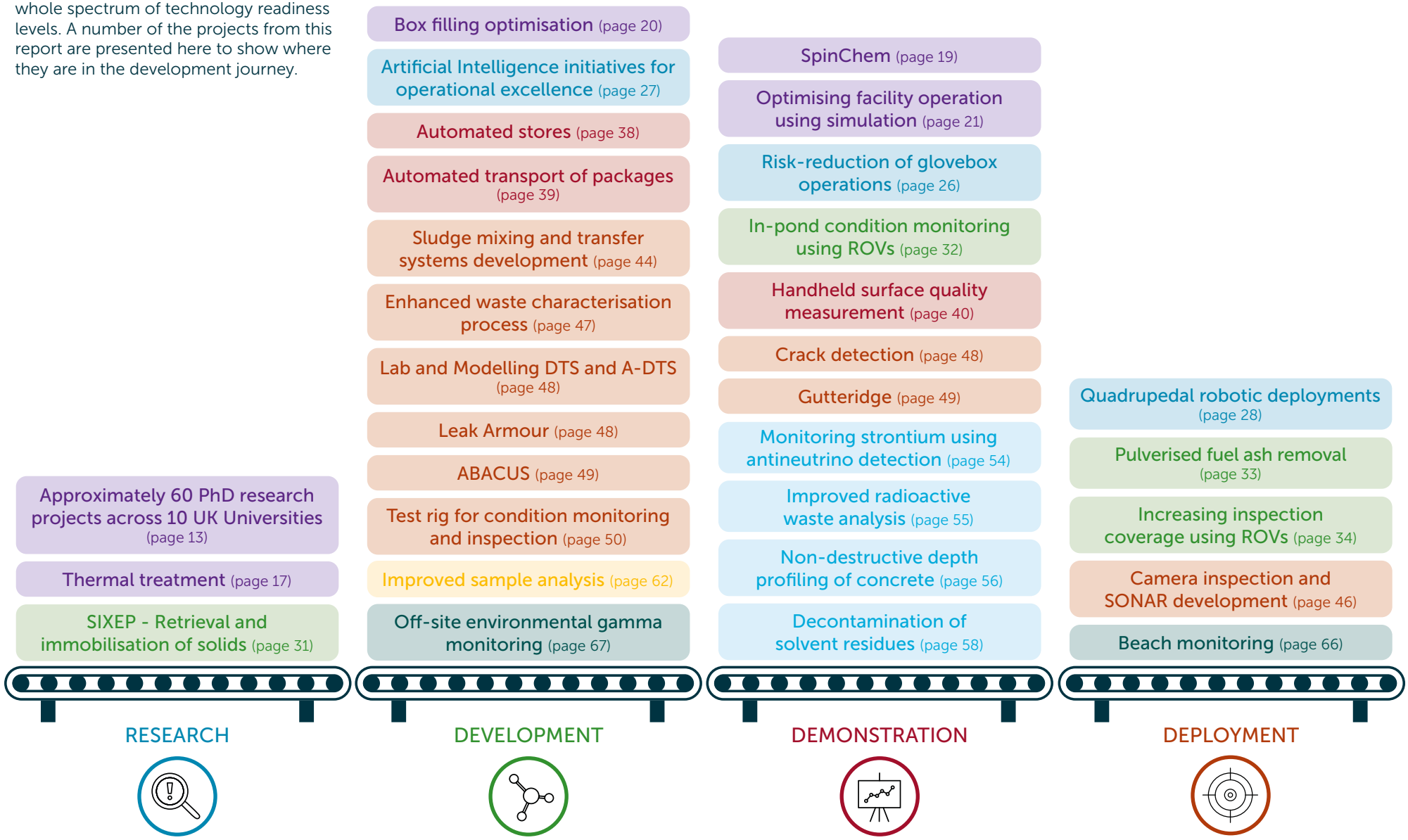
- Robotics and Artificial Intelligence (RAI): Coordinating deployment across the Enterprise.
- Higher activity waste thermal treatment: Developing pilot plants to treat plutonium contaminated material, mixed beta-gamma wastes, and pumpable wastes.
- Science programme: Coordinating the needs of the business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

We work collaboratively with the NDA Group and wider nuclear industry through our membership of the Nuclear Waste and Decommissioning Research Forum (NWDRF) and the Robotics and AI Collaboration (RAICo) Programme. We share our progress on technology developments regularly and collaborate on similar challenges when we can. This year we have learnt from the Nuclear Restoration Services Ltd (NRS) process for prioritisation to develop our own prioritisation process, linking in with the NDA value framework and considering return on investment.



Research and development conveyor

Sellafield Ltd has R&D projects across the whole spectrum of technology readiness levels. A number of the projects from this report are presented here to show where they are in the development journey.



Integrated Research Teams (IRTs)

This year we have undertaken an Enterprise-wide review of our R&D needs and opportunities, leading us to restructure our IRTs to align to these priorities. Changes from the previous year include:

- Splitting AI from Robotics to form its own team.
- Creating a Digital and Data team.
- Incorporating the Post Operational Clean Out (POCO) team's scope within the other IRTs (such as Measurement and Analysis, Robotics and Waste Treatment).
- Expanding the Waste Treatment team to include scope on Sustainability.

You can read more about all of the IRTs in our published Areas of Research Interest document [2].

Within our IRTs we have had some notable successes this year, including:

- SmartCans (reported in last year's R&D Review page 30) has been developed to the stage where it has been handed to the SNM value stream for active demonstration and deployment.
- AirCube Soft Robotics arm has been developed to the point that it has now been handed to the central robotics and AI team for final development prior to deployment (page 18).
- SpinChem has been developed and inactively demonstrated and we are planning for an active deployment in 2024/25 (page 19).
- Through Game Changers (see page 16) there have been:
  - 5 active demonstrations including demonstrations of Nottingham Robotic Snake at the Dounreay site, Raman spectroscopy in the Remediation value stream and real time gamma optical imaging in gloveboxes.
  - 23 inactive demonstrations including MicroUAVs, crack detect, and range-resolved hydrogen sensing for in-situ condition monitoring of stored waste.

The four themes of the science programme:

- Process Chemistry
- Materials Science
- Particulate Behaviour
- Environmental Science

The six technology themes:

- Waste Treatment and Sustainability
- Measurement and Analysis
- Digital and Data
- Robotics
- Artificial Intelligence
- Manufacturing

2. https://assets.publishing.service.gov.uk/media/660bce1e91a3207f0582b07c/FN_Sellafield_-_Areas_of_Research_Interest_FINAL.pdf

Embracing innovation

As Sellafield Ltd has transitioned its focus onto Remediation, the business is faced with new challenges each day. To find the best solutions to these challenges, new and innovative techniques must be explored that can provide the best outcome for the site. It's crucial to spread the benefits from these innovative projects to share best practise and inspire departments that might not otherwise be involved. This is being facilitated through two initiatives.

1. Following on from last year's successful event, hundreds of site-based colleagues have taken the chance to spend time looking into the future at our second on-site innovation event. This event 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 expanded from last year to include RAI, digital, our value stream innovation teams and projects and commercial to name a few. Interest in what technology could offer was high, ranging from high-tech robotics to vital changes people can make right now.

2. In January 2024 we launched our first innovation community of practice within the business, tying together key innovation routes and leads within the business to share best practice, collaborate, and enable key decisions relating to innovation across the business. This initial group consists of Enterprise technical, Engineering & Maintenance (E&M) and the value streams but will expand to include other areas of the business from IT, projects and commercial.

This year we will outline each area's innovation programme, processes, and procedures as well as sharing learning and best practice from innovative work which has been carried out around each area.

Images from the Sellafield Ltd innovation event

University engagement

Sellafield Ltd scientists work collaboratively with our academic partners to ensure that the best experts in the country are supporting us on risk mitigation and decision making.

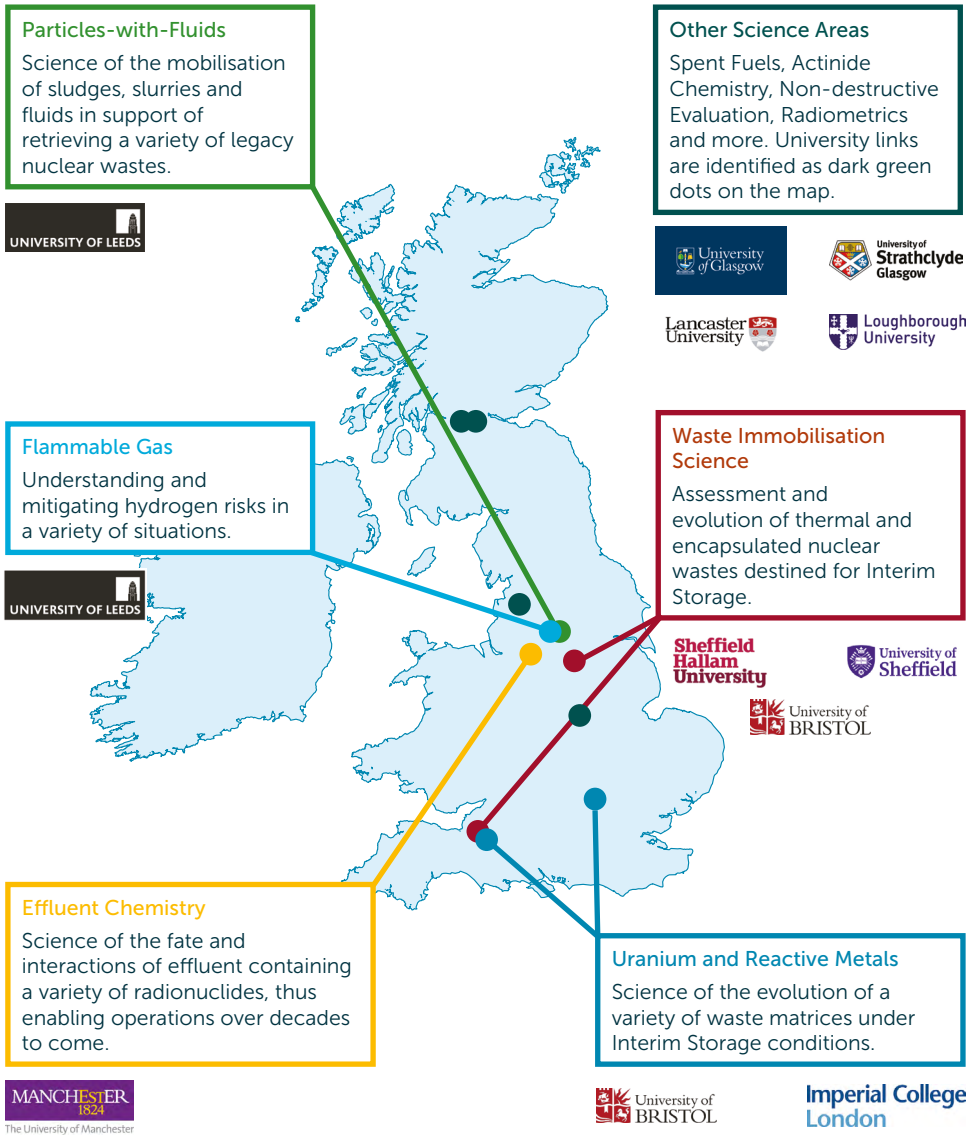
The Academic Science Programme (a subset of our academic portfolio) utilises state-of-the-art facilities (see NNUF.ac.uk) and world leading expertise to undertake research which in addition to acquiring knowledge, also develops people who will become the experts of the future.

We sponsor around 60 PhD research projects across 10 UK Universities, plus Post-Doctoral-Research-Associates and Fellowships across many science themes. Where we require additional expertise, we compete and contract Academic Centres-of-Expertise Links – of which we currently have five. These Links help us to articulate our challenges, and for University departments to use the most up-to-date resources and knowledge to address them.

Our interactions with scientists across the UK are not limited to those described above. Through many other mechanisms such as Centres of Doctoral Training (CDTs) and through supporting University led collaborative partnerships, we have access to a variety of departments in over 20 additional Universities both in the UK and abroad.

More information on key CDTs can be found below:

- Skills And Training Underpinning a Renaissance in Nuclear (SATURN) - SATURN Nuclear Energy CDT | The University of Manchester
- Nuclear Energy Futures (NEF) - EPSRC CDT in Nuclear Energy Futures | Research groups | Imperial College London
- Fluid Dynamics - EPSRC CDT in Future Fluid Dynamics (leeds.ac.uk)
- Water Infrastructure and Resilience (WIRe) - CDT WIRe - an EPSRC Centre for Doctoral Training



Map showing the primary UK academic scientific Support to Sellafield Ltd

Collaborative R&D to improve manufacturing capability

Sellafield Ltd collaborate with the High Value Manufacturing (HVM) Catapult Centres, a national network of seven specialist industry-focused research centres bridging the gap between business and academia.

The industrial membership budgets, together with Innovate UK funding, fund a programme of collaborative R&D projects across decommissioning, nuclear new build and technology development with the aim of developing innovative techniques and optimised processes for large-scale high-precision manufacturing.

Many manufacturing challenges are relevant to industry sectors outside of nuclear. An example is asset repair technologies, a project initiated through our membership research budget but also of interest to other industrial members. The High Value Manufacturing (HVM) Catapult Centres have supported the Manufactured Products Organisation and the manufacturing IRT in developing a technology roadmap to explore the opportunities available to deliver high-volume manufacture of storage containers.

They considered improvements such as automation of manufacture and in-line inspection, as well as adopting new manufacturing methods and technologies. We have also funded work specifically to target improvements to fabrication of 3m^3 containers.

20 research projects were underway during the 2023/24 financial year, funded through HVM Catapult grants or the Research Board. Examples of projects of relevance to Sellafield Ltd are:

- Digital robotic fabrication, a joint project with Sheffield Robotics aiming to demonstrate an open-architecture software solution for the programming and control of robotic welding, grinding and non-destructive testing operations. Sensors were successfully integrated into the robotic welding cell and digital twins produced for welding, weld dressing and non-destructive testing.
- Pipe welding demonstrator project producing a large-scale stainless steel tree structure. This project involved manufacturing joints using manual gas metal arc welding and the development of a laser line scanner for in-process monitoring of multi-pass robotic gas metal arc welding of pipe.
- Assessing effects of automation of dressing methods on residual stresses in welded steel by comparing manual grinding, weld shaving and robotic grinding with a non-dressed, as-welded surface using X-ray diffraction to map surface stresses.
- Factory deployment of friction repair of defects in electron beam welds on representative geometries on a steel mock-up component assembly.
- Adaptive machining project targeted at resolving issues with machining large components, such as pressure vessel forgings and large castings.

1. HVM Catapult logo

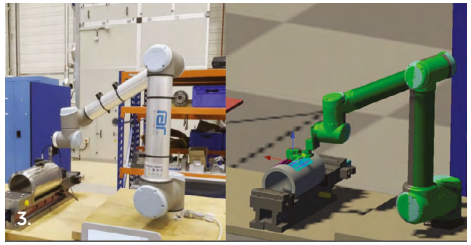
2. Innovate UK logo

3. Digital robotic fabrication project

4. The stainless steel tree sculpture

1. CATAPULT High Value Manufacturing

2. UKRI Innovate UK



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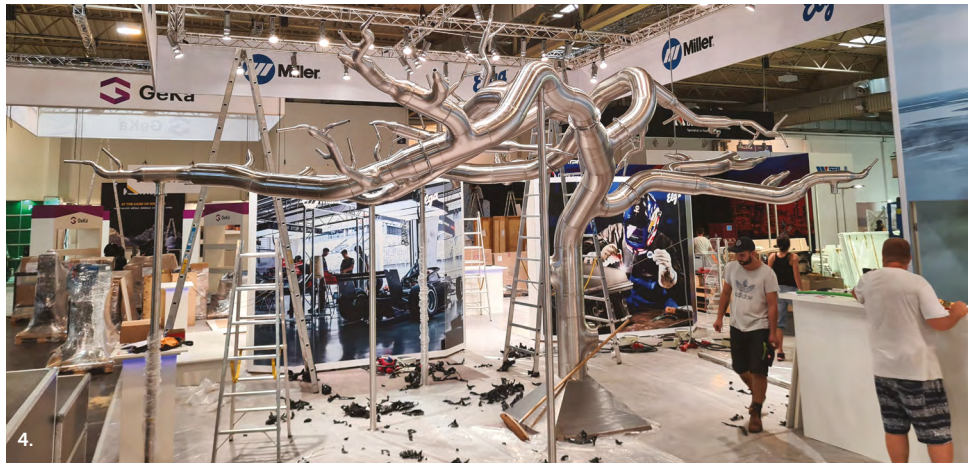

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Deployed and demonstrated innovation

Innovation teams within each value stream focus on specific challenges and explore and deploy innovative solutions to tackle them. They do this by providing support, resourcing and skills to develop and deliver innovation through their respected route. The innovation teams collect and down select ideas, maturing them into viable solutions and working with the customers to effectively deploy innovation within the business.

Innovation can come in many forms and through many routes. Last year, the innovation team captured and reported 43 deployed and demonstrated innovations in total. By capturing our successful innovations, we can showcase the benefit from them and our ability to deploy innovation within the business. A full list of all 43 innovations is listed on page 79.

Two examples from this year include:

- CARMA – A robotic autonomous contamination and radioactivity sensor, that enables continuous and autonomous monitoring of active areas. CARMA uses the Clearpath Jackal robotic platform, combined with a series of Commercial-Off-The-Shelf (COTS) components and software to provide onboard 3D mapping to locate, quantify and record areas of contamination.
- Gamma Cam on quadruped – Two separate innovative technologies delivered together. The Gamma Cam enables visual monitoring and representation of gamma sources in active areas, whilst the quadruped robot can enter active areas safely, quickly and effectively, delivering models of gamma in active areas previously inaccessible.

Innovative projects at Sellafield Ltd provide significant benefits to the company in numerous different ways. Showcasing examples offers an opportunity to share information and engagement with key areas of the business, developing a broader understanding of the challenges occurring at the Sellafield site. Examples can also be used as learning resources for good practice in future work.


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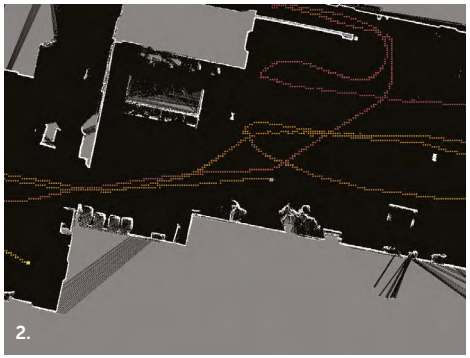
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3.

1. CARMA

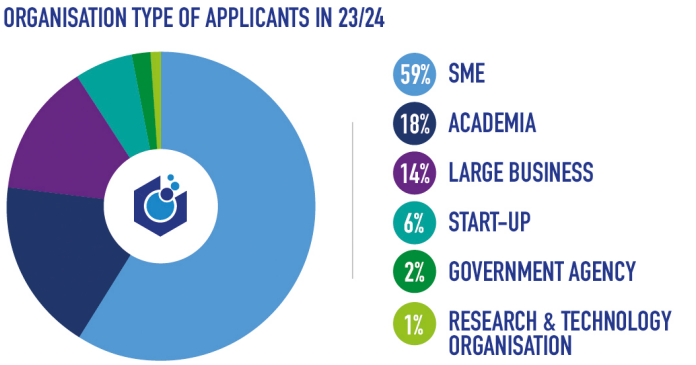
2. Dose map produced by Gamma Cam

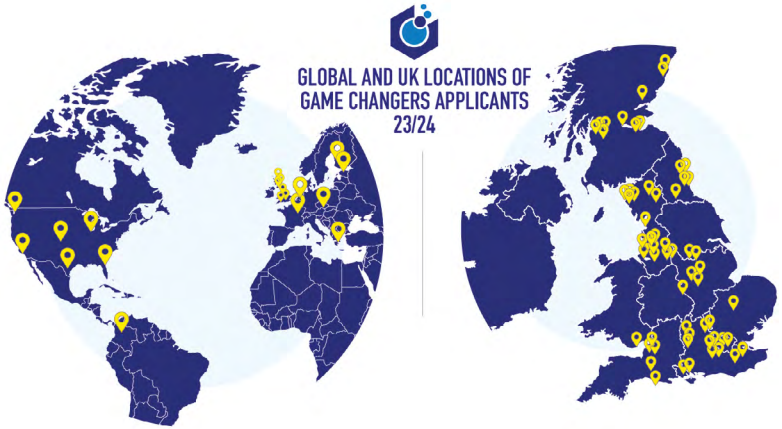
3. Gamma Cam on a quadruped robot

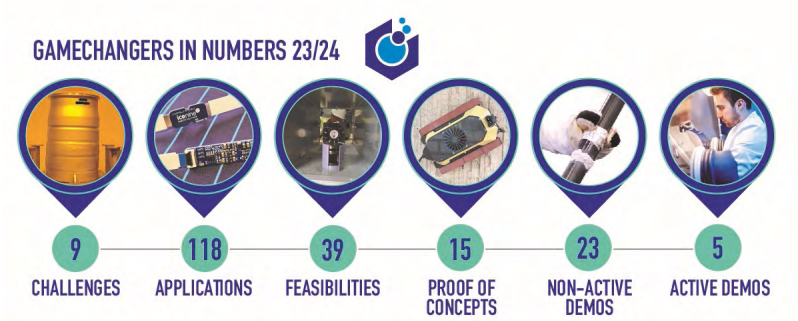
Game Changers

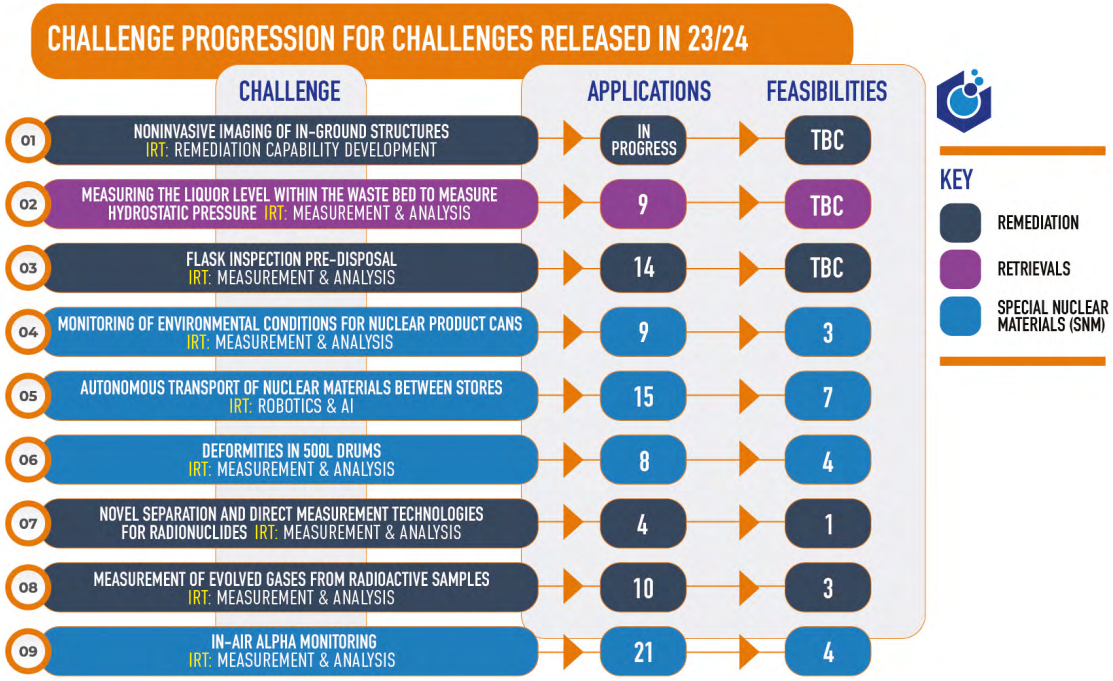
Game Changers is the UK's leading nuclear innovation programme, finding solutions and developing technologies to overcome some of the most complex challenges facing the nuclear industry. It provides a platform to connect challenge owners and solution providers across the NDA estate.

Over the past year, 9 challenges have been launched with over 100 applications from a broad range of companies. Further detail and ways to engage with innovation at Sellafield Ltd can be found in the Areas of Research Interest Document [2] on page 25 or on the Game Changers website at https://www.gamechangers.technology/.









Thermal treatment of waste

The Higher Activity Waste Thermal Treatment (HAWTT) programme was established in 2021 with the intent to enable decision making and unlocking an NDA baseline change.

A scenario-based approach was used due to the uncertain nature of long-range analytical assessments. Scenarios based on the broad waste categories of Plutonium Contaminated Material (PCM), Bulk Pumpable Intermediate Level Waste and Mixed Solid Beta/Gamma Waste were used.

The credibility and value of implementing the full lifecycle system was assessed using existing evidence and addressing credibility gaps. This underpins a national programme level credibility-based "can we" argument. Alongside this, full lifecycle value cases were developed which were compared against existing baseline plans to provide a corresponding "should we" argument.

During this assessment, a broad range of supply chain organisations have been engaged and formal contractual links with academia established. These links enable a pipeline of scientific resources to help develop a UK thermal treatment capability. This has increased the UK capability through focused development and delivery of designs, test rigs and technical underpinning and recognised the key and fragile skills required in readiness for the future deployment of thermal treatment.

The culmination of this capability development programme is the production of a Strategic Case for Change, which recommends a change in the NDA baseline, confirming HAWTT as a reference baseline capability and creating a basis for strategic guidance to flow through the NDA subsidiaries.

A range of interim implementation activities have been identified using a risk-based approach. These activities are focused on ensuring that thermal treatment technical maturity reaches parity with other potential waste treatment options, such as encapsulation. These include:

- Exploring risks such as flammable atmospheres, criticality and corrosion.
- Development of off-gas management systems.
- PCM focused R&D: Chemical modelling, CFD modelling, impact of chlorides, disposable product development, glass development, criticality case development.
- Understanding requirements for interim storage, transport and disposal in a future Geological Disposal Facility (GDF) environment, delivered in collaboration with NWS.
- Further development of glass formulations that can increase waste loading and product quality.

Project

Higher Activity Waste Thermal Treatment Programme

Benefits

Thermal treatment of waste provides real value through:

- Volume reduction, leading to significant lifetime financial and carbon cost benefits.
- Breakdown of organics and some reactive waste constituents, leading to improved waste passivity.
- Improved waste product integrity leading to improved safety performance in storage and disposal facilities.
- R&D activities in university settings, at the NNL and within the supply chain enable the UK to grow its breadth and depth of skills.

Current Status

This phase has culminated in the production of a Strategic Case for Change, which proposes the preferred way forward for the delivery of thermal treatment, informing future strategic decisions for the treatment of Higher Activity Wastes at Sellafield Ltd and beyond.

Delivery Partners

Acorn Coaching & Development, AtkinsRéalis, University of Bristol, Cavendish Nuclear Ltd, NNL, NSG Environmental Ltd, NWS, RED Engineering, Tetronics Technologies Ltd, TÜV SÜD

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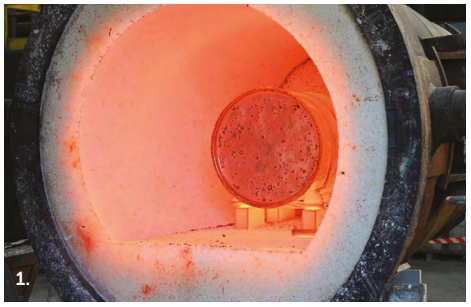
NDA Grand Challenge Alignment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2.

1. Drum skid undergoing durability and structural integrity testing at high temperatures

2. Model of the HAWTT Drummed Waste by Plasma prototype

Inflatable robotic arm

Remote deployment of tools is required for characterisation and decontamination during POCO to inspect large or hard-to-reach structures and allow modular payload deployment through 150mm inspection ports. The AirCube inflatable robotic arm provides an innovative solution to this challenge.

The inflatable arm incorporates two failsafe mechanisms: a dead-man's switch to prevent unintentional movements and an automatic failsafe mode that alerts the operator and allows safe retrieval if pressure is lost. The safety sleeve ensures that the arm can be retrieved even if punctured, providing additional protection.

Developments have enabled the arm segments to be reduced in size and increase flexibility, and progress has been made on integrating flexion sensors, electronic boards, and an encoder for the joystick. The safety sleeve was tested for puncture strength, and an inflatable gripper prototype and torsion segment were assessed with a 400g weight.

By December 2023, the arm's segments were fully wired with air supply and sensors, and the gripper could hold items up to 5kg. Initial tests showed all functionalities were operational, and the gripper lifted a 1kg load. The controller was tested, and the system could inflate/deflate segments and deflate the entire arm at once.

A successful proof-of-concept demonstration was held in February 2024 at the Engineering Centre of Excellence in Cleator Moor. The 7-segment arm, powered by a 7-bar compressor, reached 4 metres through a virtual 1 metre wall, handling a 1kg payload. The safety sleeve, made from Romar material, performed well despite lower pressure and some latency. The arm showed potential for future use with a haptic device and underwater, receiving positive feedback.

The inflatable arm will be taken forward as an active technology deployment with Remediation, SNM, Retrievals, and Central Robotics and AI collaborating on deployment through a typical cell penetration.

1-3. Proof-of-concept demonstration of the inflatable robotic arm in the Engineering Centre of Excellence at Cleator Moor on 21st February 2024


1.

2.


3.

NDA Grand Challenge Alignment

Project

Inflatable robotic arm

Benefits

The AirCube inflatable robotic arm offers significant advantages for inspecting or intervening in large-scale or hard-to-reach structures. It is powerful, robust, and electronic-free, made from high-strength textile and patented actuators, allowing it to explore complex environments with modular payloads.

Lightweight and easy to deploy and retrieve, it is safe for operators and equipment, even in contact situations. Its plug-and-play segments can be adapted for specific tasks, and it is more cost-effective than similar robotic solutions. Adaptable, resilient, versatile, strong, modular, inexpensive, and safe, it meets a wide range of inspection and decontamination needs.

Current Status

Central Robotics and AI and value streams will collaborate on a single active technology deployment through a typical cell penetration and to share learning.

Delivery Partners

AirCube, Spingeo, Xavier Poteau IE

Contact Details

Mel Willis and Yolande Smith
innovation.team@sellafieldsites.com

In-situ effluent treatment

The waste treatment and sustainability IRT are interested in R&D to enable the safer disposal of radioactive waste and improve environmental sustainability.

We have worked with SpinChem to develop a Rotating Bed Reactor (RBR) design for use in our facilities. In collaboration with AtkinsRéalis, the technology has been developed to provide the ability to process liquid effluent in-situ.

The RBR is a perforated cylinder, filled with media and restrained by a robust mesh, able to treat liquid waste. The RBR works by first lowering it into the liquid waste, before spinning rapidly. This causes the liquid waste to be drawn into the bottom of the RBR and through the media, treating the waste in the process.

The RBR is a potential solution for the in-situ treatment of liquids in tanks, heels and POCO liquors. This is a mature technology and has been deployed in the pharmaceutical and nuclear industry previously.

The vision is to deliver a new capability for the in-situ treatment of liquid wastes on the Sellafield site. Two different scale applications of this technology have been developed to proof-of-concept and supported by an inactive demonstration. These prototype devices are targeting small and medium scale applications, aimed at different waste treatment scenarios.

The small-scale device is capable of being deployed in a glovebox, targeting a specific liquid waste stream in analytical services (the treatment of contaminated liquors held in Winchester bottles). The device will be deployed into each bottle and treat the contents entirely in-situ without the need to decant the liquid. The larger scale device targets tank contents in the Enhanced Actinide Removal Plant at the Sellafield site.

Project

SpinChem - Mobile effluent treatment system

Benefits

This technology would enable treatment of radioactive liquid waste within its current storage structure, minimising the need for new infrastructure and enabling safer, cheaper, and faster disposal of radioactive waste.

Current Status

Two different scale applications of this technology have been developed and successfully demonstrated. The concept, detailed design, and manufacture for two specific applications will be completed ready for inactive and active testing during 2024/25.

Delivery Partners

AtkinsRéalis, SpinChem

Contact Details

Mark Dowson
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NDA Grand Challenge Alignment

1. Schematic of the SpinChem process where the rotating bed reactor eliminates radioactive substances from the aqueous solution

2. Prototype design of an efficient deployment mechanism for a rotating bed reactor in a Winchester bottle

3. Prototype design of a rotating bed reactor deployed into a liquid volume through constricted entry ports and at depth using a hoist

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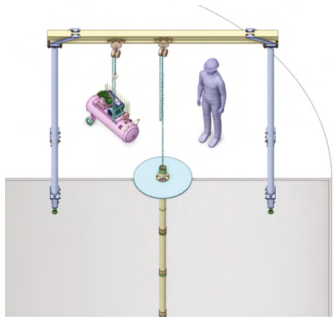

Box filling model

Sellafield Advanced Business Analytics (SABA) is the modelling capability group for Sellafield Ltd. SABA provide a diverse range of operational research solutions, including simulation models and web tools to an agreed specification. The box filling model was a Proof of Value project developed as part of SABA's responsibility to consider innovation within modelling and analytics.

The box filling model is a simulation tool, enabling the user to pack a predefined list of plant "equipment" into a box. Box dimensions, weight and activity thresholds are user defined. The plant equipment can be size reduced as defined by the user into constituent "objects", each with associated parameters including dimensions, weight, activity, and orientation.

A packing algorithm in the model takes these inputs and places the objects into boxes adhering to the various constraints defined by the user. The model then reports two key performance indicators, the number of boxes required to pack all pieces of equipment and the packing fraction for each box.

The model was developed to initiate discussion with relevant stakeholders to identify a potential use case for modelling the packing of solid waste into boxes. It has since been presented as part of a series of engagement sessions which were attended by 20 stakeholders. Discussions have taken place to determine potential use cases for the model and how it can be applied to provide the most benefit to Sellafield Ltd.

The SABA team are currently enhancing the tool to ensure that it remains applicable to a wide range of areas across the business, whilst also taking into consideration some of the more common feedback themes raised during the stakeholder discussions which include:

- Suggested functionality enhancements to the model, for example, a wider range of equipment archetypes and container types.
- Opportunities for the application of the model such as the ability to analyse cost and time benefits regarding size reduction to determine the most effective approach.

Once these enhancements have been completed, further engagement will be held with the stakeholders who have identified potential use cases for the model in their areas.

Project

Box fill model

Benefits

The model aims to reduce the cost and time taken to sort and segregate waste and increase project sustainability by packing the waste into boxes as efficiently as possible based on the model output.

Current Status

Completed planned phase of enhancements. The model will be tested and then further engagement with stakeholders will take place.

Delivery Partners

ITI Simulations Ltd

Contact Details

Henry Jackson, Jamie-Leigh Edington, Panos Frangos
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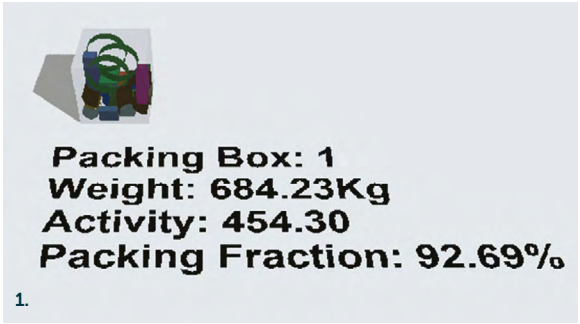
NDA Grand Challenge Alignment



1.

2.

1. Example model information for each box

2. The Objects to be packed into boxes. These are defined in the front end as equipment and then size reduced to form objects.

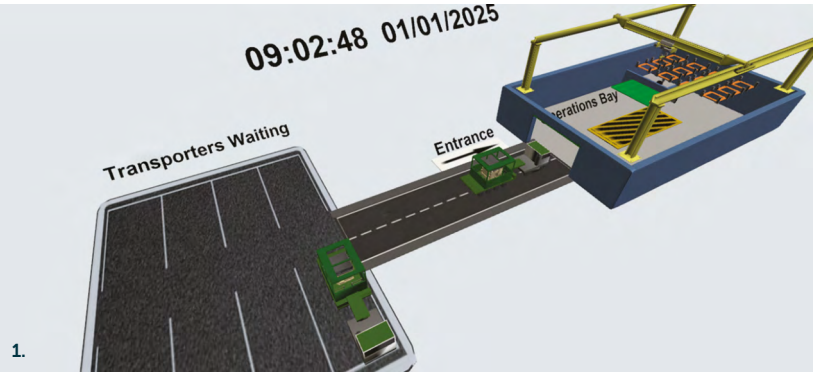
Optimising facility operation using simulation

Sellafield Advanced Business Analytics (SABA) and the Operational Technology Group have collaborated to create an environment that showcases the role simulation and modelling will play in supporting decommissioning at Sellafield Ltd, which is located at the Leconfield Engineering Centre of Excellence.

The simulation model is a fictitious visualisation of a waste storage facility, representing the movement of waste packages between a road bay and storage facility. The waste packages are unloaded by an overhead crane and stored within the facility.

The user is in control of various aspects of the model and can modify the speed the crane operates. In a scenario where the user increases the crane speed too much, the operation will cease and the user will be notified. This highlights the importance of maintaining a safe operating environment and encourages conversations around a strong safety culture.

The aim of the model is to demonstrate the modelling and simulation capability within SABA as well as the challenges faced with Operational Technology and Information Technology at Sellafield Ltd. With this successful demonstration, we hope that different areas of the business are made aware of the technology, and it be utilised to improve future projects.



1.

1. Example facility

Project

Operational Technology/Information Technology convergence

Benefits

This project will increase awareness of simulation and modelling capabilities throughout the business. Upon implementation, it will allow for better informed decisions during initial decommissioning or waste management programmes, enabling the optimal approach between safety, cost and time. It will also help attract early career individuals to Sellafield Ltd and the modelling world.

Current Status

The equipment has been assembled at Leconfield. The area will be unveiled when Leconfield Unit 18 officially opens (expected June 2024).

Delivery Partners

ITI Simulations Ltd

Contact Details

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innovation.team@sellafieldsites.com

NDA Grand Challenge Alignment

Bethan Murray

Senior technical advisor

As a secondee into the Enterprise R&D team, Bethan has been supporting the manufacturing IRT and the waste management & sustainability IRT.

Bethan studied Materials Science at Oxford University, graduating in 2017 with an MEng before joining Sellafield Ltd as a materials science graduate. She joined the Remediation value stream as a technical specialist and undertook secondments within the environment team at the Thermal Oxide Reprocessing Plant (THORP) and the materials inspection team. She provides technical advice to waste management projects and leads the Graphite Centre of Expertise at Sellafield. Bethan is a member of the Institute of Materials, Minerals and Mining (IOM3) and became a Chartered Engineer in 2023.

Wanting to take a more active role in developing new technology, Bethan was seconded to the Enterprise R&D team in October 2023. As part of the Manufacturing IRT, she has looked at new technology developments such as asset repair technologies and coatings, and additive manufacturing including 3D printing of concrete, polymers and metals. She also supports the development of waste management technologies.

Bethan has worked closely with many areas throughout the business. In her current role, she collaborates with the environment and sustainability teams, ensuring R&D and technology developments align with Sellafield Ltd's sustainability targets. She also works with others from the NDA estate to ensure irradiated graphite information, learning and knowledge is appropriately shared.

"I'm passionate about finding technical solutions and being able to improve and innovate the way that we do things."

Jibran Hussain

Technical support

After completing a BSc in Chemical Engineering followed by an MSc in Corrosion Control Engineering at the University of Manchester, Jibran worked in a range of sectors as a manufacturing engineer. In 2021 he joined Sellafield Ltd as a materials graduate and has since been seconded to a number of business areas.

Jibran's secondments have included the legacy ponds plant-facing technical team, with a focus around the interim storage facility, the manufactured product organisation, and central technical Enterprise R&D, where he worked as part of the robotics and manufacturing IRTs.

After completing the graduate scheme, Jibran began his current position providing technical support to both the manufacturing IRT and the legacy ponds strategy and technical team. He is an associate member of the IOM3, as well as the Institute of Corrosion.

Jibran's main role in the strategy and technical team is to inform the long-term strategy plan for the legacy ponds. Currently, he is focused on self-shielded boxes and the interim storage facility, while his manufacturing IRT work is focused on bringing new and novel manufacturing techniques to a range of stakeholders at Sellafield Ltd.

Working across two areas of the business has provided Jibran with the opportunity to learn from the R&D done by the central technical team and apply it to the challenges in the legacy ponds. In the upcoming year, Jibran will develop the R&D scope for self-shielded boxes Condition Monitoring and Inspection (CM&I), as well as deliver two projects that demonstrate the application of additive manufacturing with the manufactured product organisation and cold spray coatings with TWI.

"I enjoy the challenges of developing strategies or solutions because there's always something new to consider and learn, which keeps the work engaging and interesting."

Robotics and Artificial Intelligence

Robotics and Artificial Intelligence (RAI) are being embraced across the NDA estate, with Sellafield Ltd leading and managing on behalf of the group. They provide us with the means to remove people from extreme hazardous environments and help to decommission and clean up the site in a safer, faster and cheaper manner.

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 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: working collaboratively to identify opportunities and to take full advantage of what autonomous robotics can offer across the site and the NDA estate, as well as developing business tools such as large language models to improve how we extract information from multiple sources.

Each of these domains is being managed across Sellafield Ltd within the Remediation, SNM and Retrievals value streams, as well as in E&M and technology groups. The R&D is undertaken in a variety of locations, including RAICo1 situated in Whitehaven.

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.

RAICo - Robotics and Artificial Intelligence Collaboration

The Robotics and Artificial Intelligence Collaboration (RAICo) is a programme set up by Sellafield Ltd, NDA, the University of Manchester and the UK Atomic Energy Authority (UKAEA). The initial 3-year programme of technology development began in April 2022. It is focused on delivering and proving underlying RAI technologies that are required for effective decommissioning, as well as providing deployment opportunities to have maximum operational impact.

Sited in Whitehaven, West Cumbria, RAICo1 is the first of a network of RAI hubs across the UK. The facility will ultimately be used by Sellafield Ltd, NDA group, UKAEA, supply chain partners and academia to develop the technology needed to decommission Sellafield and other sites like it.

Offering the ability to test technology in environments that mirror those on Sellafield and NDA sites, such as gloveboxes and water tanks, the facility removes some of the challenges associated with working on the nuclear sites.

The strategic objectives of the RAICo programme are:

- Operationalisation of "this Generation" robotics into the nuclear sector
- Developing remotely operated solutions for decommissioning and future fusion power
- Developing intelligent customer and supply chain capability and capacity (viable innovation pipeline)
- Positive socio-economic impact in Cumbria.

This year, a variety of work has been performed as part of the RAICo programme. RoBox, two automated robotic arms secured to the ceiling of a glovebox, was tested for the safe handling of nuclear material within a glovebox. By using robotics to handle contaminated materials, human intervention in hazardous areas is reduced.

At Wälischmiller in Germany, LiRob has satisfactorily completed functional testing, endurance testing and risk analysis, and is now progressing on to Series-A design and production. LiRob is a robotic through-wall manipulator for tasks such as pick and place, bolting swabbing and cable handling and is planned to be transported to RAICo1 in September.

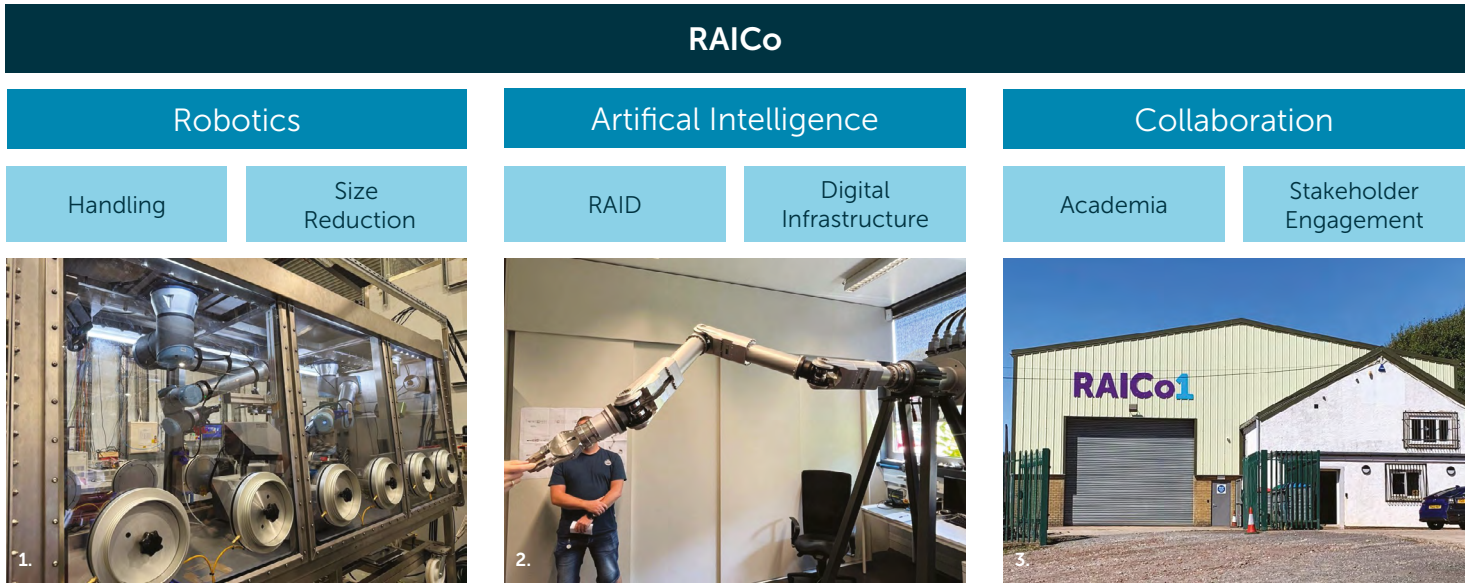
In collaboration with the University of Manchester, the CORAL project has developed autonomous and repeatable underwater robotic missions that utilise the newly developed collaborative aquatic positioning system for localisation and navigation.

Using RAI in hazardous nuclear decommissioning environments will provide the step-change in capabilities needed to move towards a cheaper, faster, and less hazardous set of next generation decommissioning activities.

1. RoBox Arms in Glovebox

2. LiRob through-wall manipulator prototype at Wälischmiller in Germany

3. RAICo1 Facility



NDA Grand Challenge Alignment

RAICo1 Facility

The RAICo1 facility began life as an industrial steel stock building in the 1980's. Under a collaboration agreement between Sellafield Ltd, UKAEA, NDA and the University of Manchester in 2021, the building was leased by Sellafield Ltd and renovated into the facility we have today.

At the facility we deal with early-stage technology projects to develop, prototype and test new technology, leading to projects for deployment and final build concepts. By also working with the supply chain and subject matter experts we ensure our work meets the customer's needs and results in a positive outcome.

The facility has a unique capability to test air, land and water environments all under one roof and includes:

- A water tank for use with Underwater Remote Operated Vehicles (ROVs) that is fully equipped with a Qualisis camera system to enable precise tracking of ROVs.
- An Unmanned Aerial Vehicle (UAV) bay with a Vicon camera system and the capability to simulate dark flying, which is important due to the number of 'dark' cells on site without adequate lighting sources.
- The floor space in the facility can be used to simulate cell environments, giving challenging surfaces for wheeled, tracked and quadruped robots to test their suitability for a task before deployment.
- The multifunction bay currently houses a glovebox that can simulate real time conditions, such as our industry standard depression.
- The control room provides a realistic environment for controlling equipment from a distance, implemented on projects that require taking personnel away from potential harm.

Finally, the AI suite enables offline development of platforms that can be built and tested without putting established networks at risk. Giving a space for this development is crucial as AI is embraced across not only the Sellafield site, but the entire NDA estate.

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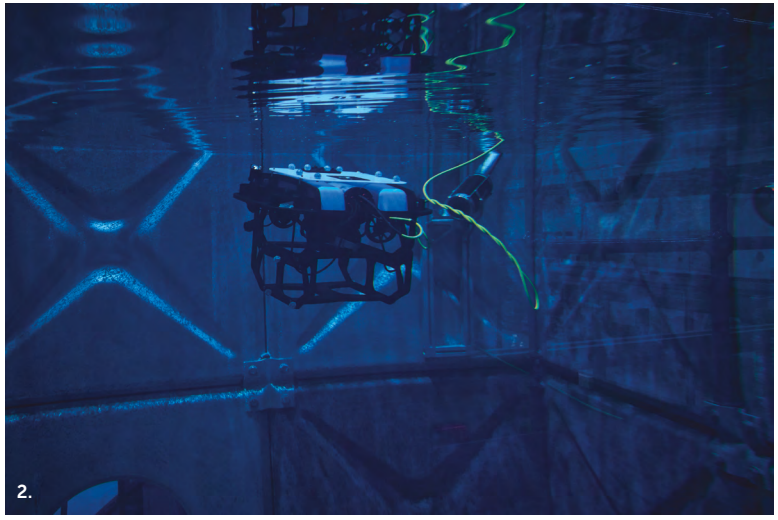

2.

1. The RAICo1 facility located in Whitehaven, West Cumbria

2. Testing of an underwater ROV

Risk-reduction of glovebox operations (RrOBO)

The Risk-reduction Of gloveBox Operations (RrOBO) project innovates nuclear glovebox operations. The baseline system for active deployment consists of a Kinova robotic arm protected by a containment sleeve and equipped with a parallel jaw gripper as the end effector. It is compatible with future tooling and mobile stands with cameras that allow for remote viewing and remote operator control of the robotic arm via a haptic controller with force feedback.

RrOBO aims to reduce risks with a robotic approach, eliminating manual handling hazards and enhancing efficiency. The system is initially targeting the clean-up and decommissioning of glovebox internals.

Stakeholder demonstrations presenting the RrOBO robotic arm deployed into a glovebox were completed at the Sellafield site by central RAI in collaboration with the Remediation technical & new capability team and our supply chain partners AtkinsRéalis and TKE, engaged through the Design Services Alliance.

The demonstration included fitting the containment sleeve, inserting the robotic arm into a glovebox and describing the selection of additional tools and capabilities that would become available through COTS items. These tools and capabilities include applying decontamination gel, swabbing, LiDAR laser scans, radiometric sensors, and many more. There was a wide range of interest from numerous organisations, such as the NDA, UKAEA, AWE, Dounreay and ONR.

The baseline system was then installed and operated in an inactive glovebox at the Sellafield training centre. Operator familiarisation sessions were run, with tasks including mock decontamination gel application and dummy waste pick and place.

The operators were able to pick up small items and place them in a can from another room after a few minutes. Feedback from the operators has been positive, with the robotic arm being able to extend further than a human arm and reach areas that are traditionally difficult to access. Additionally, there is a reduced risk of contaminated wounds by removing the need for operators to directly interact with nuclear material.

1.


2.


3.

Project
RrOBO

Benefits
Eliminates manual handling hazards, reduces contaminated wounds risk and enhances efficiency. Additional capabilities beyond handling waste are possible through the use of COTS equipment.

Current Status
Active deployment into gloveboxes on site has been approved at the Remediation portfolio board and will be delivered in 2024/25.

Delivery Partners
AtkinsRéalis, TKE

Contact Details
Yolande Smith
innovation.team@sellafieldsites.com

NDA Grand Challenge Alignment

1. Demonstration of the Kinova robotic arm in a nuclear glovebox

2. Inactive trials of the Kinova robotic arm in a nuclear glovebox

3. Kinova robotic arm control room

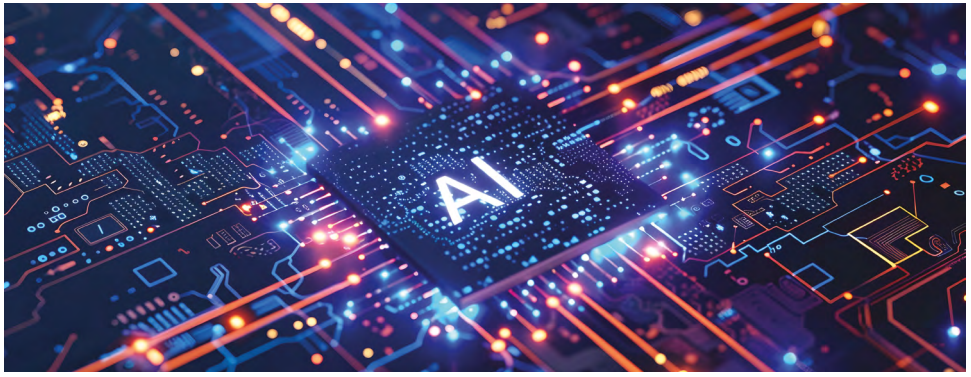
AI initiatives for operational excellence

Sellafield Ltd, in collaboration with the NDA, is leading AI projects aimed at improving operational efficiency and regulatory compliance within the nuclear decommissioning sector, including:

- One of the flagship initiatives, the Beacon AI project, focuses on developing and implementing our group AI strategy. This project aims to advance AI adoption responsibly through shared governance, policies, and procedures, promoting a culture of innovation and collaboration.
- The use of a Large Language Model (LLM), combined with a retrieval-augmented generation tool, is a cutting-edge solution that uses AI to draw conclusions from large datasets enhancing AI-generated content accuracy and relevance. Ultimately, we hope to have a virtual assistant capable of retrieving information and generating tailored reports, optimising waste management, safety protocols, and regulatory compliance with precision and speed.
- The Listener project utilises AI to categorise safety events, offering significant advantages over manual methods. AI algorithms process data rapidly, with consistency and scalability while uncovering patterns crucial for enhancing safety practices.
- SLComply.ai is another initiative revolutionising legal and regulatory compliance using Natural Language Processing (NLP) and machine learning. Traditionally, navigating legal changes was time-consuming, but SLComply.ai identifies relevant changes in near-real-time, streamlining workflows and ensuring compliance efficiently.

By harnessing AI's capabilities, we aim to bring key information and data to our workforce with ease, optimise processes, enhance safety protocols, and navigate regulatory complexities effectively. The collaborative efforts with NDA and external partners move us closer towards our shared vision for innovation and transformative change within the nuclear decommissioning industry.

As these initiatives progress towards implementation, we remain at the forefront of AI-driven advancements, setting new standards for operational efficiency and regulatory compliance. The integration of AI technologies not only enhances productivity but also shows our dedication to responsible and innovative solutions in nuclear decommissioning and safety management.



Project

AI initiatives for operational excellence

Benefits

The AI tools being developed will help us enhance our workforce's capabilities, automate tasks and improve productivity. This will ultimately lead to cost savings across the Sellafield site.

Current Status

Our ongoing AI initiatives are progressing well. Proof-of-concepts are being developed, which will validate the feasibility and benefits of the various AI applications. The SLComply.ai proof-of-concept is complete and moving forward to full-scale project implementation.

Delivery Partners

Ada Mode, PA Consulting Group

Contact Details

Jill Dunn and Paul Grima
innovation.team@sellafieldsites.com

NDA Grand Challenge Alignment

Quadrupedal robotic deployments

Manual inspections can be hazardous and could put our workers at undue risk, especially in restricted areas such as active areas, confined spaces or areas with limited access. Current techniques can require personnel to work in areas that are contaminated, high dose, at height or require plant equipment to be shut down to allow access. This can reduce plant throughput or hide issues such as leaking steam or gas lines.

Special Equipment Services and the ROV equipment programme has secured funding via E&M to accelerate deployment of quadrupeds (four-legged robots) around the site, available for use by all value streams. This approach ensures effort is not repeated and expertise is not diluted. On-site training packages have been developed for operators to ensure safe operation in complex environments.

One of the quadrupeds deployed is Spot (featured on page 42 of the Annual R&D Review 2021/22). Using Spot as a versatile platform, different payloads can be installed to provide a variety of different capabilities. These include, but are not limited to, gamma and alpha characterisation, swabbing, size reduction, 3D LiDAR scanning, high-definition video and images, asset condition monitoring including gas leak detection and vibration analysis. The use of quadrupeds is now business-as-usual for Sellafield Ltd, and support can be requested internally via the ROV K2 inspection booking page.

Having completed many high value remote controlled deployments already, delivering high value returns for the site, the ROV equipment programme is now looking at how to start gathering data autonomously. Autonomous data collection saves time and allows resource to be relocated to higher priority and value adding tasks. It also enables data to be collected in a more repeatable, frequent and structured manner than is possible manually.

This higher quality data feeds into existing systems to produce better results, such as earlier detection of failures, better data sets and the creation of a continuously updated single source of truth that enables new ways to effectively coordinate operations.

1. Spot in a specially designed suit to protect it from contamination

2. Spot deployed in a cell

Project

E&M quadrupedal robotics deployment

Benefits

The use of quadrupedal robots reduces the risk to personnel by allowing tasks to be completed remotely. Utilising robotics can also allow tasks to be completed quickly, improving key decision making for plant engineers by providing complex data efficiently and accurately.

Data retrieved by Spot has allowed project teams to start work which had not been expected for 10 years, and provided dose readings which allowed recovery of a storage vault which was out of operation for over 5 years.

Current Status

The use of quadrupeds is now business-as-usual for Sellafield Ltd, with any value stream being able to request support. Looking forward, the ROV programme is exploring ways to autonomously gather data.

Delivery Partners

AtkinsRéalis, Createc, UKAEA, University of Manchester

Contact Details

ROV.Ops.Support@sellafieldsites.com

NDA Grand Challenge Alignment

Louise Heatherington

RAICo1 operations manager

As operations manager in RAICo1, Louise enables innovation to be developed, demonstrated and pre-deployment tested within RAICo1, as well as introducing outside agencies to the facility.

Louise joined Sellafield Ltd in 1988 and has held a variety of roles within the business, giving her an extensive knowledge of different plants and processes. She started her career in operations, working in various facilities covering R&D, analysis, reprocessing and operations. She then moved into the radiological protection team in THORP, which included work within encapsulation plants, flask handling plants, the Mox demonstration facility and other associated plants.

Three years ago, Louise joined the RAI team as operations manager in RAICo1, facilitating the renovation from an old, redundant industrial building to an operational facility (see page 25). In this team, Louise directs particular focus on user requirements by means of road mapping, aiming to fully understand the customer's need before finding an appropriate solution. This may involve working with the supply chain, challenge portal, or Game Changers, underscoring the importance of selecting the most effective approach to deliver value to the customer.

Amidst Sellafield Ltd's dynamic landscape continuously presenting new hurdles, Louise facilitates the exploration of RAI across various business sectors, offering innovative solutions to demanding tasks that could otherwise seem impossible.

"My experience has given me exposure to different areas of Sellafield Ltd and helped me to understand opportunities where robotics and AI can benefit the business."

Paul Grima

Technical delivery manager

As technical delivery manager, Paul is responsible for delivering and supporting the implementation of AI across Sellafield Ltd.

Paul's journey began with a BSc Degree in IT Systems Management from UCLAN University. This academic experience aligns with his professional credentials, as he is a professionally registered Incorporated Engineer through the Institution of Engineering and Technology.

Having spent the majority of his career in the Operational Technology Group, Paul transitioned to his current role as technical delivery manager in December 2023, bringing a wealth of experience and expertise gained over nearly 17 years with us.

This transition to the RAI team was driven by a desire for new challenges and an eagerness to explore the evolving AI landscape at the Sellafield site. Paul is driven by a desire to leverage AI technologies to improve business efficiency and achieve tangible returns on investment.

His first six months within the technical team have been an eye-opening and enriching experience. Looking ahead, he is eager to drive transformative change within the RAI domain.

Outside of work, Paul is active in his local community, serving as both a school governor and a football coach for the Under 9s Cockermouth Juniors Football Team.

"I've always been interested in making improvements to whatever I do, whether it's exploring new technologies or refining existing processes."

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 effluents arising from fuel storage and waste treatment operations. The scope delivered by the value stream includes:

- The receipt and long-term storage of 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, vitrification and storage of high-level waste prior to either return of vitrified product to overseas reprocessing customers, or, disposal for UK waste.
- Operation of a complex suite of effluent facilities along with establishing new capabilities to ensure effective treatment of aqueous waste, supporting high hazard risk reduction operations and the clean out of the reprocessing plants prior to decommissioning.
- Preparing for the completion of operations in fuel storage and effluent treatment facilities and the timely cleanout and transition into decommissioning to enable effective lifecycle asset and waste management.

SIXEP – Retrieval and immobilisation of solids

There is a need to retrieve and immobilise used radioactive ion exchange solids stored on the Sellafield site. However, there are three key challenges that need to be addressed.

Breakdown of ion exchange solids

In the Site Ion Exchange Effluent Plant (SIXEP), ion exchange solids can undergo limited breakdown due to long-term radiation exposure. Further breakdown can occur during transport of the waste. Work is underway to assess the benefit of using settling aids that separate the fine particles (fines) from the liquid waste. This will make treatment of the liquid waste easier, providing significant overall design and operating cost savings compared to traditional methods of treatment.

Transporting ion exchange solids in water and in air

To move the ion exchange solids to a central pump-out location, a technique called water sluicing is used. Additional research is underway to understand the water jet sluicing process under water and through air to enable the future design of efficient retrieval equipment.

Retrieving ion exchange solids from liquid waste

As with the separation of fines from liquid waste, the retrieval of ion exchange solids from liquid waste is advantageous to minimise process design costs and significantly reduce liquid waste treatment design and operating costs.

Vacuum retrieval is a process capable of retrieving the ion exchange solids. Work is ongoing to understand the benefits, operating conditions, and limitations of this process for a future design. Future vacuum retrieval studies are being initiated to produce a design guide for the vacuum retrieval of wet granular solids and sludges.

Test rigs are currently under construction prior to commissioning and operation later this year, which will support a retrieval project. As the project progresses and some large-scale test rigs are built, the ongoing work will provide essential technology underpinning for flowsheets and equipment design.

Project
SIXEP

Benefits
Significant cost savings by enabling cheaper effluent treatment process design and operation.

Current Status
Project is ongoing, with small scale test rigs currently under construction.

Delivery Partners
NNL

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NDA Grand Challenge Alignment


1.

1. The SIXEP on the Sellafield site

In-pond condition monitoring using ROVs

Spent nuclear fuel from the UK's fleet of AGRs will be held in long-term storage at the THORP Receipt & Storage (TR&S) pond before eventual disposal in a future GDF. This will involve spent fuel pins being transferred to 63-can racks for long-term storage within the pond.

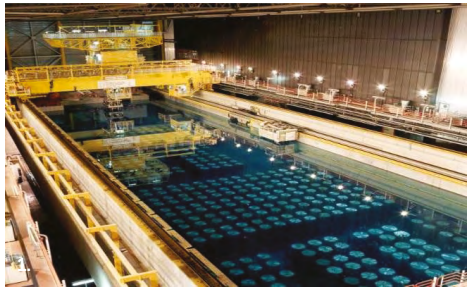
Condition monitoring is required to confirm the integrity of the spent fuel pin stainless steel cladding throughout this storage period and identify any racks that may need closer monitoring. However, an improved method for monitoring spent fuel pins within racks for indicators of cladding deterioration was required that has two key capabilities:

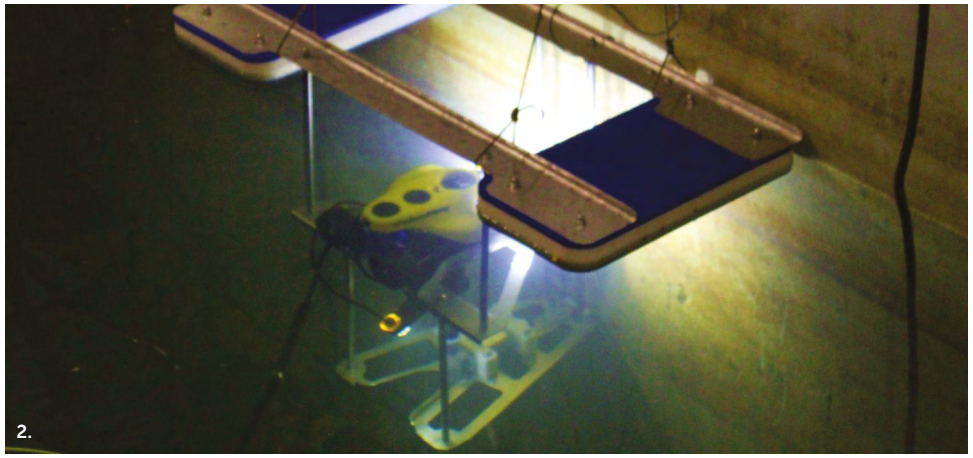
1. Remote operation to minimise operator dose uptake associated with sampling operations and allow targeted sampling of specific racks of interest.
2. In-pond monitoring system, removing the requirement of sending a radioactive sample to the laboratories for analysis and provide an almost immediate result in-situ.

Collaboration with Jacobs has led to the development of an ROV which can sample water within the racks and monitor this in-situ. An existing ROV has been modified to include an arm-mounted syringe which can perform sampling of the rack water. This will then transport the sample to an in-pond monitoring station which contains a gamma spectrometer and analyse it for key indicators of cladding deterioration.

This project has resulted in the production of an ROV rack sampler and in-pond monitoring system, developed for use in the TR&S pond. Now that inactive testing is complete, further work to implement the technology is currently underway.

By continuously improving the condition monitoring capability as technology develops, the return on investment is maximised ensuring the safe long-term storage of spent nuclear fuel.





Project

Long-term storage of spent nuclear fuel

Benefits

This project will provide improved condition monitoring of spent nuclear fuel in long-term storage, helping to ensure the integrity of the material.

Current Status

A modified ROV with in-pond monitoring station has been developed and built. Initial inactive testing is complete, and implementation within the TR&S pond is underway.

Delivery Partners

Jacobs

Contact Details

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NDA Grand Challenge Alignment

1. TR&S pond

2. ROV and monitoring station within the inactive test facility

3. ROV with modifications and its monitoring station. Copyright Jacobs Ltd 2024.

Pulverised fuel ash removal

Pulverised Fuel Ash (PFA) was one of two cement powders used in the encapsulation and capping process in the Waste Packaging & Encapsulation Plant (WPEP). WPEP supports site operations by encapsulating floc, a waste product from effluent treatment processes, in cement within drums. The encapsulated floc is then capped with inactive grout before the drum lid is secured.

PFA is a by-product from coal-fired power plants. However, since many of these power plants across the UK have closed or changed to carbon-capture technology, PFA is no longer in supply and the remaining stockpile is being shared across the NDA estate. Consequently, the Sellafield Cement Strategy recommended to remove PFA from encapsulation plants.

Experimental work was carried out by NNL to prove it was viable for WPEP to encapsulate floc without the need for PFA. On-plant trials and a workshop determined that the inactive grout cap could also be removed.

As a result, WPEP removed PFA from both the encapsulation process and the cap of the drums. This was implemented through a multi-discipline approach and managed through a flexible Plant Modification Proposal, allowing for testing and adjustments to be carried out as needed.

By removing PFA from the cement recipe, floc per drum increased from 350 to 410 litres. Subsequently, fewer drums will need to be produced over WPEP's lifetime and require final storage in the GDF.

Based on the drum reduction alone, a lifetime cost saving has been estimated at over £96 million (£100,000 per drum). This will be even greater when considering the costs saved on purchasing PFA in the future, powder / drum deliveries and maintenance on capping equipment.

Capping is associated with approximately 50% of the WPEP resource demand and a 20% constraint on throughput. Without the need to cap drums, an extra drum per day can be produced. The simplified process and increased drum fill efficiency also means WPEP can support upstream high-hazard risk reduction activities, which is important for emptying tanks in an ageing facility.

Project

PFA removal

Benefits

Removing PFA and the cap has resulted in an improved drum-fill efficiency, allowing an increase in WPEP's throughput, reduced raw material consumption and a reduction in the number of drums sent to the GDF. Due to removing the capping process, secondary liquid and conventional hazards associated with moving the grout module have been eliminated.

Current Status

This project was implemented in March 2023 and has continued successfully since.

Delivery Partners

NNL

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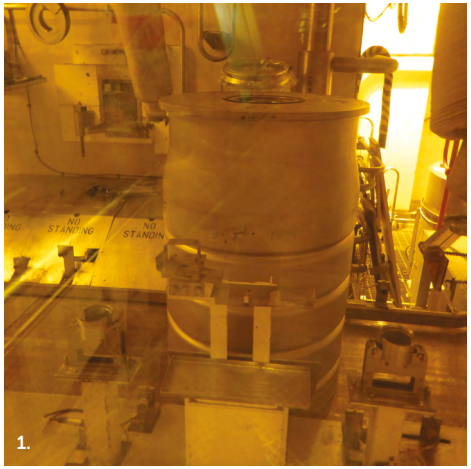
NDA Grand Challenge Alignment



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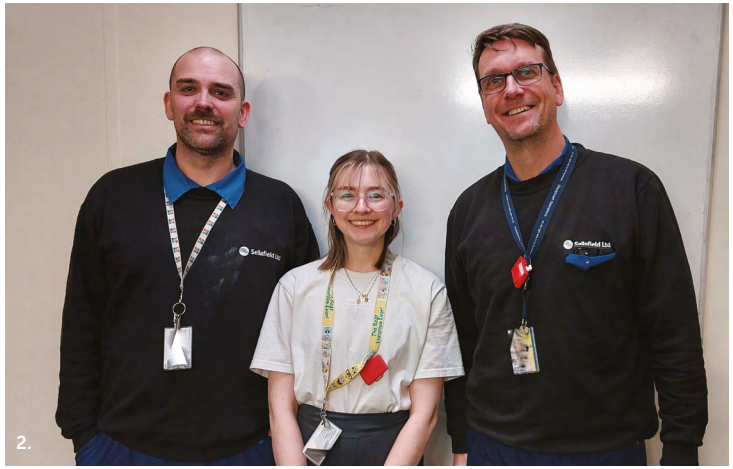
2.

1. WPEP drums in a cell

2. Part of the PFA team

Increasing inspection coverage using ROVs

The highly active buffer storage tanks store liquid waste in preparation for being processed by the Highly Active Liquor Evaporation and Storage (HALES) facility. They are large tanks enclosed within shielded cells, with very limited access, and have been in operation since the 1950's.

The tanks are subject to a regular remote inspection regime to assess their condition. However, due to the access constraints, the coverage of some assets is limited using the existing inspection technology.

A project was initiated to increase the proportion of vessels inspected. After optioneering, a ROV was determined as the most appropriate solution.

A bespoke ROV had been developed with NNL for a separate project in the facility, serving as a proof-of-concept to seek a permanent ROV inspection solution. The requirement was to procure a COTS vehicle to allow rapid replacement in the event of failure or contamination. Equipment which fulfilled the specification was identified and purchased.

The access port to the tanks is approximately 10m above the ground and through a wall, adding additional complexity to the inspection. Therefore, a system to post the ROV through the wall port and lower it to the compound floor was developed. This innovative system allows the COTS equipment to be operated in our unique environment.

In February 2024, the deployment was a resounding success. The ROV was able to gain views of the vessel which have never been seen before, increasing our understanding of the condition of the tank and aid monitoring of the condition as it continues to age.

NDA Grand Challenge Alignment

Project

Highly active buffer storage facility inspection

Benefits

Enhanced condition monitoring of key ageing nuclear asset, providing assurance that the plant is safe to continue operating. The project also provided a proof-of-concept for the successful deployment, use and retrieval of a COTS ROV for remote visual inspections across the HALES facility, thus improving cell coverage without the need for the costly drilling of new inspection ports. The use of COTS equipment also provides a cost saving compared to using bespoke equipment.

Current Status

Initial inspections have been completed successfully. Plan to expand the technique throughout the remainder of the facility.

Delivery Partners

NNL

Contact Details

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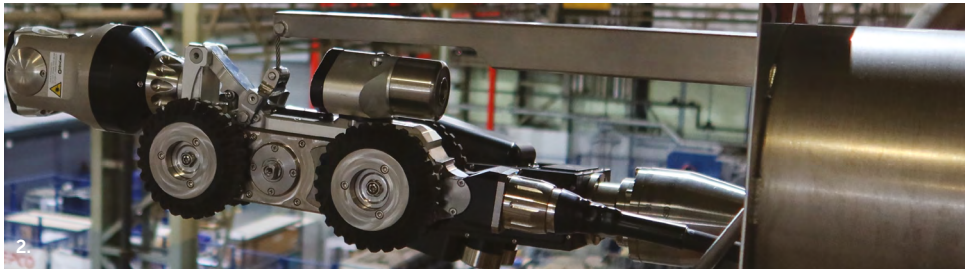
1. View of ROV deployment system in mock inspection port

2. ROV being deployed during trials

3. ROV in operation during trials


1.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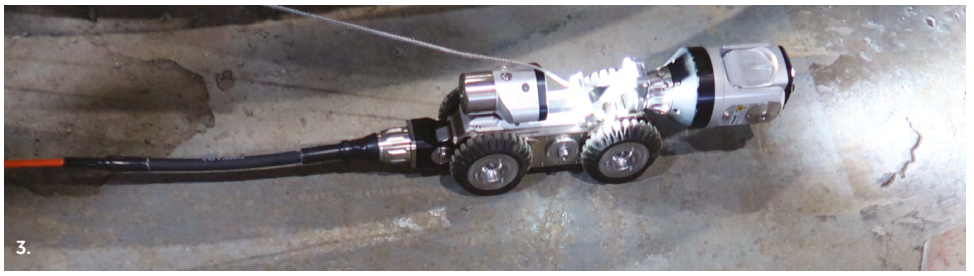
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Zoe Dennison-Drake

Senior research technologist

As a senior research technologist, Zoe's role involves supporting and conducting activities to sustain assets at Sellafield Ltd, ensuring their prolonged utilisation.

Zoe holds an MEng in Mechanical and Materials Engineering and is a member of the IOM3. Throughout her 10-year tenure at Sellafield Ltd, she has occupied various roles, with her current position as a senior research technologist.

Her role is diverse and has several responsibilities, but her main focus is plant and asset longevity. This involves looking at new ways to carry out inspections, performing erosion & corrosion assessments and investigating novel repair methods. She also oversees knowledge and information management, as well as maintaining some of the platforms dedicated to these tasks.

Lately, Zoe has been spearheading projects focused on investigating the feasibility of innovative repair techniques and initiating the development of new inspection capabilities. These advancements will enhance the ability to inspect a greater portion of assets through existing access ports.

The most rewarding aspect of Zoe's role is knowing that her efforts improve frontline engineering tasks, while also enabling knowledge sharing among technical colleagues, aiding in their development.

"As a taxpayer, I want our money to be spent on the right things at the right time, and I think the work I do helps to accomplish that."

David Hargreaves

Technical specialist

Dave oversees inspection programmes across Spent Fuel Services plants, managing strategies, compliance, and stakeholder coordination to ensure recommendations are implemented.

Dave spent eight years at Swansea University, where he pursued a BEng in Chemical and Biological Process Engineering, an MRes in Recycling Technology, and ultimately an EngD in Steel Technology.

His professional career began in 2008 with two years at the Port Talbot steelworks, serving as a process operational development specialist. Joining the Sellafield Ltd graduate scheme in 2010 through the materials science discipline, Dave became a vital member of the Magnox inspections team within the SFM technical department. In 2012, he won the graduate of the year award for his support to an inspection programme carried out in the Magnox facility. His role has evolved over time, expanding to cover various plant areas and types of inspection as he has gained experience.

In his current role, Dave manages an inspection programme across Spent Fuel Services plants. This includes producing and executing inspection strategies and writing scope documents to ensure compliance with site license conditions. Dave also serves as a Nominated Representative for NNL inspections and engages in developing solutions to inspection challenges through initiatives like Game Changers and involvement with the UK Research Centre for Non-Destructive Evaluation.

Dave has been chartered with the IOM3 since 2019 and currently mentors colleagues towards chartership, as well as participating in the recruitment processes for new graduates and placement students.

"The challenges at Sellafield Ltd are so varied, there is always interesting and innovative work to be involved with."

Stuart Beresford-Kelly

Technical manager

Stuart has been with Sellafield Ltd for almost seventeen years since joining as a graduate after earning his BEng in Chemical Engineering and MSc in Clean Technology from Newcastle University. During that time, he has worked in chemical safety, process engineering design and technical delivery.

For the last ten years Stuart has been working in SFM technical. He started his current role as supporting SIXEP two years ago, prior to which he was a senior technical advisor primarily supporting the Enhanced Actinide Removal Plant.

In his current role, Stuart's key responsibilities are securing and managing funding for development work, before liaising with Sellafield Ltd and NNL stakeholders to scope out, prioritise and deliver the work. Another vital part of his role is building collaborative practices into how we and NNL combine to deliver this work.

Recently, Stuart has been working with colleagues from NNL and other teams to understand the true requirements of the sluicing rig project (see page 31), before taking the steps to bring it to fruition. The scale of the engineering involved with this project is beyond anything the team has delivered before, making almost every day an opportunity to learn and innovate. He understands that this will take time, but crucially it ensures his team's knowledge and capability continues to grow.

Stuart is driven by getting a little bit better at the job each day. In his experience, even small lessons can allow us to deliver more efficiently without compromising safety and quality.

"The trust and collaborative spirit we have built is crucial to operating smoothly in a constantly changing environment."

Rebecca Heyworth

Technical specialist

Rebecca joined Sellafield Ltd in 2017 on the degree apprentice scheme. Over the next five years, she earned a BEng in Plant Engineering (Nuclear Plant and Process Technology) from the University of Cumbria whilst working in SFM.

Alongside earning her degree, Rebecca also achieved an apprenticeship qualification in Nuclear Engineering. Following completion of her degree apprenticeship, she now mentors other apprentices coming through the same scheme.

During her time on the scheme, Rebecca completed two secondments, one in the pre-operations support team for a new active facility, and one in system engineering for a different plant. These were great opportunities for her to see different areas of site, complete a diverse range of work, and network.

Since joining, Rebecca has progressed from technical advisor to her current role as technical specialist. She has focused on radiometric characterisation of one of the highly active waste processing plants which has enabled her to transition into becoming the characterisation lead for the plant. Her work involves investigating current available characterisation options, and identifying new routes and technologies that can be used to achieve results.

The majority of her work is longer term ongoing projects. Rebecca likes exploring how different devices and technologies can help support characterisation, and seeing projects develop from the initial concept through to completion and implementation on plant.

"I enjoy figuring out a way to obtain the required data from plant to support operations and recognising the benefits once the results have been achieved."

Special Nuclear Materials

The Special Nuclear Materials (SNM) value stream is responsible for the safe and secure 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 gaseous species within sealed packages, corrosion in hydrogen chloride and marine environments, behaviour of impurities such as chlorides and the requirements for future conditioning.
- Innovative approaches to the safe operation and inspection 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 and future storage programmes.
- Supporting NDA in developing options for the long term disposition of plutonium. Focusing on powder processing and scale up of operations.
- Understanding the disposal options for plutonium residues considering thermal, grout or direct disposal.
- Developing the evidence base for the performance of our transport packages during security threats.

Automated stores

The SNM value stream at Sellafield Ltd is responsible for overseeing the safe and secure storage of special material in the facility. In line with our current remediation mission, packages in these SNM repositories are being moved to the SPRS for longer-term, safe storage. The existing method of package exportation relies heavily on manual intervention, including working at heights and performing labour-intensive tasks to handle the hazardous materials.

This process, consisting of thousands of operations, presents potential injury and radiation exposure risks to operators, and increased likelihood of damage to packages. As a result, a project was established to investigate automated robotics as a solution for replacing manual operations, with the goal of reducing risks, enhancing safety and improving efficiency in package handling.

Through collaboration with the NNL, the SNM innovation team was able to design and demonstrate an effective automated system tailored to address the identified challenges in the SNM store. The system, based on a commercially available KUKA mobile platform with an integrated KUKA arm, was able to navigate the store independently and utilise extraction, shielding removal, manipulation and inspection capabilities to facilitate a safe, streamlined package handling process into SAFKEG containers.

The outcome of the project was a global first in nuclear sites, a system that demonstrated a feasible method for exporting packages without human intervention. Upon deployment within the SNM value stream, this innovation promises a notable decrease in operator exposure, enhanced safety through reduced manual handling, increased package processing capacity and minimised risks of damage and contamination. This outcome can also help with shaping future storage strategies and potentially sets the stage for safer and more efficient operations, yielding substantial savings for taxpayers and fostering a cleaner working environment for future personnel.

1/2/3. Testing the automated system in a test facility


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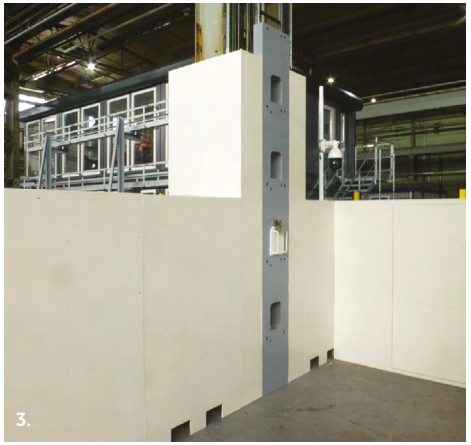
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Project

SNM automated stores, safer store working

Benefits

An automated packaging system minimises operator exposure and enhances operator safety by reducing manual handling, increases package throughput and decreases the likelihood of package damage.

This project has also provided valuable insights into project execution methodologies. By delivering the project through our innovation team rather than following traditional project procedures, we achieved a total running cost estimated at £3-5 million, compared to the likely expense of £20-50 million for a project of similar scale under traditional processes.

Current Status

The project is now entering the final stages of development focusing on developing an integrated system that encompasses the tooling and control to the main robotic platform.

Delivery Partners

KUKA, NNL

Contact Details

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NDA Grand Challenge Alignment

Automated transport of packages

As Sellafield Ltd progress our mission of safe operational clean-up, we have a requirement to provide secure storage facilities to house our SNM inventory. Legacy SNM stores coming close to their design life are due to be emptied, with the packages transferred into new purpose-built facilities. Therefore, we need to remove, in some cases repackage, and store our product packages in long-term storage facilities within the Sellafield site.

Currently, stores transfers are carried out by manually placing the product packages within vehicles that then transfer the product across the Sellafield site.

This process typically takes place using drivers under armed escort. There is a challenge in recruiting and maintaining skills for a manual method of transferring packages. Therefore, the automation of this process has clear benefit for Sellafield Ltd.

The SNM innovation team has used the Game Changers programme to perform seven feasibility studies exploring the automation of package transfers between stores on site. The objective was to identify any possible ways of automating this process, with a view to developing a solution in 3-5 years.

The outcome of the feasibility studies has shown that COTS solutions are available to deliver automated transport of SNM packages. These are already built to UK military security standards and fit within our current cyber requirements.

This 3-5 year planned project has shown that active demonstrators can be delivered within 18 months of project commencement. We are currently reviewing proposals for concept studies with the aim to deliver a demonstrator capability in 2025.

1. Example of a COTS automated transport system that was identified as part of initial gamechangers feasibility assessments

Project

Automated Transport of SNM Packages

Benefits

Benefits include:

- Reduced need for manual operations.
- Reduced cost based on wages, fuel and potentially time spent.
- Reduced logistical planning.
- Improved package monitoring during transports.
- Increased operational capability.

These benefits can also be deployed across the Enterprise, as sample transport and logistics is an agnostic challenge with a variety of possible use cases.

Current Status

Feasibility studies completed, currently reviewing proposals for concept studies to deliver demonstrator capability in 2025.

Delivery Partners

Digital Concepts Engineering Ltd, IDV Robotics Ltd, NNL

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NDA Grand Challenge Alignment

Handheld surface quality measurement

SNM packages must be inspected to better understand their condition, inform business decisions and ensure compliance with the regulator's requirements. Currently, packages are assessed by visual inspection and a digital camera. However, this does not quantify the size and depth of some features that are found on packages, such as scratches, pitting corrosion or dents, which need to be understood to comply with the inspection criteria documented by our alpha containment group.

To resolve this, a COTS piece of equipment called GelSight Mobile™ was identified with the ability to analyse surface features and provide measurements to help inform decisions for the continued storage of these packages. This handheld equipment enables quick analysis and can be moved between different stores within a facility.

The technology uses an elastomer that distorts to the shape of the feature, which is illuminated by six light sources inside the device. An image is captured that is later analysed by the GelSight Mobile™ software. Each of the light sources is activated in turn and an image is captured for each. The software interprets these six images to give a 3D model of the surface.

To determine if GelSight Mobile™ was sufficiently accurate and practical to use, testing was carried out with NNL to compare it against another metrological device called the NANOVEA optical profiler. The NANOVEA profiler is an accurate profilometer, however, it is a large benchtop device which would be impractical to implement onto plant.

For this testing, dummy cans (inactive test packages) with scratches, pits, through holes and dents of various sizes were supplied to NNL for comparison between GelSight Mobile™ and the NANOVEA metrological device. This gave example test pieces which are representative of real SNM packages in storage. From the testing, NNL found that the GelSight Mobile™ was quicker in capturing and analysing the data, simpler to operate and more portable than the latter. While the data from the GelSight Mobile™ did not always perfectly match the Nanovea measurements, they were generally in good agreement.

The testing has provided confidence that GelSight Mobile™ is a viable solution to fill the gap in our capability. Work to understand the requirements for implementation on plant is reaching completion. It is expected the output will give confidence to purchase and deploy the GelSight Mobile™ system.

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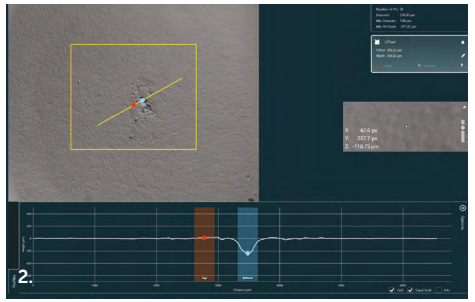
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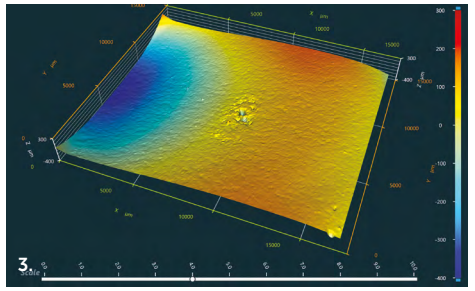
3.

1. GelSight Mobile™ Shock Protected Edition

2. Pitting corrosion analysis on SNM package

3. 3D render of pitting corrosion on SNM package

Project

SNM package inspection

Benefits

Using the handheld GelSight Mobile™ system on the Sellafield site will provide quantitative data to inform business decisions regarding the condition of packages. The new system provides quick analysis of package features, resulting in minimal dose penalty and is extremely portable, so easy to move between SNM stores.

GelSight Mobile™ provides cheaper, quicker analysis (minutes vs weeks), than the current method of determining the depth of features on packages.

Current Status

The use of the GelSight Mobile™ device has satisfied the cyber security and safety case requirements on site. Our next steps include internal assurance and, if successful, the purchase of the system and active testing in SNM stores on live packages.

Delivery Partners

NNL

Contact Details

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NDA Grand Challenge Alignment

Residues disposition strategic review

There are around 9,000 packages of plutonium residues at the Sellafield site which are by-products arising from UK reprocessing and fuel manufacturing activities. These residues are a physically and chemically diverse subset of our total plutonium inventory and are beyond economic recovery. Therefore, they need to be disposed of as waste to the GDF.

The purpose of this project is to identify and develop viable waste processing routes for all plutonium residues with the goal of reducing the associated safety and security hazard posed by this material as soon as reasonably practicable. To achieve this, a strategic plan is required for the full lifecycle of residues disposition, which includes transport from current stores, characterisation, waste treatment and packaging, interim storage, and final transport to the GDF.

This is a significant challenge and so far, work has been carried out in collaboration with NDA, NWS, NNL and other external organisations, as well as working across different programmes within Sellafield Ltd. The first step involved conducting investigations, consolidating, and reviewing inventory data to improve the understanding of the waste inventory and assigning the residues into appropriate waste families. Studies were carried out which identified approximately 400 packages that are suitable for managing via an existing waste route.

For the remaining packages, technical assessments of potential technologies will be carried out based on the chemical compatibility of the residue waste families, with early trials investigating a thermal route for disposition set to take place later this year.

Current work has allowed us to start formulating disposal options for all residues and start putting together a lifecycle strategic plan, expected 2024/25. Next steps include generating lifecycle process schemes, evaluating options before selecting a preferred route, undertaking technology readiness assessments and developing a programme business case.

Project

Residues disposition strategic review

Benefits

Benefits include:

- A plan to place the residues beyond reach to reduce the long-term security and management burden.
- Reduction of operational risk including manual handling and manual glovebox activities.
- Set strategic direction for the business to enable and accelerate delivery of our mission.
- Lifetime value for money.

Current Status

This work is ongoing, a programme has been initiated this year for residues disposition.

Delivery Partners

NNL

Contact Details

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NDA Grand Challenge Alignment

Brenden Wilkinson

SNM technical inspection manager

As an SNM technical inspection manager, Brenden leads the inspection programme and manages a team overseeing storage facility safety and compliance.

Having started his career on the Technical Specialist Trainee Scheme in 2010 (now known as the Degree Apprenticeship), Brenden worked towards a BEng in Plant Engineering alongside working in SNM over the course of 5 years.

Wanting to broaden his experience, he undertook factory acceptance testing as PreOps lead for the box encapsulation plant product store direct import facility for two years before returning to SNM as a technical advisor. Following three years in this role, Brenden was promoted to SNM technical inspection manager in 2021.

Brenden is responsible for ensuring package and facility safety standards are met before shipment to SRP. His role involves managing a team, while also actively engaging in inspections and addressing challenges, such as integrating new technologies into old facilities.

His team is actively looking to improve inspection capability using new techniques, such as GelSight Mobile™, featured on page 40. Over the past year Brenden has developed mentor guides to ensure his team carry out inspections in line with the ONR's License Conditions.

Brenden's current focus lies in delivering inspection programs and identifying technology to aid inspections within gloveboxes. He is driven by the dynamic and diverse working environment, facing a variety of challenges due to the wide age range of packages in Sellafield Ltd's repository.

"The most satisfying part of my job is the actual exposure I get to plant. I am able to carry out inspections, understand problems first hand and see the value that my work adds."

Peter Kinsella

Residues disposition strategy lead

As residues disposition strategy lead, Peter is responsible for leading and supporting the development of strategies for the safe and secure disposal of SNM residues.

Peter joined Sellafield Ltd in 2015 after obtaining a Master's degree in Chemistry with Medicinal Chemistry from Newcastle University. He began his career in the Analytical Services laboratories as a radiochemist, before moving to the central technical department supporting site-wide R&D projects.

After broadening his knowledge of the business during these roles, Peter returned to Analytical Services in the strategy and technical team, delivering studies for the future of low active analysis and AS residues. His current role working on strategies for all SNM residues, which started in 2023, was a natural and welcomed progression from working on the AS residues inventory.

Peter's main focus is tackling the complex issues associated with the disposition of SNM residues. This involves finding safe storage solutions for the hazardous material where no clear pathway currently exists, thereby providing innovative solutions to a crucial mission.

Peter became a Chartered Chemist with the Royal Society of Chemistry in 2019. He has also chaired the local Cumbria Royal Society of Chemistry section organising informational talks, school and outreach activities and influencing Science, technology, engineering, and mathematics within the local community.

"This work will take decades to deliver and it's exciting to be involved with and have an impact on something so early in its lifecycle."

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 Retrievals East River facilities also support wider site-led nationally important missions now and in the future.

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 (LfE) 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 requirements.
- Developing 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.
- Pursuing opportunities to enhance mission delivery.

Sludge mixing and transfer systems development

To reduce the risks associated with the ageing First Generation Magnox Storage Pond (FGMSP) at the Sellafield site, radioactive Intermediate Level Waste (ILW) sludge is currently being transferred into several large buffer storage vessels in the Sludge Packaging Plant 1 (SPP1).

The Sludge Handling & Export Plant (SH&EP) has been proposed to reduce the hazard associated with the sludge by receiving it from SPP1 and conditioning/ treating it into a form suitable for safe interim storage and ultimately geological disposal.

The sludge is a heterogenous mix of corroded Magnox (fuel cladding) and spent fuel. The wide range of particles sizes (nanometres to millimetres) and particle densities results in varying rheology and settling behaviours which makes the design of a sludge transfer and handling system difficult.

SH&EP is currently in the early front end definition stage and evaluating three diverse sludge treatment options, with a range of technologies and engineering approaches to hazard reduction. This requires an effective method for identifying key knowledge gaps to enable opportunities for early learning and design maturement. A 'product' based planning approach was adopted and developed to produce a robust technical and engineering development plan.

One of the major knowledge gaps and challenges to overcome is around the design of the sludge mixing and transfer systems, a key part of the SH&EP programme, which includes:

- Solids deposition and potential for blockages in pipework during transfer.
- Flushing out and cleaning pipework to prevent accumulation.
- Re-suspension and agitation of settled sludge solids in vessels.

Integrated teams, bringing together our technical experts and engineers, along with supply chain delivery partners, were appointed to deliver the structured and phased development programme. The programme consisted of a mix of initial desk-top assessments, use of both scaled and full-scale development rigs and, where possible, incorporation of COTS equipment.

The development programme and trials for the sludge mixing and transfer systems were successfully carried out at multiple sites under supply chain arrangements. Some of the key learnings and demonstrated outcomes were:

- Suitability of pumps, and an understanding of their performance parameters.
- Dilution system control to prevent material deposition in pipework and potential blockage.
- Line flushing systems to keep pipework clean.
- Viability of using a traditional agitated vessel through small scale agitation trials provided confidence to invest in larger scale detailed trials to provide more data.

Products

Specialist products / physical items to be generated by the project (e.g. plant / buildings, areas, systems).

Work

Project activities required to define and deliver planned products (e.g. planning, design, analysis, specification).

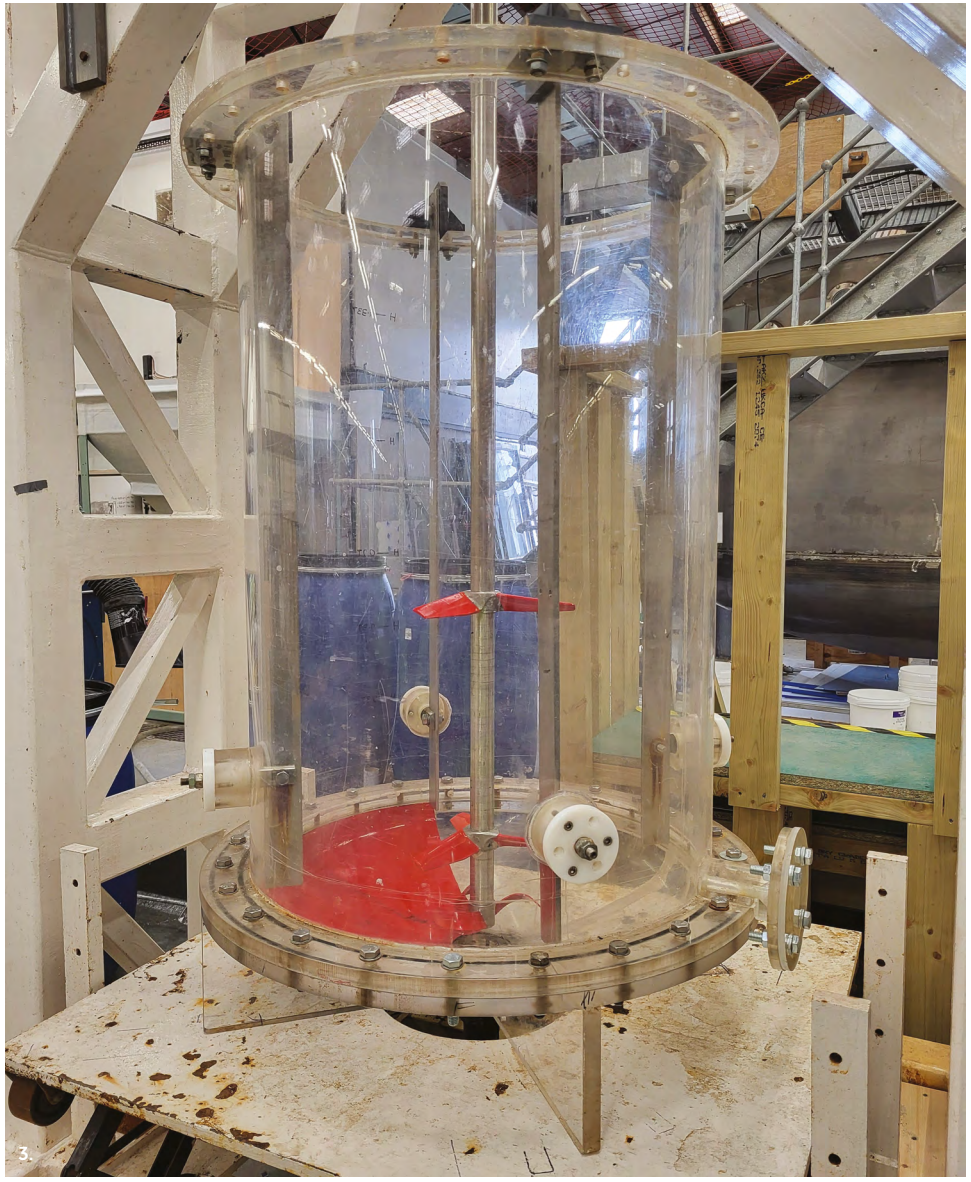
Scope

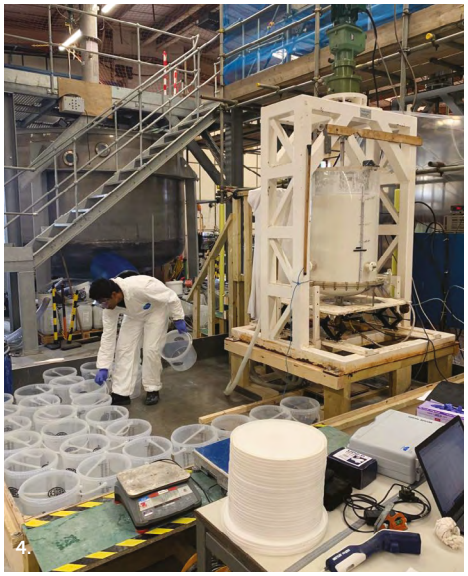
1.

2.

1. Approach to the project

2. Peristaltic pump rig. This is a COTS item and is the preferred container filling pump in the SH&EP process.





3. The clear Perspex 0.6m diameter agitation vessel and agitator configuration in readiness for the small scale agitation trials. The red painted sections are to check for erosion of the agitator impellor and dish end of the vessel once agitation testing is complete and the tank is drained.

4. Small scale agitation testing under way with test materials charged to vessel

NDA Grand Challenge Alignment

Project

SH&EP technical and engineering development programme

Benefits

The sludge mixing and transfer systems is just one part of the overall technical and engineering programme. Demonstrating the viability of the SH&EP process through trials for handling and conditioning an increased concentration of sludge solids will reduce the number of product packages that will be generated for storage and disposal.

This programme provides the underpinning and technical and engineering risk mitigation to enable the initiation of the SH&EP project with greater delivery certainty and confidence.

Current Status

Technical experts will be working with engineers to translate the R&D learning into engineering proposals and underpin plant design. Further trial programmes for the conditioning/ treatment technology options are about to commence.

The output will support the overall option down-selection and preparation of a business case for approval in September 2025 to support major project delivery.

Delivery Partners

Framatome Ltd, Jacobs,
The Decommissioning Alliance

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Camera inspection and SONAR development

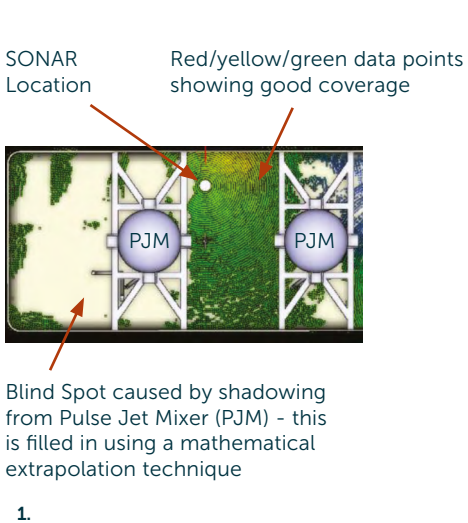
SPP1 has three Buffer Storage Vessels (BSVs) which are currently receiving and buffer storing sludge from FGMSP. There is a need to understand the sludge characteristics and volume uptake within SPP1.

SONAR equipment installed within each BSV is used to determine the settled sludge profile and total volume taken up by sludge. However, the SONAR has limited coverage within each BSV due to the limited number of SONAR devices and shadowing caused by internal furniture. When shadowing occurs, extrapolation between datapoints is used to fill in the gaps. Furthermore, it was also uncertain how accurate the SONAR measurements were in areas with good coverage.

Camera inspections were proposed to provide visual confirmation of the settled sludge bed relative to known items within the BSVs. These images can be compared against the SONAR measurements to determine its accuracy.

The NNL camera inspection team carried out camera inspections in SPP1 utilising maintenance ports within the BSVs. This work has resulted in the validation of SONAR measurements in well-covered regions and provided insight into those with poor SONAR coverage. Consequently, it has enhanced comprehension of sludge profiles in these regions, as well as understanding the accuracy and limitations of SONAR extrapolation techniques.

SONAR scans and camera inspections will continue to take place periodically as SPP1 continues to fill with sludge and operations are conducted to flush equipment that is submerged by sludge.



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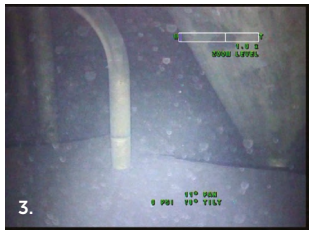
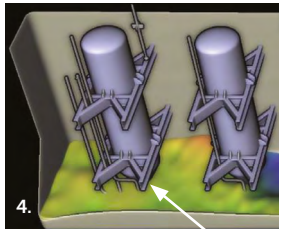
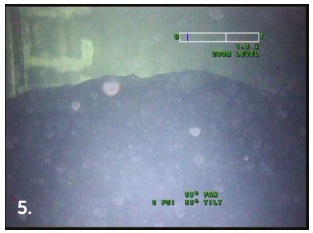
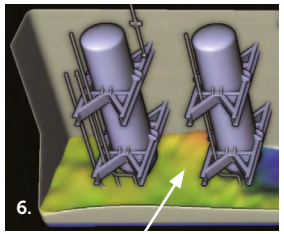




Camera view





Camera view

1. Representation of SONAR coverage

2. Tank when empty

3. Tank with settled sludge

4. Most recent SONAR scan. Craters in the sludge bed around PJM nozzle were not picked up by SONAR.

5. Mound of sludge against wall

6. Mound is picked up by SONAR shown in red. This provides confidence that SONAR can pick up contours in the sludge bed in areas with good coverage.

Project

SPP1 camera inspection and SONAR development

Benefits

SONAR has provided the ability to determine the volume and profile of sludge remotely and reliably, whilst camera inspections have provided the necessary data to validate the SONAR results and improve the extrapolation techniques.

The camera system cost approximately £12,000 (+~£5,000 per camera inspection) which has provided significant return on the investment to validate the SONAR system in SPP1, which cost in the region of £2-3 million.

Current Status

The work is ongoing – SONAR scans take place every 6 months and camera inspections are performed on an ad hoc basis as required.

Delivery Partners

Fortis Remote Technology, NNL

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NDA Grand Challenge Alignment

Enhanced waste characterisation process

The Pile Fuel Cladding Silo (PFCS) is a nuclear waste legacy facility located at the Sellafield site. In 2023, PFCS achieved a significant step forward in high hazard risk reduction by safely retrieving and disposing of waste from Compartment 5 into the first waste container. Following this, the waste container was sent to the Box Encapsulation Plant Product Store for buffer storage, pending future treatment.

Waste characterisation is required to assess the safety of treatment, conditioning, and storage of waste packages. Therefore, the PFCS plant-facing technical team were tasked with proposing a method for characterising the waste removed from the PFCS, aiming to help inform future decisions around managing the material.

The team developed the Enhanced Waste Characterisation Process (ECP) to characterise the waste retrieved from the legacy compartments within the PFCS. The ECP uses a "best endeavours" approach to obtain physical, chemical, and radiological data of the legacy nuclear waste before disposal into modern 3m^3 waste containers for buffer storage.

The ECP captures observational data (i.e., visual identification of the waste and its physical properties) by analysing CCTV footage from the retrieval and filling process of the waste containers. The ECP also obtains key data from PFCS retrievals operations by the consignment form, operator's logs, Sellafield Ltd personnel, and the Waste Container Inventory Assignment Toolkit, which estimates the radionuclide inventory for each waste container.

The result of the project was the generation of a Waste Package Enhanced Characterisation Record. This provides a clear summary of key inventory information for each waste package and contains relevant information for the waste package disposability records. The PFCS plant-facing technical team continuously assess the fidelity of the process to meet the needs of the programme and stakeholders.

Project

PFCS early retrievals programme

Benefits

The PFCS waste characterisation process supports disposal resulting in financial and resource benefits to Sellafield Ltd in the future.

By carrying out thorough characterisation at the outset of waste remediation, it can be ensured that the waste is correctly managed, thereby maximising storage capability and minimising future workload.

Current Status

The early retrievals programme is focused initially on retrieving the waste from Compartment 5 as it is representative of a wide cross section of waste types. This will allow the techniques and processes to be developed, optimised and applied to other compartments.

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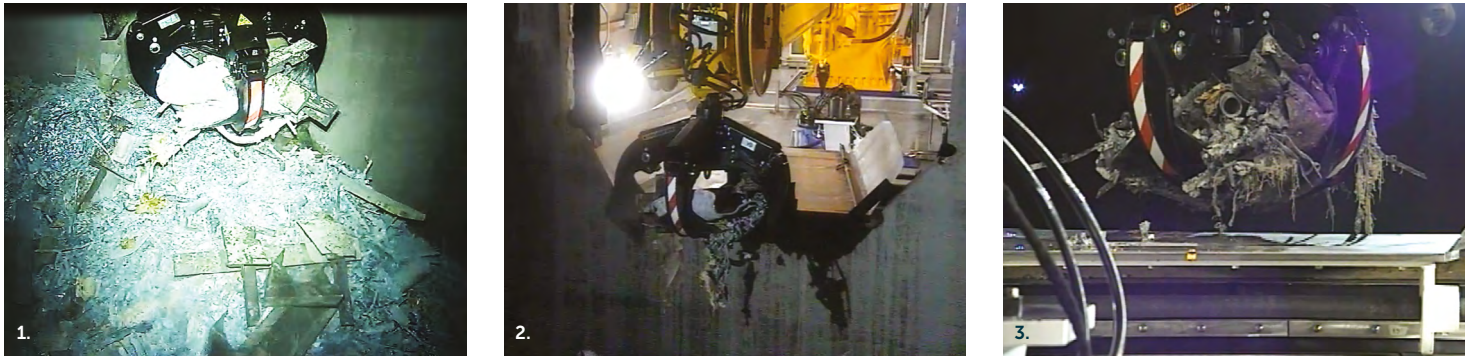
NDA Grand Challenge Alignment



1-3. CCTV images of PFCS retrievals operations

Finding and addressing leaks

The Magnox Swarf Storage Silo (MSSS) building is known to have several leaks present. It is important that the leaks are detected and dealt with to avoid further contamination and aid in recovery operations. Three of the several projects initiated to tackle these challenges are described below.

Crack monitoring in concrete

This laboratory demonstration used laser interferometry, an effective tool for assessing the integrity and safety of composite structures because of its high accuracy, non-destructive nature, and ability to provide detailed information about surface deformations.

It is based on the principle of interference of light waves, where a coherent light source is used to illuminate the surface of the object being tested. The reflected light from the object interferes with the incident light, producing a series of bright and dark fringes that correspond to the surface deformation of the object.

Detect groundwater anomalies

This laboratory and modelling demonstration featured both distributed sensing and active-distributed temperature sensing technology to detect groundwater plume thermal anomalies and flows via blind tube deployment. This work supports the autonomous detection of leaks within MSSS and was carried out in collaboration with the University of Birmingham. The project included data collection from blind tubes on site, and the outcome was a fully functional experimental test-rig, simulating heat transport in sandy porous media around two different types of blind tubes.

Sealant particles to stop leaks

Leak Armour explored the use of sealant particles to stop or slow down known leaks. A laboratory demonstration to block leak paths was carried out using MAGNOX sludge simulant with a viscosity modifier. The gel sealant was demonstrated to significantly reduce the flow in the test rig, with a further set of tests required to refine the process of creating leak paths in the sludge substrate to better replicate the conditions found in MSSS. Optimising the gel sealant can be undertaken in parallel with the leak path work in the future.

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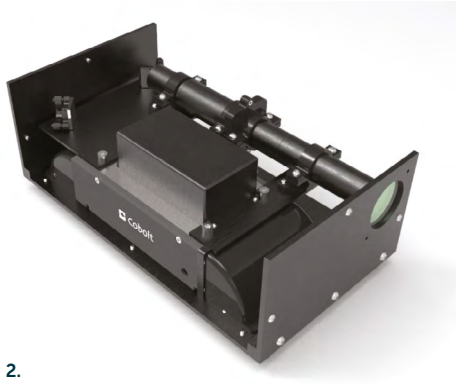

2.

Project

MSSS leak management project

Benefits

Enhanced leak detection and management will minimise ground contamination and offer cost savings by reducing the resources needed to address issues post-occurrence.

Current Status

All three projects have completed proof-of-concept. Further testing is required in the leak sealant project to better recreate conditions in MSSS and optimise the solution.

Delivery Partners

Laser Optical Engineering Ltd, Steer Energy, University of Birmingham

Contact Details

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NDA Grand Challenge Alignment

1. Leak Armour testing

2. Laser interferometry equipment for crack monitoring

Ground monitoring

There is a requirement at the Sellafield site to monitor both the ground and groundwater to identify any potential contamination and enable targeted remediation efforts.

Conventional groundwater monitoring techniques typically rely on a snapshot 'spot monitoring' approach, which may not fully represent conditions. This may limit understanding of overall contamination distribution and transport, leading to inefficient remediation. Our current method of monitoring strontium-90 contamination in the ground only measures gamma radiation, providing limited functionality.

Therefore, two projects were carried out to investigate alternative methods for monitoring materials in the ground and groundwater.

The first project, ABACUS, uses ruggedised hardware and bespoke data analysis techniques to measure levels of strontium-90 contamination in the ground. Contamination levels are calculated by measuring the bremsstrahlung radiation that is produced by strontium-90 particles around the edges of boreholes and blind tubes. This is a promising step towards being a viable operational instrument replacing existing hardware in use on site.

ABACUS has been validated in a laboratory setting and the next phase is to conduct a demonstration in an active site to validate its use and further develop the state-of-the-art bremsstrahlung signature-based strontium-90 measurement technique.

The second project, Gutteridge Haskins and Davey (GHD) flux estimates, were developed to measure the movement of groundwater contaminants (chlorinated solvents and radioactivity) dissolved in groundwater using the existing boreholes at the Sellafield site. The passive flux meter technology was deployed at boreholes at the Sellafield site and was able to report the rate of movement of contaminants, as well as the time-averaged groundwater contaminant concentrations. This is beneficial as it allows us to better:

- Understand potential future remediation requirements
- Measure current management performance
- Manage environmental liabilities more effectively
- Calibrate existing groundwater models.

This technique, coupled with the use of innovative, simple, disposable devices left in-situ within groundwater and optimised to specific contaminants of concern, has the potential to provide estimates of groundwater and contaminant flux using the existing borehole network at the Sellafield site.


1.


2.

1. ABACUS equipment

2. Flux meter

Project

MSSS leak management project

Benefits

Improved monitoring of material in the ground and solute transportation through groundwater will result in better informed remediation decisions and an improved management of environmental risks.

Current Status

The passive flux meter technology was successfully tested on site, receiving accurate repeatable readings.

ABACUS has been successfully tested in a laboratory, but the device has not yet been integrated into a unit compatible with use in a borehole for in-field testing.

Delivery Partners

Gutteridge Haskins and Davey Ltd, Hybrid Instrument Ltd.

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NDA Grand Challenge Alignment

Test rig for condition monitoring and inspection

To ensure waste packages within the ILW stores are evolving as predicted, CM&I is required. A crane-mounted system provides the benefit of enabling inspection during each stage of the packages' lifecycle; from filling, to monitoring, and finally emptying of the package.

RED Engineering was awarded a contract to manufacture and test a prototype of an integrated crane-mounted inspection system. The system is designed to perform dimensional inspection, detailed inspection, and thermal imaging using various technologies such as Digital Image Correlation (DIC), DSLR cameras, and FLIR Boson cameras.

During proof-of-concept trials at RED Engineering, collaboration opportunities emerged with multiple supply chain partners to aid in development of other CM&I technologies, including:

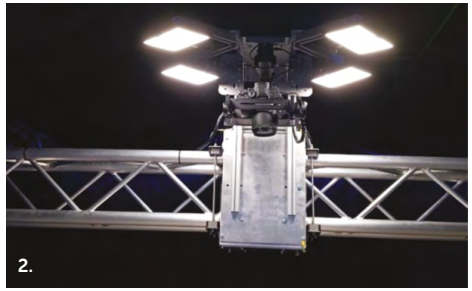
- Fraunhofer's successfully demonstrated capability for in-situ monitoring of hydrogen, which detects concentrations dissipated through filters on storage boxes (see page 36 of the Annual R&D Review 2022/23). Testing the technology at RED Engineering allowed for a more realistic scenario, bringing the technology a step closer to deployment on plant.
- The University of Strathclyde investigated the use of hyperspectral imaging to detect salt deposits and package damage. Demonstration trials were undertaken at RED Engineering on the test rig, with results currently being analysed.
- Finally, National Physical Laboratory (NPL) provided guidance on camera setup requirements for DIC and contributed to its development. Future plans involve further integration of DIC with NPL and completing the system's functional specifications for a deployment prototype, followed by commissioning trials.

Overall, these collaborations advance the development and feasibility of the integrated CM&I system for deployment in industrial settings.

1. Hyperspectral Imaging collaborative trials with RED Engineering and Strathclyde University

2. Integrated Crane Mounted Camera System DSLR detailed camera set up

3. Ranged Resolved Hydrogen Detection collaborative trials with RED Engineering and Fraunhofer. Green line shows laser level.



Project

Condition Monitoring & Inspection

Benefits

This project enables us to work collaboratively with several research institutions and engineering firms to expand our understanding of the technology capabilities and test them on a purpose-built rig.

The test rig enables the technologies to progress closer to plant and the collaborative utilisation of the test rig has enabled cost savings across these other technologies.

Current Status

Ongoing development and implementation of technologies to support CM&I.

Delivery Partners

Fraunhofer Centre for Applied Photonics, NPL, RED Engineering, University of Strathclyde

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NDA Grand Challenge Alignment

Colin Milton

Strategy & technical manager

Colin supports the technical underpinning of the SH&EP project and is responsible for sustaining engagement between the project, the legacy ponds programme and Sellafield strategy, working closely with the Retrievals value stream strategy lead.

Colin graduated from the University of Leeds with an MEng in Chemical Engineering and is a Chartered Engineer with the IChemE. He has worked in multiple roles within the nuclear and petrochemical industries, with a significant part of his career spent at the Eastman Chemical Company in the polymers business stream.

Colin began his current position as the strategy and technical manager for the FGMSP and SH&EP projects in 2015. From a technical perspective, Colin ensures that the technical and engineering development programmes for SH&EP are robust, filling any knowledge gaps and providing the underpinning information required by engineers, designers and safety/environment teams to progress the SH&EP configuration and design.

This year Colin has focused on completing the remaining key trials for the SH&EP appraise and select stage, as well as compiling the learning from the technical and engineering development programmes into key position statements (see page 44).

The most rewarding part of the role for Colin is interacting with the great people that he works with and the continuous learning environment regardless of experience level.

"Change is good. Innovating and finding better ways to do things is what I enjoy at Sellafield Ltd."

Sarah Bibby

Legacy ponds programme technical manager

As technical manager of the legacy ponds programme, Sarah is involved with finding solutions to the complex technical challenges associated with retrieving and storing waste from the legacy ponds.

Sarah completed her BSc in Chemistry at Manchester Metropolitan University in 2007 before working in various R&D roles linked to precious metal refining and catalysis. She joined Sellafield Ltd in 2014 as a technical specialist in THORP, supporting operations and reprocessing for 5 years before moving to central technical as the IRT lead for POCO.

In 2020, Sarah wanted to take on more responsibility by becoming the decontamination Centre of Expertise lead and moved to Remediation to manage the decontamination technical team. She has also undertaken secondments into operations and strategy roles including POCO transition manager and Retrievals strategy manager.

Her primary responsibilities are managing teams of technical experts, developing new technologies, and ensuring alignment with programme goals. Sarah enjoys addressing technical challenges, particularly related to retrieving fuel from legacy ponds and managing material in older facilities. Older facilities are very different to more modern plants like THORP, so it is important to understand their history and challenges.

Since joining Sellafield Ltd, Sarah has completed a Master's degree in Material Science, become a chartered chemist and is currently part of the Sellafield senior coordinator team for chemistry, supporting the professional development, mentoring and assessment of chemists.

"I strive to get the best out of individuals, to provide a different way of thinking and to offer different solutions to challenges."

Dr Julio Vazquez Chavez

Senior technical advisor

In providing technical support to the PFCS plant-facing technical team, Julio helps to ensure accurate characterisation of waste and proper inventory assignment during waste retrieval and packing processes.

After completing his Bachelor's degree in Chemical Engineering at Texas A&M University, Kingsville in 2013, Julio began his professional career as a non-destructive testing field inspector in the Oil and Gas sector. The following year, he co-founded a domestic and industrial chemical manufacturing company called JUMASA, whilst continuing to work within different roles in Oil and Gas.

In 2016 Julio began a Master's degree in Material Science and Engineering at the University of Leeds, followed by a PhD in Nuclear Reprocessing. After completing his PhD in 2023, Julio joined Sellafield Ltd in his current role.

Julio's primary focus at Sellafield Ltd has been helping to optimise the huge PFCS waste retrieval and storage operation. His work has included creating waste characterisation records to ensure that the process is fit for purpose for interim storage and future disposability. His role has also provided him with the opportunity to innovate, notably working on reassessing the fundamental needs of the program for waste characterisation.

Julio has enjoyed the continuous learning required in his role with the plant-facing technical team, as well as tackling unprecedented challenges due to the nature of the job in PFCS.

"I am driven by the knowledge that my job contributes to the high hazard and risk reduction of the Sellafield site, and strongly believe that nuclear decommissioning will be one of the greatest achievements and legacies for humankind."

Kane Harper

Graduate mathematician

As a graduate mathematician in the Retrievals strategy team, Kane is responsible for using statistical analysis to support and underpin ongoing strategic assessments to drive down the financial impact on the business and the taxpayer.

Kane completed his BSc in Mathematics and Computer Science from Lancaster University in 2023. Since joining the Sellafield Ltd graduate scheme in October 2023, Kane has been working on statistical analysis of waste generation profiles to refine and underpin technical assumptions for future legacy waste storage capabilities. The goal of his work is to reduce the engineering requirements of the operations carried out on the Sellafield site, and as a result lower the associated cost.

He has used novel mathematical tools to provide greater technical underpinning of the strategic goals of the value stream. Kane's successes are driven by the integral and ongoing support from his colleagues in the Retrievals strategy team, as well as the wider Retrievals strategy & technical team, encouraging professional and personal development in a challenging, but friendly environment.

Moving forwards, Kane will be seconded to another part of the Enterprise to develop a broader technical understanding and implementation of mathematical modelling and AI. He will then return to Retrievals and use this skillset to further improve and refine how the value stream and company can deliver our strategic objectives.

"My role uses my technical skillset to help drive innovation, whilst also exposing me to the broader Enterprise and senior stakeholders."

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 improving operator working conditions.
- Tools and techniques for the removal of plant and equipment.
- Surveillance 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 (ILW).
- Developments in demolition techniques.
- Land remediation technologies.
- Waste disposal and records.

The Remediation technology & innovation 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, aligned with each delivery area (initial decommissioning, final decommissioning and solid waste).

Monitoring strontium using antineutrino detection

There is a need for new long-term, wide-area monitoring of fission product contamination that has entered the ground. Currently, expensive point sampling via boreholes, requiring a team of samplers, is used. This potentially exposes them to industrial and radiological hazards. Antineutrino detection offers a new remote monitoring method.

In a radioactive beta decay, a neutron changes into a proton with the emission of an electron plus an antineutrino. The electron (beta radiation) is quickly absorbed by any shielding before causing harm and cannot, therefore, be detected. The antineutrino, however, passes easily through all matter with little interaction. This ghost-like particle can be used to monitor the process of shielded beta activity.

Antineutrino physics is well understood by the scientific community and is routinely studied at such facilities as CERN. However, it has only recently become sufficiently reliable that it can be used for nuclear monitoring. Several groups around the world have used it to study operating nuclear reactors. The next step is to apply it to the monitoring of nuclear waste and material.

The detector, a solid scintillator with fibre optics, photomultipliers and sophisticated trigger electronics, is self-contained. It is housed in a half-height shipping container with all supporting equipment and requiring only a standard main power supply. Data can be downloaded remotely and the system can be maintained by non-specialists, with only the occasional specialist visit for maintenance.

The technology is particularly well suited for long-lived high-energy beta decays. These are often key in radiological impact studies. Strontium-90 is a good example, and we have concentrated on this material due to its significance for long-term site management. It is also applicable to the monitoring of similar material that is heavily shielded, whether in temporary storage or final engineered disposal.

The detector has recently been deployed on the Sellafield site to monitor an isolated shielded source of known inventory as a verification exercise. It will then be deployed to monitor material in more challenging geometries. As part of the Game Changers project, a parallel exercise on its long-term commercialisation has been conducted.

Project

Anti Neutrino Detection with VIDARR

Benefits

An antineutrino detector offers long-term monitoring of nuclear waste with improved accuracy, efficiency, and cost-effectiveness. It offers safety benefits, low ongoing costs, and potential for 3D imaging.

Initial deployment will cost approximately £1m, but it can carry out a significant element of a long-term monitoring programme that is approximately double that per annum based upon a conventional approach.

Current Status

The detector was deployed on the Sellafield site in May 2024 to monitor an isolated shielded source as a verification exercise. It will then be deployed to monitor material in more challenging geometries with an emphasis on sub-surface monitoring.

Delivery Partners

FIS360 Ltd, University of Liverpool

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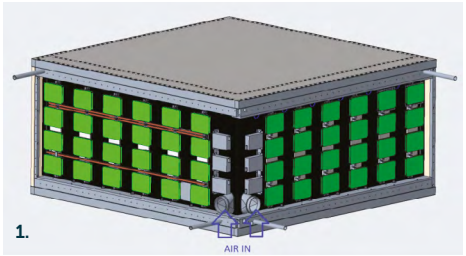
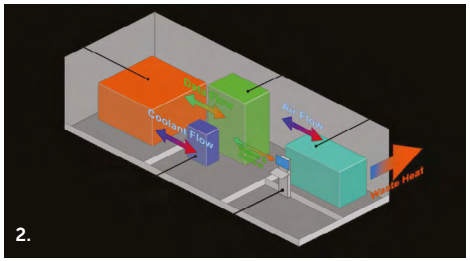
NDA Grand Challenge Alignment





1. The detector without radiation shielding and outer skins, showing the digitiser electronics (green), insulation of the inner cavity (black) and connectors for air/liquid cooling

2. 3D view of the VIDARR container laboratory, showing the layout of the contents, the four main zones, and associated heat flow

Improved radioactive waste analysis

Model Free Characterisation (MFC) is a new and innovative technique developed by Cavendish Nuclear to perform radioactive waste analysis. The MFC technique has the potential to improve radioactive waste analysis of items with complex geometries (such as those present in storage ponds) for the Sellafield site, as well as the wider NDA estate.

When performing waste characterisation, a 'model' is nearly always necessary to convert the signal measured into the activity present. Constructing the model itself can be a time consuming process. In most cases, the time taken to develop the model and to perform the analysis is far longer than the time taken to perform the measurement of the item itself.

The existing technique for this type of measurement is to use High Resolution Gamma Spectrometry (HRGS) and In-Situ Object Counting System (ISOCS). This requires complex computer models to be produced detailing material types, densities, or phyiscal dimensions of the item to convert measured count rates into activities. The production of these models is expensive, time consuming, and requires a specialist technician of which there is a shortage.

However, MFC requires no knowledge of the physical construction, such as material types, densities, physical dimensions of the item to generate a model. It only requires the external 'shape' of the item and its relative location with respect to the measurement locations themselves.

MFC involves performing multiple gamma spectrometry measurements around an item. At each measurement location, the 'shape' of the gamma spectrum measured is analysed. A simple 3D 'free space' representation of the item's volume is all that is required to determine the amount of activity present.

This technique can now be used for planning purposes and the intent is to develop it further over the next 12 months to allow sentencing of waste items.

NDA Grand Challenge Alignment

Project

Non-intrusive, real time characterisation toolkit

Benefits

MFC can determine the internal activity of items without the time and expense associated with model-based characterisation techniques.

Current Status

The tool is now available for activity assessment for planning purposes. A package of work is planned for next year to further develop and substantiate this tool and allow it to be used for sentencing.

Delivery Partners

AtkinsRéalis, Cavendish Nuclear Ltd

Contact Details

Rochelle Heyhoe, Johnny Perry, Eryk Ryzko
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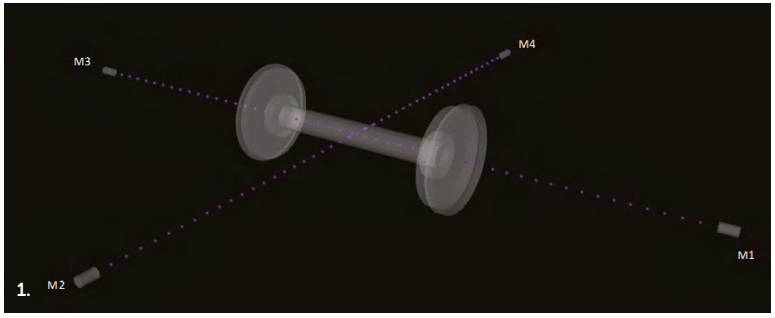
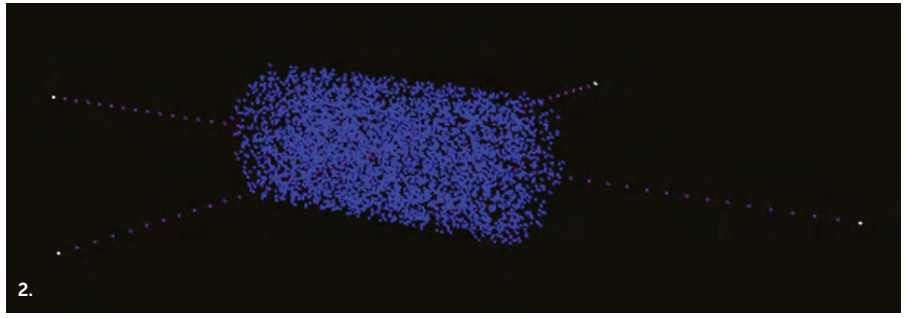
1. MFC analysis geometry showing the actual Carousel geometry and 4 measurement positions (M1 – M4)

2. MFC 'free space' model showing the Carousel represented as a simple cylinder



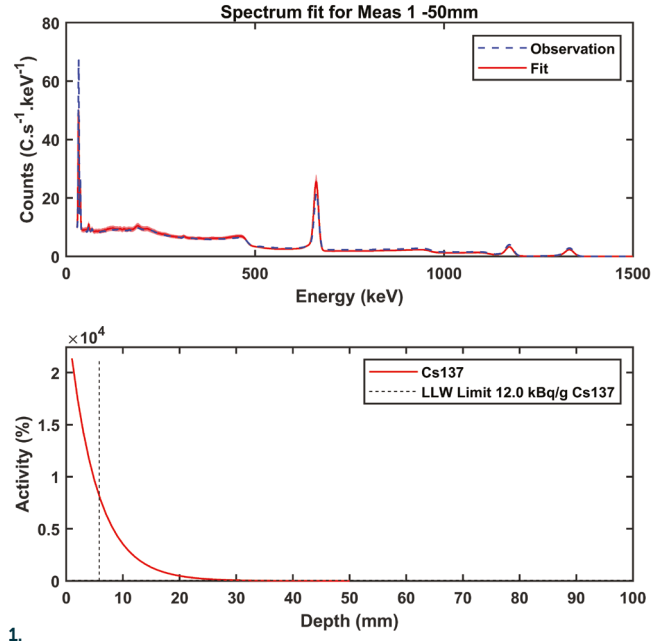


Non-destructive depth profiling of concrete

Sellafield Ltd and the wider NDA estate host a variety of concrete structures which are subject to a range of contamination scenarios. The porous nature of concrete causes contamination to be absorbed into the surface, typically to depths of a few millimetres. Contaminated concrete can have different waste categories depending on depth, presenting challenges on dose rate and waste segregation. Knowledge of how far activity has penetrated into different concrete structures will be important to decision-making and work in the future.

Non-Destructive Depth Profiling (NDDP) of concrete is a set of techniques used to determine how the activity of concrete (such as a contaminated wall) changes with depth from the surface, without the need for destructive activities such as core sampling. The technique takes advantage of different levels of attenuation of the X-ray and gamma ray spectrum of caesium-137 through concrete. Of particular interest is its use in identifying the depth of the ILW / Low Level Waste (LLW) boundary in contaminated concrete structures, to inform planning of waste segregation.

Successful trials of NDDP techniques took place from 2014 to 2018 involving Canberra UK (now Mirion), Cavendish Nuclear and Createc. This year, Cavendish Nuclear and Createc have been contracted to perform a detailed review of their methodology and a sensitivity analysis of their techniques. By gathering learning on the analysis methods used in NDDP, we will have a better understanding of their constraints and provide final confidence in using NDDP for a range of scenarios.



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3.

Project

Non-intrusive real-time characterisation toolkit

Benefits

The costs of core sampling and analysis are assumed to be £5m for ponds and wet bays. Of this, £3m could potentially be saved through the use of NDDP, which equates to a £30 million saving accounting for all contaminated civil structures on site. In addition, non-destructive, in-situ techniques save time compared to physical testing.

Current Status

Complete – NDDP can be used to support depth-profiling measurements in the future.

Delivery Partners

Cavendish Nuclear Ltd, Createc

Contact Details

Amelia Dawson
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NDA Grand Challenge Alignment

1. An example output from a D:EEP analysis showing the experimental spectra, with best fit alongside the calculated depth profile

2. The Cavendish NDDP system being deployed in FGRP in 2017

3. The Createc NDDP system being deployed in FGRP in 2017

Improved records management

Most key information generated by the Remediation value stream passes through one or more governance committees. This presented an opportunity for standardisation across committees and improvement to records management, with five key areas of the process targeted. These areas and the benefits are listed below.

- Submission of papers to committee:
  - All committees have the same arrangements making training and cover for absence better for secretaries.
  - Authors are best placed to provide metadata for a record, therefore the process of gathering metadata in support of record management is carried out when a paper is submitted.
- Secretarial management of committees:
  - Documents coming through committees are stored centrally in SharePoint, facilitating sharing and communication.
- Review of papers:
  - A question set which is utilised after the review of each record establishes the accountability for management of that record, as well as embedding the changes in process in those attending.
- Record of decisions:
  - Centralising the committee papers and outcomes in a SharePoint library allows an easy overview of the status of any records, metrics for records going through committees and the ability to follow a document as it moves through multiple committees.
- Approval, transfer of records to long term storage:
  - Connects governance with records management, utilising two key processes for short term and long-term benefit.

Four out of five of these areas have introduced automation using Feature Manipulation Engine (FME) and FME Server software, which links to our Enterprise records management system. These improvements create time and administration efficiencies within the governance process alongside standardising the process.

Project

Strategy for the management of data information and records

Benefits

Improved records management reduces the burden of effort on individuals and creates time and administration efficiencies within the governance process. By standardising the process, it improves the quality and accessibility of the data.

Current Status

The new process is currently running as a pilot with two committees within Remediation, soon to include three more. The individual committees trialling the process are providing feedback for refinement ahead of a wider roll-out later this autumn.

Contact Details

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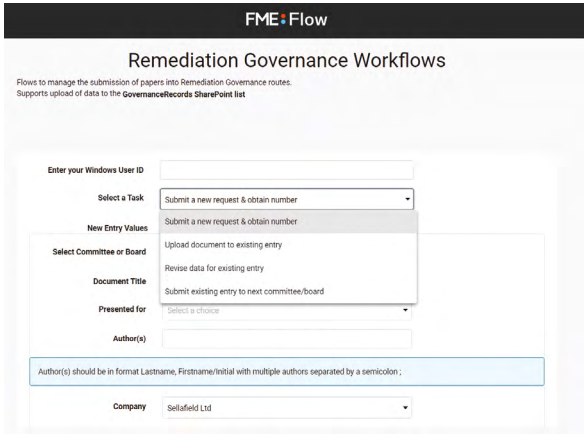
NDA Grand Challenge Alignment



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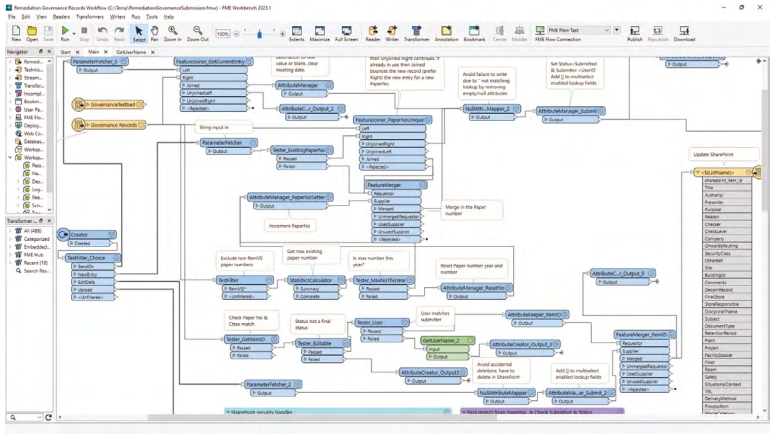

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1. FME Remediation Governance Workflows

2. FME Workbench

Decontamination of solvent residues

Operations at THORP and the Magnox Reprocessing Plant have now concluded. These facilities used organic solvents within their chemical separation processes, namely Tri-Butyl-Phosphate (TBP) and Odourless Kerosene (OK). Sellafield Ltd are aware that solvent residues remain within some vessels and pipework. If these residual solvents are not sufficiently removed, they will pose additional challenges during decommissioning due to flammability risks which require slower and more costly dismantling methods.

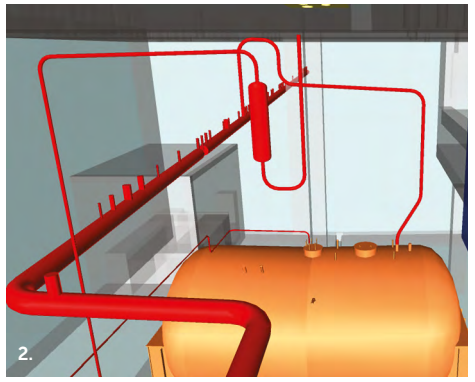
Process Decontamination Systems Ltd (ProDecon®) responded to this challenge via the Game Changers programme to develop an efficient means of residual solvent decontamination. The vessels and pipes within both reprocessing plants present unique decontamination challenges because of their limited accessibility and the limitations on effluent management and aerial discharges.

Based on the initial feasibility study results, ProDecon® were asked to complete a proof-of-concept. This started with a desktop study to assess how they could clean out the solvent stock tank at THORP, a difficult to access vessel with solvent composition and effluent routes similar to other vessels.

The team identified the V-Purge™ (vapour phase) decontamination technology, which employs a combination of steam and proprietary detergents, to be the best available technique for decontaminating the solvent stock tank. This included an assessment of the potential impact on aerial and liquid effluent routes and computer modelling of the fluid and vapour-phase dynamics.

An inactive demonstration of the V-Purge™ decontamination technology recently took place at the NNL Workington rig hall. A mock-up of the active vent line from the vessel was constructed along with the associated vent header and vent route to THORP's ventilation abatement system. The inactive demonstration showed the potential for this technology to be used during POCO to remove solvent residues from facility vessels and pipes.

1.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Project

Vapour-phase decontamination of solvent residues

Benefits

Implementing technology that removes flammable material from inside nuclear vessels and pipework prior to decommissioning significantly reduces safety risks and cost associated with dismantling those vessels.

Current Status

Proof-of-concept, including inactive demonstration, completed and now seeking opportunities for active demonstration of this technology.

Delivery Partners

FIS360 Ltd, NNL, Process Decontamination Systems Ltd

Contact Details

Lewis Drake, Chris Massey, Edward Todd
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NDA Grand Challenge Alignment

1. ProDecon® personnel and inactive test vessel during the inactive technology demonstration

2. 3D model of solvent vessel and associated vent pipework

Chris Massey

Technology and innovation manager

Chris began his current role in May 2023 and is now responsible for the development of tools and techniques to support facilities undergoing POCO.

Chris completed his BSc in Chemistry and Polymer Science at the University of Lancaster before joining the graduate scheme at Sellafield Ltd in 1989. During his time here, Chris has held numerous commissioning and operational roles within the THORP facility including commissioning team member, shift team manager and operations manager.

In 2017 he moved into a POCO preparations role to help prepare the THORP facility following completion of its reprocessing mission. Following success in this role, he transitioned to technology and innovation manager for all POCO-related facilities.

Now that the Magnox Reprocessing facility has completed its final operational rundown, both the Magnox and THORP facilities are undergoing POCO. This provides opportunities to develop and deploy tools and techniques to help with the remediation of both facilities.

Recently Chris has focused on developing chemical and electrochemical decontamination techniques to help with this task, as well as developing remote characterisation tools and long-reach deployment arms to reduce exposure risk to operators. After 35 years with Sellafield Ltd, Chris plans to retire later this year and will be focused on maintaining continuity of knowledge and passing on key learning and experience to colleagues.

"I have enjoyed developing innovative technologies to enable hazard reduction during POCO of the Magnox and THORP facilities, helping to create a safer and cleaner environment."

Francesca Laws

Technical information manager

As a technical information manager, Francesca works on the management of data, information and records for legacy facilities.

Francesca describes herself as a geographer, having studied Physical Geography at university. She joined Sellafield Ltd over 15 years ago as a graduate working in decommissioning (now the Remediation value stream). During this time, she has engaged with various areas of the business, covering a wide range of disciplines from environmental risk assessment, R&D, safety case and project management. This has given her an interesting and insightful introduction to the work and challenges associated with Sellafield site.

She utilised her physical geography skills when she moved into the land quality & end states team, supporting the technical work of contaminated land management and groundwater monitoring. During this period, she returned to university part time to study Geographical Information Systems (GIS), before eventually returning to Remediation, and starting her current role as technical information manager.

Francesca is currently supporting the challenge of building up a baseline of data, information and records for facilities operated during a non-digital age. She enjoys the technical aspect of the work as well as the customer interaction involved, engaging with people in different areas of the business to help solve their challenges. Recently, Francesca has been working on the automation of records management and opportunities to digitise legacy facilities (see page 57).

"I enjoy working with data and seeing the most made of it, using the principle of 'collect once, use many times'."

Jennifer Rochford

Characterisation technical lead

Jennifer joined the Remediation characterisation team in 2014 following completion of a PhD in the aqueous chemistry of the Sellafield ponds at The University of Manchester and has since progressed to the position of technical lead. She is responsible for characterising waste generated on the Sellafield site, ensuring the Best Available Techniques (BATs) are used alongside developing new methods to drive efficiencies.

Since joining Sellafield Ltd, Jennifer has utilised her PhD to help characterise all manner of wastes generated around the Sellafield site. Her work ensures that waste disposal guidelines and facility standards are followed and helps prevent any mismanagement or routing of waste. She also explores potential improvements to processes through the supply chain and the wider NDA estate and is hands on in testing innovative technologies.

Collaboration is central to Jennifer's work, coordinating closely with other teams and specialists, such as waste advisors, project managers, and the contaminated land team. This collaborative approach aims to ensure the effective use of everyone's effort and share relevant knowledge through developing the team where necessary to enhance the overall efficiency of operations.

Recently, she has been working with Game Changers to develop in-situ analytical techniques that aim to reduce the amount of laboratory sampling required to characterise waste. This would lead to cost and efficiency improvements while also freeing up resources within analytical teams allowing them to focus elsewhere.

Moving forward, Jennifer will continue to develop innovative techniques for waste characterisation, use data for strategic planning, and promote effective leadership within the team to ensure that all waste is successfully managed through appropriate characterisation and sentencing.

"I enjoy helping team members develop, supporting them on their journey towards leading portfolios. Seeing them excel and display the growth in their capability is an aspect of my role I truly relish."

Site Management

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

- Strategy & technical, underpinning the forward direction for the directorate to ensure the right decisions are made to support the rest of the Sellafield site.
- 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.
- Active area services, including welfare and laundry facilities.
- 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.
- E&M provision across the site.
- Site management projects, providing major asset upgrades and improvements.
- Land allocation and management including roads, bridges and car parks.
- Site logistics management for both materials and people, including on-site buses, commuter service provision and vehicle access.
- Strategy, portfolio and 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.

Site Management

70+
substations on site

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

120km
of high voltage cable

19km
of steam mains

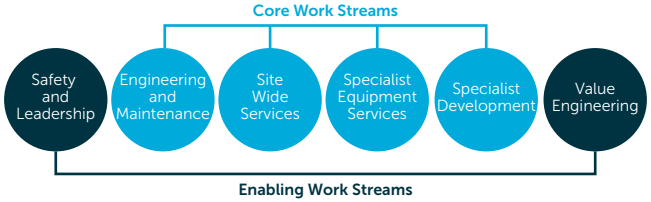
40km
of road and tracks on site

1,750m³
of sewage effluent processed every day

1,000
shipments in/out of site each year

2,000m³
domestic water supplied per day

E&M Delivery Strategy



Improved sample analysis

Analytical Services are responsible for providing analytical capability for operations on site. Going forward, a major customer requiring these services will be the new SRP.

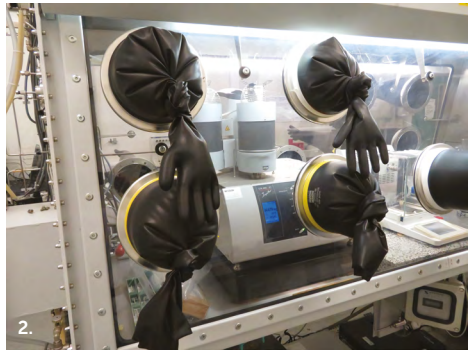
Our current analysis uses separate procedures for measuring loss on heat, moisture, carbon and chloride. By devising a method to perform all these analyses in one operation, we can conserve resources and time due to the enhanced efficiency of the process.

Analytical Services engaged with NNL to evaluate the use of combined qualitative and quantitative analysis of SNM using ThermoGravimetric Analysis – Mass Spectrometry (TGA-MS). Inactive trials of the TGA-MS system were undertaken by NNL, using materials that chemically resemble the SNM product.

The TGA-MS functions like a scale housed within a furnace that heats the sample to 800°C. Chemical contaminants are volatised at certain temperatures, identified by characteristic mass losses in the sample. The gas produced in the furnace is connected to a mass spectrometer, enabling identification of the substances volatilised. NNL were tasked with evaluating the accuracy of this new TGA-MS analysis technique in relation to established data, proving its suitability for use.

Various conditions and instrument set-ups were investigated using titanium dioxide containing Poly-Vinyl Chloride (PVC). A linear correlation was seen between the initial mass of PVC and the resulting mass spectrometer response when volatilisation by TGA-MS was performed in air, providing confidence in the quality of the analysis. Further work to improve the system could include testing carbon dioxide as a carrier gas with in-line chemical sensors alongside the mass spectrometer.

By measuring and detecting multiple substances in a single process, there is a significant reduction in waste. The TGA-MS will support the site mission of high hazard reduction and continued safe storage of the UK's nuclear inventory.



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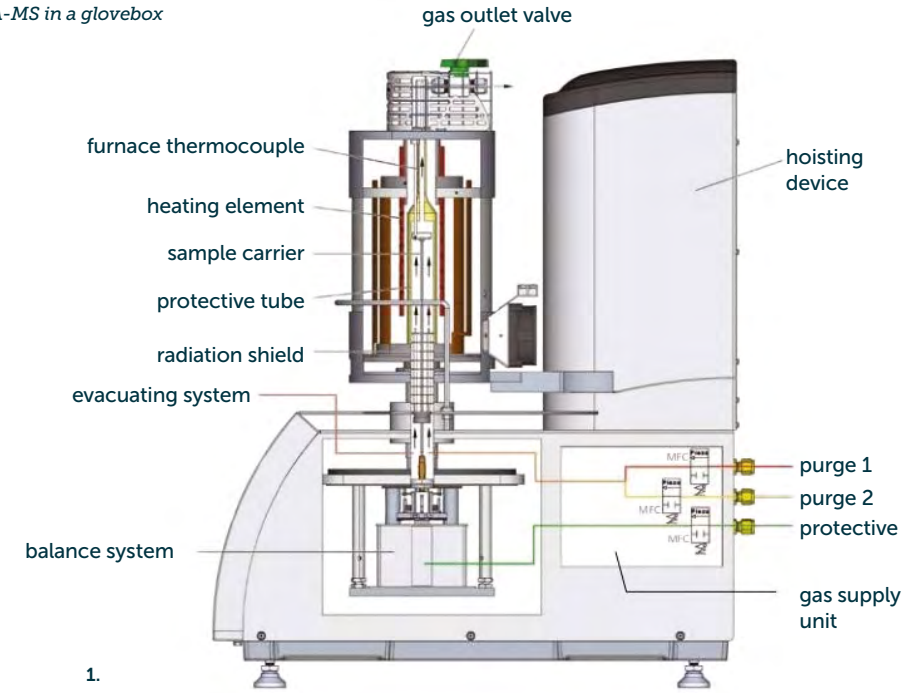
1. TGA-MS diagram

2. TGA-MS in a glovebox



1.

Project

Analytical services future states programme

Benefits

TGA-MS would reduce waste outputs and resource demands compared to current analytical methods. Less training is required for a single analytical procedure compared to the multiple analytical methods currently employed.

It also accelerates the delivery of analytical results, reducing the timeframe from 2 hours to 40-80 minutes. Incorporating TGA-MS represents an investment in new analytical capabilities for the Sellafield site.

Current Status

The evaluation of TGA-MS for qualitative analysis of volatile gases on in-active trials is complete. Expected future work is the commissioning of the active instrument in NNL Central Laboratory within a glovebox to enable testing with SNM. This is anticipated to start in 2024/25.

Delivery Partners

NNL

Contact Details

John McQuirk
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NDA Grand Challenge Alignment

Reduction of hydrofluoric acid use

Hydrofluoric acid (HF) is an extremely hazardous chemical that can cause serious injury or even death on contact, particularly in its concentrated form (≥40%). HF is used in several processes in the Analytical Services laboratories, so eliminating or reducing its use where possible would reduce handling risks to operators.

A review was carried out to identify processes where HF is used, and whether there were opportunities to reduce or eliminate it. HF has properties which make it uniquely useful for certain applications, and in some cases removing or replacing it in processes is not possible. However, one major opportunity for elimination was identified.

HF is currently used with nitric acid for the stabilisation of effluent samples requiring radiochemical analysis. This ensures that sample integrity is maintained. Operations relating to stabilisation, handling and analysis of these samples account for approximately 92% of HF operations in Analytical Services but research on industry best practice indicates that nitric acid alone should be sufficient to stabilise these samples.

The protocol for the stabilisation of effluent bulks for elemental analysis does not use HF. Therefore, there is a significant opportunity to create a single stabilised bulk for each effluent. This would deliver significant improvements in operational efficiency and environmental impact. A single stabilisation protocol will save significant operator time (sampling, sample receipt, sub-sampling, stabilisation, bulking, training), reduce storage requirements, and remove the requirement for chemicals and consumables thus hugely reducing cost and the volume of waste.

These changes deliver long-term benefits, as when Low Active (LA) sample analysis moves into the supply chain, stabilisation and bulking of these effluent samples will continue to be completed in-house in the Sample Management Capability (SMC).

1. Staff member in personal protective equipment to handle HF

Project

Analytical services operations

Benefits

If validation is successful, the risk to operators will be greatly reduced, with continuing benefits once the analysis of these samples moves to the supply chain in 2026.

Improved efficiency of stabilisation and bulking of effluent samples will save time, cost, space, and reduce waste.

Current Status

Validation is planned to ensure no impact on the analysis methods used, and to the stability of radiochemical species in effluent samples. If successful, implementation of the changes is anticipated to be complete by August 2025.

Contact Details

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NDA Grand Challenge Alignment

Danielle Myers

Technical specialist

As a technical specialist working in analytical delivery, Danielle is responsible for providing technical support and guidance in current operations, as well as future strategies for analytical provision.

After graduating from the University of Oxford with a Master's degree in Chemistry, Danielle completed her PhD in Chemistry at the University of Manchester, focused on organic chemistry and new methods for organic synthesis.

Following this, she worked as a process development chemist at Vertellus for three years, developing and scaling up processes for chemical manufacture. This work gave her valuable laboratory experience transferable to her current role at Sellafield Ltd, which she has been doing for almost two and a half years.

Recently, Danielle has been involved in a project investigating sample integrity in AS laboratories to assess current storage methods for different samples and identify potential improvements in storage. Improving storage will help maintain sample stability prior to analysis, leading to more representative test outcomes and hence a better service for customers. Some improvements to this could also provide safety benefits to laboratory personnel, as well as improved efficiency and lower costs.

In the future, Danielle's work will focus on helping find the best way forward for near-term analysis of highly active and medium active samples.

"The most satisfying part of the job is coming up with innovative solutions to problems in order to provide the best quality analysis for our customers."

Environmental Management

Environmental management covers a broad scope on behalf of the business, in areas of high regulatory scrutiny and pace of change in relation to policy, legislation and regulatory expectations. The team sits within Sellafield Ltd's Environment, Safety and Security (ES&S) directorate and acts for Sellafield Ltd's environmental compliance and standards, and environmental monitoring and assessment both on and off site.

Environmental management forms part of the wider environmental capability which extends across the value streams and projects delivery directorate. The Environmental Permit for Radioactive Substances Activities issued by the Environment Agency (EA) places a specific requirement on Sellafield Ltd to establish a programme of R&D in support of compliance with the limits and conditions of the permit. Furthermore, the environmental permit requires a triennial review of our statutory environmental monitoring programme including:

- Detailed findings of any research on the behaviour in the environment of radionuclide discharges from the Sellafield site.
- A summary of any developments with respect to the sustainability of ecosystems and communities of wildlife species.
- A summary of any developments with respect to the radiation exposure of humans via the food chain and other exposure pathways including novel or unusual pathways.

The research detailed in this section address the first of these requirements, aiming to improve our understanding of how radioactive material that was legally discharged from historical operations on the Sellafield site behaves in the environment.

Beach monitoring

Routine beach monitoring for radioactivity has been carried out since the early 1980s. This was originally to detect material accidently released from the Sellafield site but was subsequently extended to consider a wider range of materials.

In 2006 we started monitoring beaches local to the Sellafield site with specialised vehicle-mounted equipment. The aim of the programme was to recover and characterise discrete radioactive objects from the beaches and provide assurance to the public and stakeholders. We currently survey over 100 hectares of beaches between Drigg and Allonby every year.

Since 2006 more than 3,500 radioactive objects have been recovered from the beaches. Approximately 70% were primarily alpha-rich (containing plutonium and americium) and 30% were classified as beta-rich (containing caesium-137). All recovered items were also classified by size, with 80% being particles (<2 mm in size), and the rest larger objects.

Research conducted by the UK Health Security Agency, Golder Associates and the British Geological Survey has investigated the detailed characteristics of sub-sets of beach finds. These investigations involved using scanning electron microscopy, chemical analysis, radiochemistry, gamma spectrometry and dosimetry. The results showed that alpha-rich particles were plutonium-bearing iron and iron oxides, beta-rich particles were associated with a wider range of matrices and beta-rich larger objects were primarily contaminated natural materials.

Further work by AtkinsRéalis updated the conceptual site model for beach finds, identifying that they were likely to have been released to the environment in the past and are moving in a generally northward direction along the coast, akin to the movements of natural beach materials.

A risk assessment conducted by UK Health Security Agency showed that the risks to beach users were very low and significantly lower than the typical risks that people accept when using beaches. The ongoing monitoring work aims to provide stakeholders with assurance that the risk assessment remains valid.

Ongoing research will develop our understanding of how radioactive particles in sand beds are moved by waves, through collaborating with a university-led research consortium.

2.

1.

Project

Environmental monitoring for public and stakeholder reassurance

Benefits

Improved understanding of the radioactive material recovered from the beaches demonstrates our compliance to regulatory requirements and provides assurances that the risks to the public are very low.

Current Status

The programme is ongoing and a framework contract has been awarded to Nuvia Ltd to conduct beach monitoring programmes up to the maximum contract duration of 10 years.

Delivery Partners

AtkinsRéalis, British Geological Survey, Department of Health and Social Care Committee on the Medical Aspects of Radiation in the Environment, EA, Golder Associates Ltd, NRS, Nuvia Ltd, UK Health Security Agency, West Cumbria Sites Stakeholders Group

Contact Details

Richard Hill, Peter Sanders and Laura Newsome
innovation.team@sellafieldsites.com

NDA Grand Challenge Alignment

1010
0101

1. Nuvia Groundhog beach monitoring system

2. Scanning electron micrograph of a beta-rich particle

Off-site environmental gamma monitoring

Sellafield Ltd have a duty to assess the off-site environment at locations where radioactivity, legally discharged from legacy operations, could reside or accumulate due to continually changing natural processes. Currently, ground-based methods such as personal probe surveys or vehicle-mounted platforms are utilised for monitoring, mapping, and sampling at sites like beaches and estuaries. While low-cost, simple to operate and fast to deploy, these approaches are time-consuming and inefficient when compared to now well-established aerial technologies, such as Unmanned Aerial Systems (UAS) equipped with radiation detectors.

When equipped with modern detector technology, such as large-volume solid-state scintillator detectors, this highly automated approach allows for regular repeat surveys and monitoring data collection to be performed with little or no user input, with rapid transfer into our geospatial tools for visualisation and processing.

Given the remote nature of the monitoring sites, an opportunity to trial enhanced surveying methods could be of benefit to Sellafield Ltd, its regulators/stakeholders, and enhance public awareness of environmental assurance activities.

In collaboration with the University of Bristol, this project seeks to pilot the UAS data monitoring approach at the Esk Estuary, where radioactivity distributions have been identified as requiring further investigation through analysis of data produced by the statutory Sellafield environmental monitoring programme.

Successful implementation of this approach would not only yield the desired data at the estuary, but also save time and resources in the future by reducing the need for manual input in the data collection process. Additionally, a successful outcome will further inform future decisions regarding the adoption of such systems across the organisation, potentially replacing manual data collection entirely.


1.


2.

Project

Environmental monitoring for public and stakeholder reassurance

Benefits

UAS monitoring allows improvements to radioactivity mapping within publicly accessible areas of West Cumbria. Such data is reported to the EA and reviewed by West Cumbria site stakeholder group and COMARE contaminations working group.

The use of a UAS provides significant safety and resource benefits over traditional manned surveys of the estuarine mudflats.

Current Status

This project is ongoing with initial surveys planned for Summer 2024.

Delivery Partners

University of Bristol

Contact Details

Dr Richard Hill, Dr Laura Newsome
innovation.team@sellafieldsites.com

NDA Grand Challenge Alignment

1. UAS equipped with radiation detector

2. Survey over the Ravenglass Estuary

Katherine Dumbell

Graduate environmental advisor

As a graduate environmental advisor seconded into the environmental technical assessment team, Katherine is currently responsible for assisting in the delivery, execution and justification of the Environmental Monitoring Programme. In doing so, Katherine's work will help to identify our impact on the environment, including both radiological and non-radiological effects.

In October 2023, shortly after graduating from the University of Oxford with a BA in Geography, Katherine joined the Sellafield Ltd graduate scheme. She is a graduate member of the Institute of Environmental Management and Assessment and is successfully applying her expertise to inform decisions about the Environmental Monitoring Programme.

Katherine is currently reviewing the impact of carbon-14 in the environment and how we monitor this radionuclide. This has involved reviewing published literature on carbon-14 in the environment, attending workshops with the EA, reviewing discharge data and data collected from the Environmental Monitoring Programme, as well as conversations with the laboratories that analyse our samples. This work will help determine whether the current monitoring of carbon-14 in the environment is fit for purpose, and whether any changes to the process are required.

In her first role since graduating, Katherine has felt that there has been a lot of information to take in but relishes the idea of continuing to learn about the business and do what she can to make a positive impact on the environment.

"I am motivated by a deep passion for the environment and sustainability. I want to develop my skills so that I can contribute to helping protect the environment and promoting principles of sustainability."

Dr Richard Hill

Environmental technical assessments manager

Richard is responsible for the team delivering the statutory environmental monitoring, discharge records and beach monitoring programmes in line with Environmental Permits issues by the Environment Agency. These are legal requirements and Richard's work ensures we are compliant.

Richard holds a BSc degree in Biology from the University of York, specialising in applied and environmental biology, followed by a PhD in Environmental Physics from the University of Plymouth. His professional journey began at Westlakes Scientific Consulting in 1997, where he advanced to Head of the Environmental Modelling Group before joining Jacobs in 2010 and was Divisional Director for Environmental Permitting, Air Quality, and Noise assessments.

In 2014, he transitioned to Sellafield Ltd's environmental monitoring and assessments team, focusing on developing compliant environmental assessment tools and monitoring programs. Since 2022, Richard has led the transfer of mandatory environmental monitoring programs to the supply chain.

The end of reprocessing at Sellafield Ltd has resulted in a significant change of focus for Richard's team, as the direct discharges from site operations have reduced significantly and required changes to the monitoring and assessment approaches. However, the overall dose impact of site operations has not significantly changed, principally due to past discharges. His team are now working with regulators on what this refocusing requires and how they can optimise monitoring programmes to ensure that we create a clean and safe environment for future generations.

"I am passionate about the role that the nuclear industry has in providing clean and safe energy and in ensuring that the legacy of past operations is appropriately assessed and managed to retain public confidence in our mission going forward."

Engineering Centre of Excellence

At the Engineering Centre of Excellence in Cleator Moor, West Cumbria, the team, led by Head of Off Site Developments Craig Branney, are at the forefront of solving UK nuclear industry challenges.

The centre is built on its people and its culture. The team are achieving UK nuclear world-first innovations, solving complex nuclear industry challenges, which are successfully deployed on the Sellafield site.

The way the centre operates challenges people to think about the art of the possible with a core focus on engineering problem solving. The team works directly with the supply chain to test and trial potential solutions in its safe off-site environment.

Interest in the centre's six-week Sprint projects is increasing as more people see the benefits of developing a solution along with the supply chain so it can be smoothly and successfully deployed on site.

This approach means it is able to introduce innovations and products to help achieve Sellafield Ltd's mission safer, faster and more cost efficiently. Once proven, those solutions are shared with the wider NDA estate.

The centre's location also truly opens the door to West Cumbria and enables it to deliver its own positive socio-economic impact in the wider Cumbria community.

Innovative approach to commercial partnerships

Our Engineering Centre of Excellence has been purposefully created with the mission to bring together supply chain companies with the specialist expertise of our teams in a collaborative environment to solve challenges at the Sellafield site and across the wider NDA estate.

This is an innovative approach to commercial partnerships. Every department at the centre is focused on collaboration to accelerate the deployment of safe, effective, cost-efficient, rapid and sustainable solutions to nuclear industry challenges.

Craig Branney, Head of Off-Site Developments, said: *"We are challenging people to think what is the art of the possible with a core focus on engineering problem solving.*

Like any organisation, the Engineering Centre of Excellence is built on its people and its culture - and here at our base in Cleator Moor, Cumbria we are extremely lucky to have some incredible people, achieving world-first innovations, all with a can-do attitude backed by a willingness to collaborate and a determination to succeed.

Our people thrive on solving complex nuclear industry challenges, and they show true resilience and dedication every day to achieve outcomes which are then successfully deployed on the Sellafield site.

What we are implementing at this centre is a UK nuclear industry first. We have adopted a new way of working where we act as the customer and work with the supply chain to develop products which meet our needs.

Our team work directly with the supply chain to test and trial potential solutions, in our safe off-site environment. This different approach means we are able to introduce innovations and products to help achieve Sellafield's mission safer, faster and more cost efficiently. Once proven we are then able to share those solutions with the wider NDA estate."

More than 25 supply chain companies were involved in the centre's first sprint project of the year supported by Resolve, a collaboration of four supply chain partners, Forth, React Engineering, CORE Nuclear Solutions and COMS.

Lesley Bell, high level waste plants reliability engineer, took part in one of the sprints, which related to improving processes at the Waste Monitoring and Compaction Plant. She said, *"To work with such a range of supply chain partners from across the country and abroad has really opened my eyes to what solutions are available."*

1. Sprints hosted at Sellafield Ltd's Engineering Centre of Excellence

Accelerating the safe use of robotics

The Engineering Centre of Excellence is focused on finding solutions to engineering and maintenance challenges, including accelerating the safe use of robotics, such as UAVs, ROVs and quadruped robots to remove people from harmful environments and deliver the NDA mission safer, faster and more cost-efficiently.

The centre's teams of engineers work with specialist robotics operators, supply chain companies, end-users, and future operators to ensure innovations are developed specifically to answer challenges at Sellafield Ltd and the wider NDA estate.

The centre allows for a different approach to innovation and successful delivery of new technologies. Innovation is woven into the fabric of the organisation through the people, culture, environment, specialist expertise, the ability to test and learn in a safe, non-nuclear space, and by embracing other supply partners who have easy access to the centre's innovation bays and the challenges shared by the industry.

Our UAV team's innovative use of UAVs has transformed inspection and monitoring processes at the Sellafield site, enhancing safety, improving efficiency, reducing cost, and benefiting the environment.

Thanks to the creative can-do approach to innovation taken by the Engineering Centre of Excellence, drone flights at the Sellafield site have increased in the last five years from one flight every six months to 200 flights a year.

By utilising UAVs for inspections, the team has significantly reduced the need for human presence in harmful environments, minimising the risk of radiation exposure and other potential dangers. The implementation of UAVs has also streamlined inspection procedures and increased operational efficiency.

Our UAV team's innovation has led to significant cost savings. By utilising drones, they have reduced the need for expensive and time-consuming manual inspections resulting in significant cost reductions for the company. Additionally, the improved efficiency has minimised downtime and increased productivity, further contributing to financial savings.

1. Spot at the Engineering Centre of Excellence

1.

Additive manufacturing & reverse engineering

Jack Williamson, Engineering Technical Support at the Engineering Centre of Excellence, is leading an innovative approach to supporting the E&M teams on site.

Jack is part of a working group proving that additive manufacturing is ready to be deployed across the Sellafield site with technology which can be trusted to deliver. To ensure compliance, a roadmap to achieve ISO standard accreditation for additive manufacturing is being created.

One core challenge which additive manufacturing addresses is that some components across Sellafield's ageing plant asset base are becoming obsolete. Reverse engineering components provides a fast, efficient, and cost-effective solution in the fight against obsolescence.

Components can be produced with extremely high accuracy without any detriment to their integrity or performance. This means that the value streams and sub-operating units can get the necessary spares, reducing downtime and improving plant productivity. By comparison, asking companies to restart production lines for obsolete components is expensive and often challenging due to the skill base and minimum order quantities.

Additive manufacturing also lends itself to a just-in-time manufacturing process, saving logistics complexity and storage needs. Instead of having stores, departments will be able to request replacement parts that can be rapidly manufactured using 3D printing techniques.

This in-house capability will support departments across the Sellafield site, and specific focus is being given to Spares & Obsolescence, and the E&M department tackling this ever-evolving challenge.

The Engineering Centre of Excellence is using 3D printing technology to test and prove the integrity of components. Once complete, this will enable us to deliver our mission safer, faster, and more cost-efficiently.

Project

Additive manufacturing & reverse engineering

Benefits

Additive manufacturing is a quick and cost-effective method of producing obsolete parts without compromising integrity or performance. We can reduce downtime and improve plant productivity by ensuring that we have the replacement parts we need when we need them.

Current Status

The additive manufacturing team at the Engineering Centre of Excellence supports various departments within E&M, notably the EDS sprints. They employ a rapid prototyping approach guided by the principles of *"fail fast, fail cheap, fail forward."*

The team also assists the ROV/UAV departments with additive manufacturing needs for various payloads and prototyping. Furthermore, they have initiated a collaborative project with selected supply chain partners to develop a strategy for rolling out higher-quality grade components. This initiative aims to expand the team's impact on value streams and establish a new standard for the site. The team are also undertaking a reverse engineering programme using 3D scanning equipment to replicate critical parts that have become obsolete.

Delivery Partners

Co-Lab Engineering, CREAT3D Ltd, Forth Engineering, Hexagon Metrology, Mark3D UK Ltd.

Contact Details

Jack Williamson
innovation.team@sellafieldsites.com

NDA Grand Challenge Alignment

1.

2.

1. Jack Williamson at the Engineering Centre of Excellence

2. Part of the Engineering Technical Support team

Using rigs to enhance training

Test rigs provide a safe, controlled environment for trainees to gain practical experience in diagnosing and fixing issues, enhancing their problem-solving skills.

The upskilling programme at the Engineering Centre of Excellence pairs E&M team leaders with staff who wish to improve their skills on the five state-of-the-art rigs within the training facility. The rigs cover many vital skill sets, including process flow and electrical fault-finding. The equipment can be set up with faults that mirror the problems present on operational equipment within the Sellafield site.

From pipework installation to voltage identification and pressure testing, the rigs shape how learners train in a variety of essential tasks, and champion the ongoing learning of E&M staff across the Sellafield site.

Unlike the environment on the operational site, the rig hall provides a setting where trainees can take their time to understand and resolve issues. This approach encourages thorough learning and allows trainees to ask questions and look into complex problems without the fear of making mistakes.

Adam Smith, engineering development maintenance team leader at the centre, said: *"This initiative has grown and grown since we started. We provide the opportunity to all E&M staff, and the value is being seen by team leaders and craft learners alike.*

With two new rigs arriving since the new year, we've been busy developing even more opportunities within the upskilling programme. We have watched the rig hall become a hub for developing knowledge."

The rigs enhance the skills of current employees and ensure that new starters receive a solid foundation in their training. The structured training environment fosters a culture of continuous learning and improvement.

This approach not only boosts the confidence and competence of the E&M staff but also contributes to the overall safety and efficiency of operations at Sellafield Ltd.

1. Bay 2 rigs at Sellafield Ltd Engineering Centre of Excellence

Electrical virtual reality programme

The electrical Virtual Reality (VR) programme, set to go live on 8th July 2024, aims to utilise VR to enhance staff training. This initiative will be attended by all electrical craft personnel.

VR allows us to enhance training by providing a secure environment for staff to practise electrical isolations, allowing users to learn and make mistakes without the risk of physical harm. Additionally, VR training has shown higher retention rates compared to traditional training methods, enhancing the overall learning experience.

The electrical VR programme can also shorten the time required for personnel to gain the necessary experience for nominations. Instead of relying on an area's Senior Authorised Person (SAP) or Authorised Person (AP) to provide sporadic training sessions, which can be disrupted by ongoing plant issues or the unavailability of the plant, trainees can spend a full day in a virtual environment with an experienced SAP/AP.

This ensures that the training is focused and uninterrupted, providing comprehensive learning without the typical distractions or limitations of a live plant setting.

David Eldon heads the Emerging Technologies team and said: *"The use of VR has been ad hoc to date. We're creating a sustainable model for the future. This team, and in particular Dan Haughin, have been exploring all necessary avenues to make that happen. We've been a demanding and intelligent client, really pushing our supply chain colleagues to think outside the box. It has paid off and soon more than 300 electrical personnel will benefit from the work undertaken."*

During the full day of training the electrical craft personnel will also be shown how to complete Isolation Test Certificates, with the aim of standardising the process across the Sellafield site.

1.

2.

1. Sellafield Ltd staff member wearing a VR headset and controllers

2. Images of the VR training

Project
Electrical virtual reality programme

Benefits
The electrical VR programme is designed to streamline and enhance the upskilling process for electrical craft personnel. By leveraging VR technology, the programme offers a safe, efficient, and effective learning environment.

This innovative approach is expected to significantly improve the quality and speed of training, ensuring better-prepared personnel for the electrical isolations and nomination processes.

Current Status
The electrical VR programme is due to go live in July 2024, with more than 300 electrical personnel able to benefit from the work.

Delivery Partners
HU Media, V360ENERGY

Contact Details
David Eldon
innovation.team@sellafieldsites.com

NDA Grand Challenge Alignment

Amanda Smith

Head of Unmanned Aerial Vehicles

Amanda is a pioneer in the world of drones and the first female chair of the national COMIT2Drones organisation, which encourages shared learning across industries, and aims to make drone technology a trusted, well-governed and essential tool for UK construction and infrastructure industries.

Alongside being the chair of the COMIT2Drones organisation, Amanda is also a member of the Critical National Infrastructure working group for drones which includes Network Rail, National Highways, National Grid, and Transport for London.

Earlier this year Amanda represented the UK at a major international drone event at the Flyability User Conference held in Lausanne, Switzerland. She shared with the international audience how she and the team at Sellafield Ltd successfully operate drones to deliver operations safer, faster and more cost-effectively.

The pace of change over the last five years at Sellafield Ltd is amazing. Through Amanda's leadership, flights have increased from one drone flight every six months to over 200 flights a year, and she thinks by 2029 we could achieve fully autonomous flights.

Amanda aims to inspire other women to join the drone community, and wants to engage with them earlier in school, as early as primary school age, to let them know that they can do these types of jobs. She believes that "You don't need to have a degree to have a career in the drone industry. You need to understand how things work, have a good grasp of Maths, English and the Sciences and be a good communicator - everything else is about attitude and a willingness to learn.

"We are at the forefront of drone developments now and it's super exciting."

Claire O'Connor

Engineering Centre of Excellence socio-economic lead

As socio-economic lead, Claire has developed a work experience programme which engaged with 15 schools and 73 students in 2023, delivering 2,263 hours of work experience in the centre and 1,122 hours of outreach support (including open days, curriculum support, and school visits).

Claire makes it her mission to offer opportunities to young people of all abilities, ensuring that the centre's work experience programme promotes diversity and inclusion. She gives up her time at weekends to help provide pathways to employment for young people and raise awareness of science, engineering and maintenance careers.

She understands how meaningful work experience encounters empower individuals, reduce inequality, and contribute to economic growth while promoting social inclusion and overall well-being.

She has led the creation of a self-sustaining ecosystem of employment opportunities and training programmes which amplifies the impact of the centre's work. This has resulted in Claire and her team winning a Sellafield Ltd WAVE Award for inspiring the younger generation and a Manifesto Award.

Claire organised the centre's first careers day in Autumn 2023 when 55 members of Sellafield Ltd staff explained their roles within the business and offers advice on the routes available to over 200 young people. These include apprenticeships, degree apprenticeships, graduate and student placements, and roles across mechanical and electrical disciplines.

"The experiences you have at school shape your attitude and expertise for the future. We want to play our part in laying the foundation for the next generation of engineers and innovators."

Appendix

Supply chain companies and organisations

Acorn Coaching & Development	Hybrid Instrument Ltd	SpinChem
Ada Mode	IDV Robotics Ltd	Spingeo
AirCube	ITI Simulations Ltd	Steer Energy
AtkinsRéalis	Jacobs	Tetronics Technologies Ltd
British Geological Survey	KUKA	The Decommissioning Alliance
Cavendish Nuclear Ltd	Lancaster University	TKE
Co-Lab Engineering	Laser Optical Engineering Ltd	TÜV SÜD
CREAT3D Ltd	Loughborough University	UKAEA
Createc	Mark3D UK Ltd	University of Birmingham
Digital Concepts Engineering Ltd	National Nuclear Laboratory	University of Bristol
FIS360 Ltd	National Physical Laboratory	University of Glasgow
Forth Engineering	Nuclear Restoration Services	University of Leeds
Fortis Remote Technology	NSG Environmental Ltd	University of Liverpool
Framatome Ltd	Nuclear Waste Services	University of Manchester
Fraunhofer Centre for Applied Photonics	Nuvia Ltd	University of Sheffield
Golder Associates Ltd	PA Consulting Group	University of Strathclyde
Gutteridge Haskins and Davey Ltd	Process Decontamination Systems Ltd	V360ENERGY
Hexagon Metrology	RED Engineering	West Cumbria Sites Stakeholders Group
HU Media	Sheffield Hallam University	Xavier Poteau IE

Abbreviations, Acronyms and References

FGMSP	First Generation Magnox Storage Pond
GDF	Geological Disposal Facility
ILW	Intermediate Level Waste
IOM3	Institute of Materials, Minerals and Mining
IRT	Integrated Research Team
NDA	Nuclear Decommissioning Authority
NNL	National Nuclear Laboratory
NRS	Nuclear Restoration Services
NWS	Nuclear Waste Services
ONR	Office for Nuclear Regulation
PCM	Plutonium Contaminated Material
PFCS	Pile Fuel Cladding Silo
R&D	Research and Development
RAI	Robotics and Artificial Intelligence
RAICo	Robotics and Artificial Intelligence Collaboration
RAID	Robotics and Artificial Intelligence Data
ROV	Remote Operated Vehicle
RrOBO	Risk-reduction Of gloveBox Operations
SABA	Sellafield Advanced Business Analytics
SFM	Spent Fuel Management
SH&EP	Sludge Handling & Export Plant
SIXEP	Site Ion EXchange Plant
SNM	Special Nuclear Materials
SPP1	Sludge Packaging Plant 1
SRP	Sellafield Product and Residue Store Retreatment Plant
TBuRD	Technical Baseline underpinning Research & Development
THORP	THermal Oxide Reprocessing Plant
UAV	Unmanned Aerial Vehicle
UKAEA	UK Atomic Energy Authority
WPEP	Waste Packaging & Encapsulation Plant

References

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Summary of deployed and demonstrated innovation

The projects that have deployed innovation across Sellafield Ltd in the past year are summarised below. For further information on any of the projects please contact innovation.team@sellafieldsites.com.

Sellafield Ltd

Project	Contact
Removing Cement Powder and Cap from Encapsulated Drums	Bethann Walker
Sand Bed Rig Work on Polyelectrolyte Dosing to Underpin Plant Operation	Peter Rand
Employee Application Pilot	Stacey Nelson & Craig Basnett
Rapid Ion Exchange Test Method Validation	Peter Rand
Deployment of Radiometric Sensor with Quadruped	Johnny Perry
Programme and Project Partners Common Data Environment Azure Landing Zone Platform	Neil Wilkinson
Security Posture of Sellafield Ltd Cloud Platform (Azure/Landing Zones/M365) to OS:SNI	Neil Wilkinson
Innovation Quickstart Guide	Jake Nicholson
Digital Twin and Cyber Range	Jill Dunn
Site Based Innovation Event	Hilary Royston-Bishop
Sellafield Enterprise Management System (SEMS)	Paul Z Holmes
Unlocking of Hydro-Cyclone by High Pressure Water Jetting	Georgia Street

Special Nuclear Materials (SNM)

Project	Contact
Store Duct Condition Monitoring	Andrew Begbie
Glovebox Window Clear	Andrew Begbie
SRP Package Smart Sensor Inactive Trial	Edward MacNeil

Retrievals

Project	Contact
Tried and Tested Retrievals: The PFCS Offsite Proving Facility	George Hodgson

Remediation

Project	Contact
Gamma Optical Video Imaging Camera (GOVI)	Jonathan Norman
Development of Controlled Waste Skip Tracking System Across Site	Craig Robson
De-risking of the Hot Spot Locator Spectral Gamma Camera in FGRP	Cian Grattidge & Elizabeth Bode
Detecting Heels in Vessels (Using Neutron Backscatter)	Anna Nicholson
Model Free Characterisation	Rochelle Heyhoe & Nick McKerrow
Non-Destructive Depth Profiling of Concrete	Kara Vouilloz
CARMA II	Matthew Nancekievil

Site Management Strategy and Technical

Project	Contact
Long Range Wide Area Network Utility Metering	Alex Hill & Kavinda Samaratunge
Carbon Modelling	Alex Hill

Summary of deployed and demonstrated innovation

Information Services Organisation (ISO)

Project	Contact
Cofense – Email Security Solution	Andrew Shutak
Plant WiFi	Jack Metcalfe
Control and Electrical Systems Archive and Retrieval (CAESAR) replacement project	Jack Metcalfe
Adoption of NDA Resource Booking Tool Condeco	Louise Hewitt
Multi-user Microsoft Teams Access Devices	Louise Hewitt
Adoption of Gov Delivery Communications	Louise Hewitt
Hexagon J5 Plant Logs for Lotus Notes Plants	Steven Bell
TenableSC – Network Vulnerability Management Solution	Andy Shutak
Cobalt Strike – Penetration Testing/Breach Attack Simulation	Andrew Shutak
Introduction of QR Codes Across the Business	Russell Sirkett

Sellafield Advanced Business Analytics (SABA)

Project	Contact
Power BI Application Evaluation for PFCS Simulation Model	David Dewar
SABAssist	Faye Rathmill

Programme and Project Partners (PPP)

Project	Contact
Application of 4D Planning to Support PPP Major Projects	Faye Cooper
SRP – Batch Furness Change of Specification	Faye Cooper
Lightly Shielded Stores Value Study	Faye Cooper

Information, Communication Technology

Project	Contact
Local Rules Digitisation	Chris Underwood

Remote Technologies Group

Project	Contact
Deployment of COTS Crawlers for Nuclear Environments	Deon Bulman

Standards and Assurance

Project	Contact
Embedding the waste management hierarchy: a flash approach	Lindsay Tandy

Sellafield Ltd

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