



United Kingdom  
National Nuclear  
Laboratory

Public Interest Reinvestment Contributions to

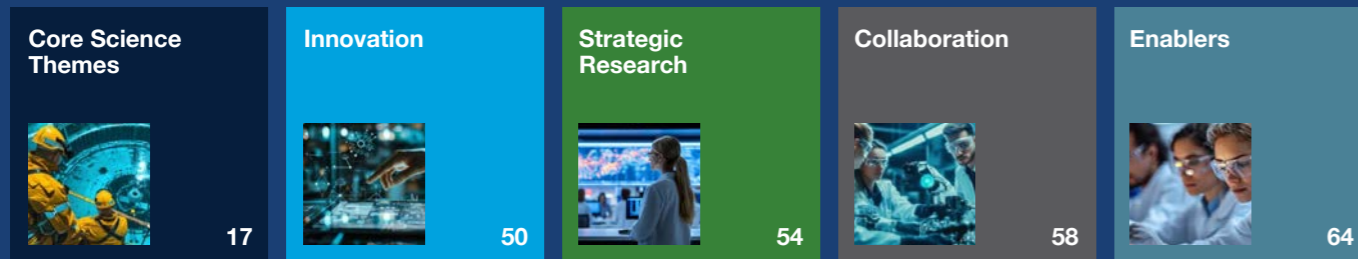
# Environmental Restoration

2024-2025



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## Introduction from UKNNL



**As the UK's lead civil national laboratory for nuclear, UKNNL has formed effective, strategic partnerships to deliver world leading science and technology. UKNNL remains committed to working collaboratively, taking responsibility to deliver a step change in Environmental Restoration of the UK's nuclear legacy; the ongoing commitment to achieving this is reflected in the strengthening of existing relationships established with organisations such as Sellafield Ltd, the Nuclear Decommissioning Authority (NDA) and its operating companies.**

**Richard Gibson**  
Vice President of Legacy Sites, UKNNL

The work undertaken through UKNNL's science and technology agenda remains key in addressing some of the biggest challenges faced in clean-up operations of nuclear facilities. This work is funded via the reinvestment of earnings that UKNNL generates through customer-focused projects.

UKNNL is therefore pleased to present the following report detailing the delivery of public interest reinvestment in FY24/25, featuring the work carried out relevant to UKNNL's Environmental Restoration Focus Area in support of the NDA Group of companies.

Whilst again focusing on the science and technology achievements over the last year, this report will additionally showcase examples of how we build on prior projects, develop science, technology and capability over several years, and what we plan to achieve over the coming financial year.

We aim to maintain and further develop the thriving partnerships formed, by collaboratively working with Sellafield Ltd, the NDA, Ministry of Defence (MOD) and others to help play our part in delivering Environmental Restoration of the UK's nuclear sites, harnessing nuclear science to benefit society.

We also continue to focus long-term via the Collaboration Agreement in place with Sellafield Ltd, to identify key challenges and technologies which would aid the clean-up of the Sellafield site. This collaboration was again nominated for an Institute of Collaboration Working (ICW) award, recognising the approach to working alongside Sellafield Ltd. The following report highlights examples of work demonstrating the contribution UKNNL makes across many technical areas of importance.

These are underpinned by technical skills and capabilities and enabled by factors such as our facilities, infrastructure, supporting capabilities and supply chain. UKNNL continues to strive towards the vision for a cleaner, safer environment for generations to come, whilst observing that this would not be possible without the commitment, trust, and integrity of our collaborating partners.

## Introduction from Sellafield Ltd



As part of the NDA group, Sellafield Ltd works closely with UKNNL to deliver innovative and value adding solutions towards our contribution for creating a clean and safe environment for future generations. This report is a fantastic opportunity reflect on how Sellafield’s partnership with UKNNL continues to drive scientific innovation and deliver tangible value for the Sellafield site and the NDA mission.

**Robin Ibbotson**  
Chief Technology Officer,  
Sellafield Ltd

The collaboration agreement between Sellafield and UKNNL, held since 2017, has been a significant factor in fostering innovation and investing in people, skills, and the application of science. I am delighted that this collaboration has now been embedded across the NDA group enabling a wider network of experts to come together and work on some of the most important challenges faced in nuclear today.

This report underlines our commitment to our joint missions and how UKNNL’s use of its earnings support the NDA and Sellafield.

By supporting PhD research and studies, we are nurturing a pipeline of technical talent and ideas that helps us technically underpin our strategy, whilst yielding new approaches to site restoration, waste management and hazard reduction.

By funding investments into UKNNL’s infrastructure and capabilities we are enabling scientific research and analysis into novel topics that can support a step change in Sellafield’s lifetime plan and operations.

By collaborating more widely with our group but also industry and supply chain partners we are tapping into a greater breadth of skills, knowledge and capability than we ever have done unleashing potentially game-changing results.

## Introduction from NDA Group



To clean up the UK’s earliest nuclear sites safely and efficiently, collaboration between the organisations involved in their remediation is pivotal. The NDA promotes effective, working partnerships to deliver an ambitious and effective strategy to ensure that clean-up operations are a success.

**Clive Nixon**  
Group Chief Nuclear Strategy Officer,  
NDA Group

The NDA and our subsidiaries (Sellafield, Nuclear Restoration Services, Nuclear Waste Services and Nuclear Transport Solutions) all work closely together with UKNNL, and crucially, with academia and other industry partners to help deliver our mission to safely reduce the hazard and risks of the UK’s nuclear legacy.

As a foundational organisation of the nuclear enterprise, we are one of the custodians of our sovereign reputation, playing a vital role in ensuring the environmental stewardship and technical leadership in our sector, supporting and enabling the nation’s energy security. What we do really matters—and that’s why effective collaboration between our organisations is not only important, but essential.

It’s through collaborating that we deliver real impact ensuring that the environmental restoration of nuclear sites in the UK is delivered efficiently and effectively, ultimately delivering value for money for the UK taxpayer. We employ an NDA groupwide approach with UKNNL delivering synergies and alignment on what matters most as well as working closely with other public sector organisations such as MOD.

The progression of innovative technologies through the Technology Readiness Level (TRL) scale to become deployable on nuclear sites will also be key for decommissioning activities. It is therefore encouraging to see that the earnings of UKNNL are being reinvested in this way to progress the technologies, people and supporting infrastructure capable of delivering a step change in environmental restoration.

Such investment represents a commitment to safely transforming the landscape and returning nuclear sites to future generations in a way that respects their surrounding communities and the environment. The decommissioning journey is a challenge, but also a source of great pride for the NDA and the UK, as we ensure that our actions today make way for a cleaner, safer tomorrow. A successful and sustainable UKNNL is a cornerstone of our work.

# Context

UKNNL aims to deliver nuclear science to benefit society by enabling nuclear outcomes for government and supporting the growth of the UK nuclear sector. Government owned but operationally independent, UKNNL is continuously committed to reinvesting in Science and Technology. Such reinvestment enables the fulfilment of UKNNL's responsibility as UK's lead civil national laboratory for nuclear fission and Public Sector Research Establishment (PSRE).

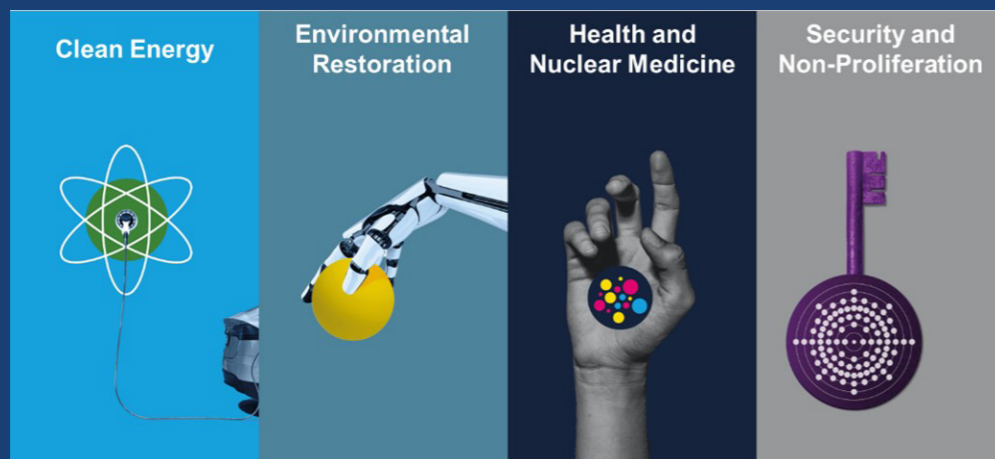
Science and Technology at UKNNL is aligned to four key focus areas – Clean Energy, Health and Nuclear Medicine, Security and Non-proliferation, and Environmental Restoration. This enables the targeted development of solutions, technologies and capabilities most relevant to the sector, ensuring value for Sellafield Ltd, the NDA, Ministry of Defence (MoD), the Department for Energy Security and Net Zero (DESNZ) and other customers.

The Environmental Restoration focus area aims to drive a step-change in the clean-up and management of the UK's nuclear legacy, and centres on investment in innovative, sustainable and safe solutions for the management of hazardous nuclear waste.

The three pillars of our Science and Technology agenda – Core Science, Strategic Research, and Innovation – all provide a pathway to deliver on the aims of Environmental Restoration. Investment in this area brings lifetime value for money through:

- Innovative research and development activities which drive forward crucial technologies and tools for deployment within the sector enabling faster, cheaper, and safer decommissioning

- Development of expertise and skills across the waste life cycle critical to sustain the knowledge base required to deliver solutions to diverse challenges across nuclear licensed sites
- Futureproofing capabilities, facilities and infrastructure to support and sustain continued delivery for the sector



# Overview

The following Gantt Charts provide an overview of projects related to Environmental Restoration and approximate indication of timescales.

There is focus on the delivery within the FY24/25-25/26 timescale and as such some projects are multi-year and may have commenced prior to this or are due to finish after these dates. Where possible this has been indicated. Exact timings may be subject to change. The core science themes featured are those relevant to the Environmental Restoration focus area.

## Activity: Core Science Themes

Robotics	2024			2025												2026								
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Conducting physical trials and setting up of capability demonstration	▶																							▶
Investigation, development, and benchmarking of OCR techniques for automated text reading																								
Operation of NNUF-HR facility to test and develop remote operations and equipment for use in sort and segregation, size reduction, laser cutting, waste management and retrieval, and glovebox operations	▶																							▶
Co-funded PhD studentship with University of Strathclyde on 'Ensuring Decommissioning Safety, Integrity and Verification through Advanced Sensor-Enabled Cutting'	▶																							▶
Co-funded GREEN PhD studentship with Lancaster University on Advanced control system design for enhancing the situational awareness of the robotic platforms in the nuclear environment	▶																							▶
Proposed approach to improving reliability claims on computer-based robotic systems for safety casing	▶																							
Contribution to UK Cross-Industry RAS Development Task Force and co-chairing of the National RAS Regulations, Standards, and Ethics Committee	▶																							▶
Review of AI models for robotics: barriers and opportunities for adoption in nuclear decommissioning																								

## Activity: Core Science Themes

Nuclear Safety	2024					2025					2026														
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	
Leading on criticality safety aspects identified as being of national strategic importance in influencing Relevant Good Practice in the UK, e.g. (i) UK lead role on criticality-related ISO standards [facilitating UK industry input], (ii) representing the UK on the Organisation for Economic Co-operation and Development Nuclear Energy Agency Working Party on Nuclear Criticality Safety, (iii) fulfilling the role of Secretariat lead on ANS-8 plus leadership of the ANS-8.20 working group, and (iv) leading the UK Working Party on Criticality sub-group dedicated to the application of sensitivity and uncertainty tools in criticality safety code validation																									
Providing key input into broader safety-related aspects identified as being of national strategic importance in influencing Relevant Good Practice in the UK, e.g. (i) the Safety Case Forum sub-groups on "Safety & Engineering Integration", and "External Hazards", plus (ii) various activities associated with the UK Shielding Forum [e.g. contributing to shielding Good Practice Guides]																									
Continued support to the execution of a low temperature critical benchmark experiment with Lawrence Livermore National laboratory (f/24/25), followed by the write-up of the evaluation for submission to the International Criticality Safety Benchmark Evaluation Project (ICSBEP) Handbook (f/25/26)																									
Completing Independent Review of the DEIMOS ICSBEP benchmark evaluation for a High-Assay low Enriched Uranium (HALEU) TRISO fuel experiment																									
Promotion of good practice in Chemotoxic safety, including production of a journal article on improved dispersion modelling to reduce pessimisms																									
Coordinate the UK Working Party on Criticality Continued Professional Development webinar series with Sellafield																									

Materials Performance	2025					2026																		
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Validation of small-scale testing techniques to obtain bulk-scale mechanical properties from mm-scale samples																								
Graphite waste management for the reduction of quantity of intermediate level waste																								
Graphite Core Dismantling for Minimising Graphite Waste Volume (PhD, University of Manchester)																								

## Activity: Core Science Themes

Decontamination and Decommissioning	2024					2025					2026												
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
Simulating contaminated materials (UKNNL, Horizon 2020, PREDIS programme, and Sellafield Ltd)																							
Characterisation via hyperspectral imaging (PhD, University of Manchester)																							
Magnetometry for Non-destructive examination (PhD, University of Warwick)																							
Underwater characterisation using LIBS (PhD, University of Manchester)																							
Long range alpha detection (PhD, Queen Mary University)																							
Gamma mapping using uncrewed aerial vehicles (PhD, University of Bristol)																							
Simulating the contamination of stainless steel (PhD, University of Lancaster)																							
Sludge transport dynamics (PhD, University of Liverpool)																							
Multiphase flow modelling (PhD, University of Leeds)																							
Capture of fume from laser decontamination (PhD, University of Loughborough)																							
Hydrogel decontamination (PhD, University of Manchester)																							
New composite zeolites for nuclear waste remediation (PhD, University of Birmingham and Diamond Synchrotron Light Source)																							
Non-contact pressure measurement of sealed special nuclear material containers (University of Warwick, Sellafield)																							
Contamination and Decontamination of Urban Concrete After Radiation Emergencies (University of Lancaster)																							
Wireless Technology Hub Development																							
Muon tomography for characterisation of hazardous items (University of Glasgow)																							
Nuclear Fuel-debris Characterisation via Multi modal Spectroscopy and Analysis (JAEAU, University of Strathclyde)																							
Analysis of Active Coupons from Magnox North Dissolver (UKRI application)																							
Small bore pipe inspection robots (UKRI application)																							
Fenders- Frontiers in Electromagnetic Non-Destructive Evaluation (UKRI application)																							
Sustainable Treatment and Immobilisation of Challenge Waste (STREAME, EURAD2)																							
Decontamination Technology Progression (ARC-DARTs)																							



## Activity: Collaborations

International Collaborations	2024					2025					2026														
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	
PREDIS (Pre-Disposal Management of Radioactive Waste)	▶																								
PATRICIA (Partitioning and Transmuter Research Initiative in a Collaborative Innovative Action)	▶																								
PUMMA (Plutonium Management for More Agility)	▶																								
FREDMANS (Fuel Recycle and Experimentally Demonstrated Manufacturing of Nuclear Solutions)	▶																								▶
Gemini4.0	▶																								
HARPERS (HARmonised PracticEs, Regulations and Standards in waste management and decommissioning)	▶																								
SECURE (Strengthening the European Chain of supply for next generation medical Radionuclides)	▶																								
OPERA - High performance modelling of systems	▶																								▶
EURAD 2																									▶
TRANSPARENT (Technological Research Action Necessary for Safe PARTitioning And Nuclear Transformation)																									▶

University Collaborations	2024					2025					2026														
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	
Simulating the contamination of stainless steel (PhD, University of Lancaster)	▶																								
Capture of fume from laser decontamination (PhD, University of Loughborough)	▶																								▶
Wireless instruments for nuclear digitalisation	▶																								▶
Graphite Waste Management (PhD, CINDe & University of Manchester)	▶																								
The use of LIBS for the analysis of effluents and underwater materials (University of Manchester)	▶																								
Probing the Performance of AGR Fuel Cladding (using Raman Spectroscopy Mapping) (University of Liverpool)	▶																								▶
Experimental Measurement for the Validation of CFO for flows in confined geometries of relevance to liquid Metal reactors	▶																								

## Activity: Innovation

Innovation	2024					2025					2026														
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	
Active demonstration of EASD gel at B204 and demonstration of processing waste/ encapsualtion in situ																									
Active demonstration of Aspigel and demonstration of processing of waste/encapsualtion in situ																									
Winston ultrasonic probe for decontamination (development with third party)	▶																								
Delta Crane - material removal from MSSS - Game Changers																									
ClearSpeed voice analytics for security vetting	▶																								
Uranium and Aluminum Hydroxide separation using electro deposition																									
Horizon Scanning- Early careers session - "How can UKNNL empower and engage young talent for a sustainable nuclear future?"																									

## Activity: Enablers

Technical Skills and Capability	2024					2025					2026														
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	
Continuous delivery of online e-learning courses and virtual training	▶																								▶
Continued knowledge management development by holding talks on a range of topics; some in conjunction with Sellafield Ltd	▶																								▶
Onboarding of Graduates, Apprentices and Post-Docs																									

# Environmental Restoration: Vision, Ambition and Role

## Our Vision

To drive a step-change in the clean-up and management of the UK's nuclear legacy, supporting the UK's national missions and enabling the sharing of expertise and decommissioning solutions internationally.

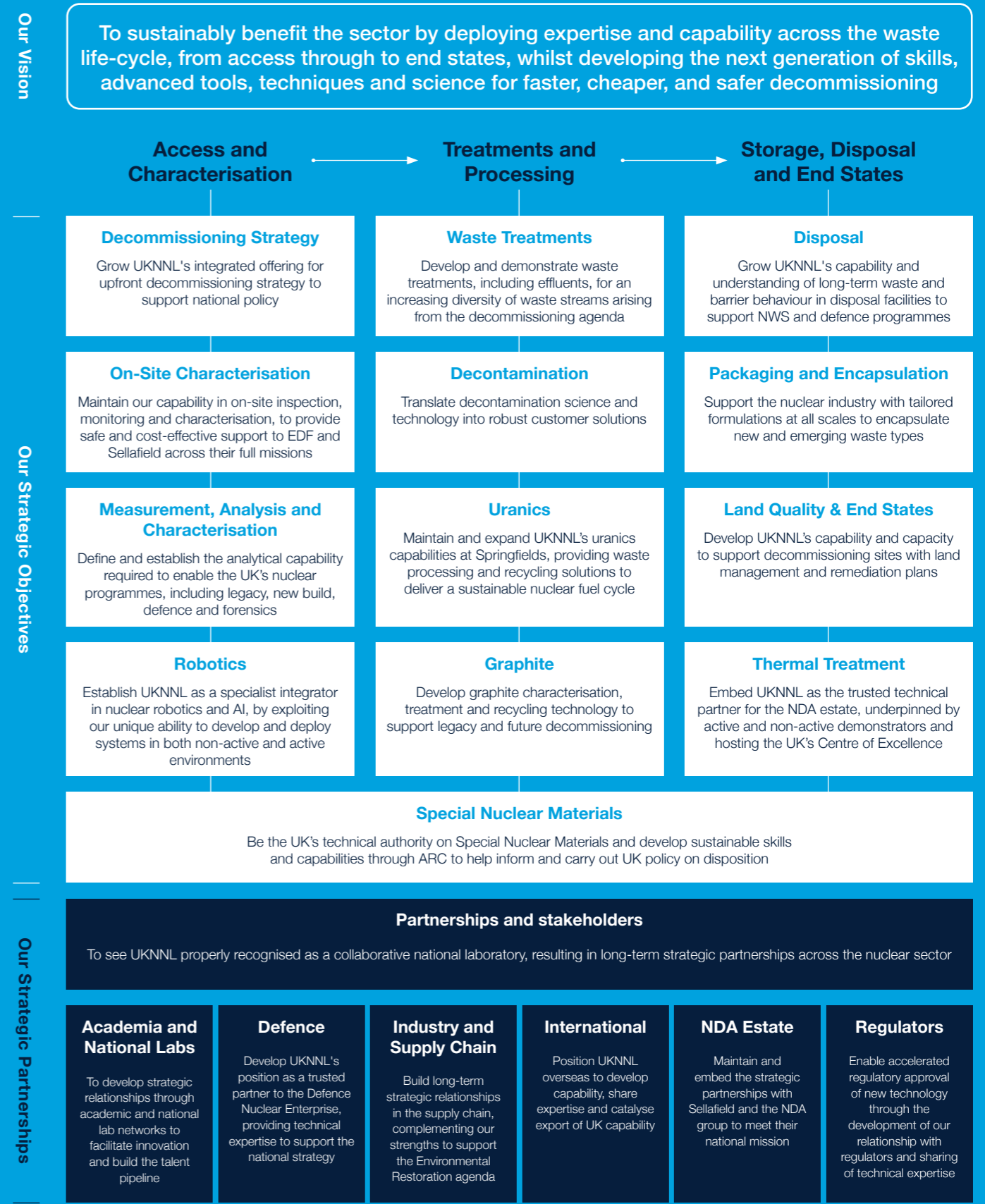
## Our Ambition

- Delivering the next generation of decommissioning science and breakthrough technologies.
- To be the natural custodian of strategic nuclear capability on behalf of the UK.

## Our Role

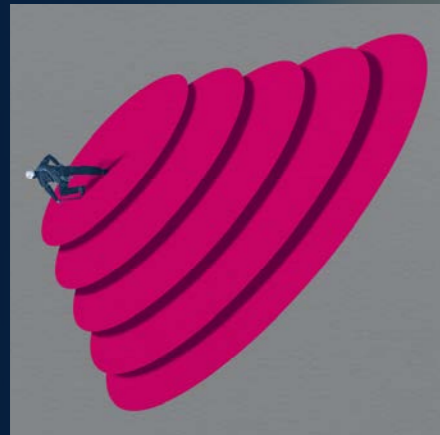
- The embedded Technical Authority providing specialist services and innovating new solutions.
- A proving ground for industrialising technologies from academia and SMEs.
- Informing and underpinning government policy with technical insights.

# Environmental Restoration: Objectives Work Breakdown Structure



# Science and Technology

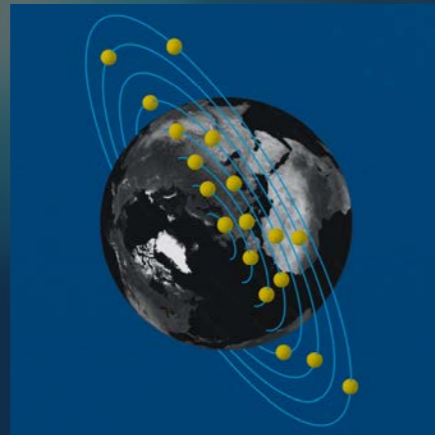
The Science and Technology agenda at UKNNL is consistently reviewed to maintain its involvement in topics which remain relevant to the nuclear industry today and into the future. It consists of three pillars, led by scientists working collaboratively on a national basis and internationally.



**Core Science**

The three pillars of the Science and Technology agenda are Core Science, Strategic Research and Innovation.

This report focuses on work across the core science themes that support the delivery of environmental restoration aims across the nation and further afield.



**Strategic Research**

Developing skills and capabilities in these themes enables UKNNL to provide support to organisations like Sellafield Ltd, the NDA, and the MOD.

Investment also allows UKNNL to be flexible between pushing technology directed towards existing requirements and allowing the market to pull our work into other areas.



**Innovation**

## UKNNL Core Science Themes

- Advanced Fuels
- **Decontamination & Decommissioning**
- **Disposal**
- **Environmental Radiochemistry**
- Hydrogen
- Irradiated Fuel Characterisation
- Medical Radionuclide Science
- **Materials Performance**
- Nuclear Safeguards & Security
- **Nuclear Safety**
- **Plutonium, Advanced Recycle & Isotope Separation (PARIS)**
- Reactor Chemistry & Corrosion
- Reactor Technology
- **Robotics & Artificial Intelligence**
- **Thermal Treatment**

(**Bold** indicates themes delivering significant environmental restoration investment)

Through S&T investment we provide exciting and fulfilling opportunities to deliver world-leading research and help build the capability needed to deliver the UK's nuclear ambitions.

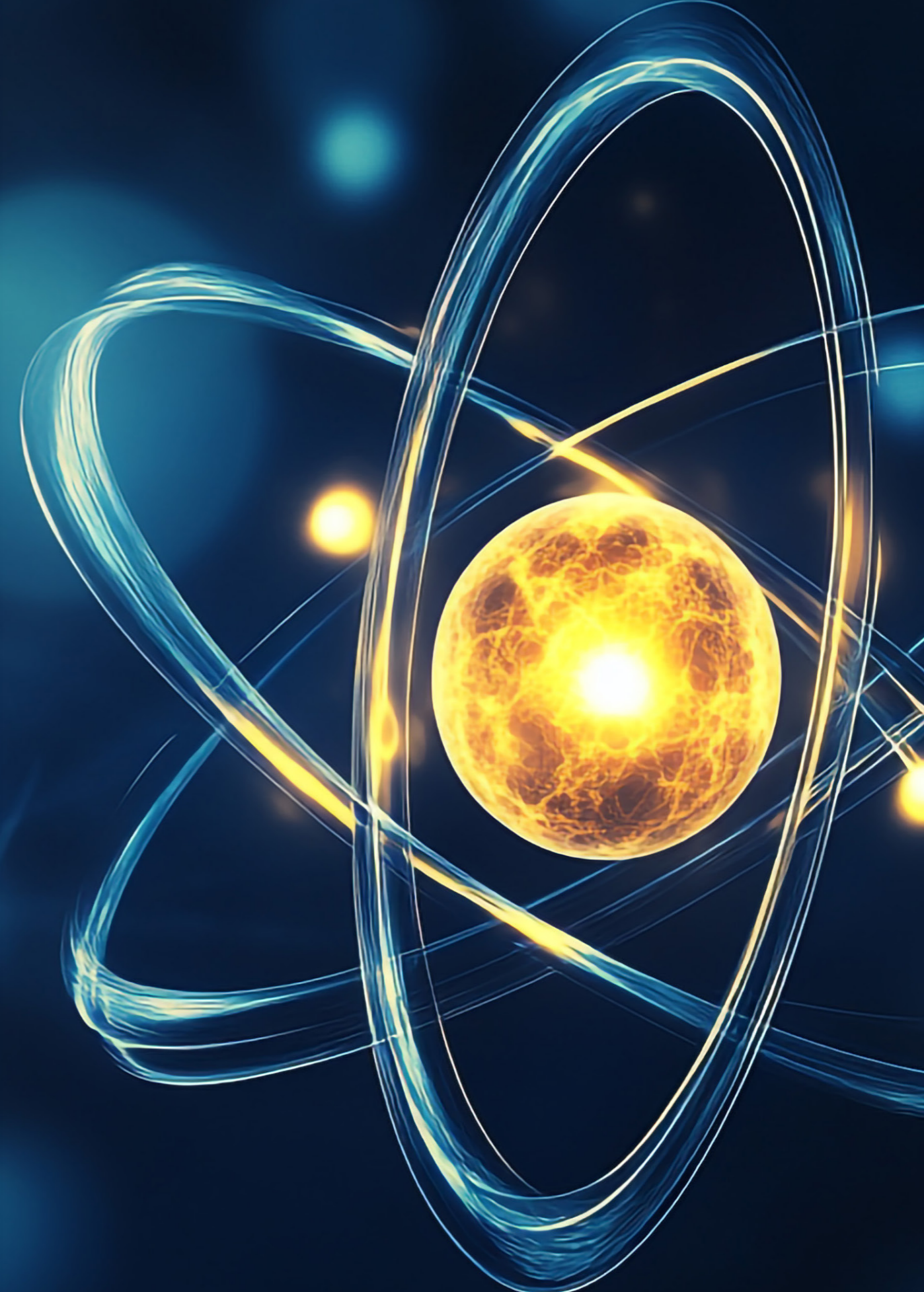


**Jon Hyde**  
Head of Science and Technology, UKNNL

As the UK's lead civil national laboratory for nuclear fission, we have a responsibility to push the boundaries of what's possible. Through our strategic partnerships with Sellafield, the NDA and the wider nuclear sector we are translating cutting-edge research into real-world solutions. By investing in people, facilities and innovation, we're ensuring the UK has the sovereign capability it needs now and in the future.



**Dr Gareth Headdock**  
Chief Science and Technology Officer, Deputy CEO, UKNNL



Core Science Theme:

# Decontamination and Decommissioning

## Summary

The Decontamination and Decommissioning (D&D) Core Science Theme (CST) focuses on the study of contaminated materials and the development of innovative decommissioning technologies to accelerate the environmental restoration of nuclear sites.

## Core Science in Focus

The D&D theme currently consists of a broad range of collaborative projects which aim to progress the TRL of technologies to help achieve cost reductions of technology implementation, waste volume reduction, reduced radioactive hazards and improved decision making for the decommissioning of nuclear facilities. The overall outputs from D&D projects are helping to restore the environment surrounding nuclear facilities once operations have ceased and allows for greater consideration of the environment for future operations.

Since its creation, the theme has leveraged the Technical Services Agreement (TSA) framework and focused on progressing decommissioning technologies relevant to Sellafield Ltd challenges, achieving active laboratory testing and on-plant demonstration and supporting safety case development for future deployment. Progress in this area has been accelerated in recent years through secondments of UKNNL staff members linked with the CST, Anne Callow and Rob Mayhew, into Sellafield Ltd.

Many of the technologies developed through the CST have relevance to the UK's nuclear legacy, designed to address challenges across the NDA estate. The theme also contributes globally to research and development focused on decommissioning through international programmes of work such as EURAD2, working collaboratively with research organisations across Europe on pre-disposal treatment of radioactive waste streams.

### Decontamination & Decommissioning

Provide underpinning knowledge on contaminated materials to inform decommissioning strategies

Generate new characterisation and decontamination technology ideas for deployment in radioactive environments

Drive innovative technologies through the TRL spectrum in collaboration with our partners and customers

Training and development of people, providing new skills and capabilities for the sector

# Case Study : Non-Contact Pressure management of Special Nuclear Material (SNM)

## Challenge

The UK has a legacy stockpile of Special Nuclear Material (SNM) packages arising from operations. Monitoring the behavioural markers, such as pressure, of these packages is essential for the safe storage, processing, and disposal of the SNM contained within them for the decommissioning of the facilities that currently house these packages. Presently, a non-destructive, non-contact method to record the internal pressure of the SNM packages is not available for plant use.

## Solution

Research was carried out investigating the relationship between the internal pressure and external vibrations of SNM packages using acoustic techniques. This work was carried out by Elizabeth Sharp during her PhD at the University of Warwick, in collaboration with Sellafield Ltd, the NDA and UKNNL, and has been developed further through investment by the Decontamination and Decommissioning CST.

## Technology

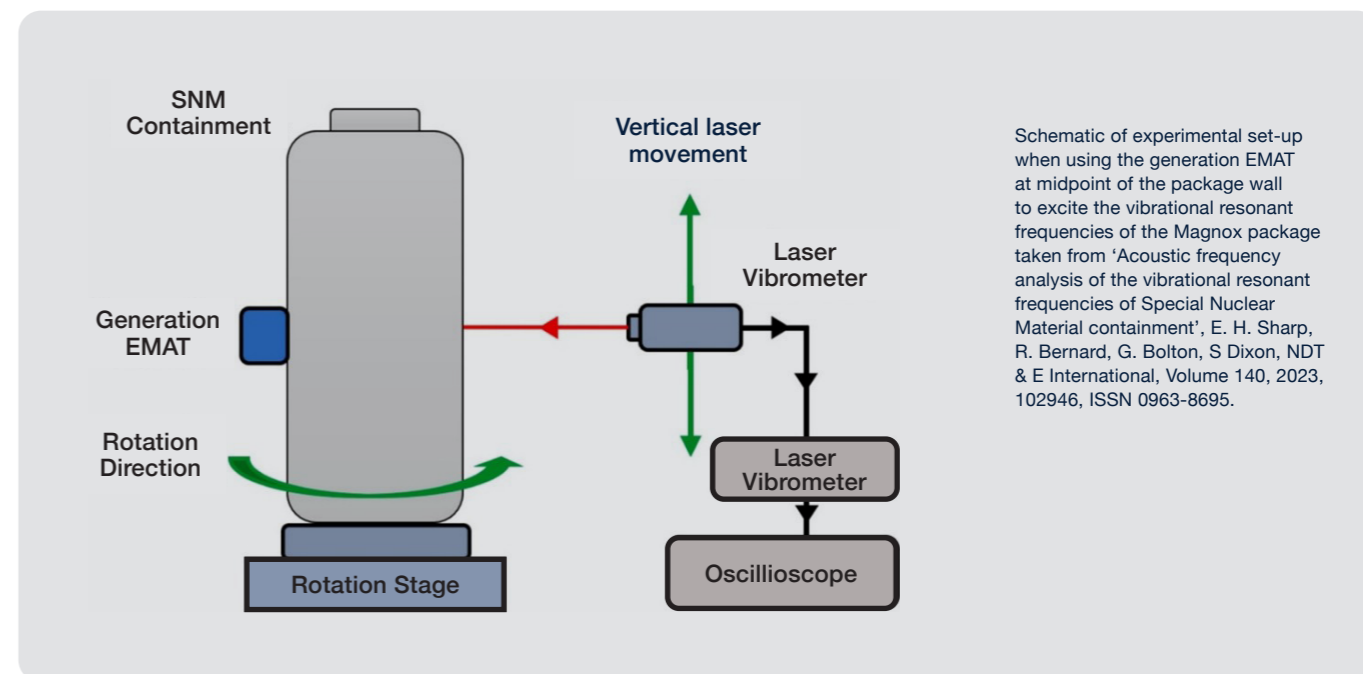
Electromagnetic Acoustic Transducers (EMATs) were the principle behind the non-destructive method developed for pressure measurements of SNM packages. EMATs placed near the outer surface of a package can generate and detect acoustic waves within a material's surface. The vibrational output recorded from this is related to the internal pressure of the package. As the package's internal pressure increases, the vibrational resonant frequencies also increase in value. Using the technology requires no surface preparation or mechanical coupling for the generation or detection of vibrations. To accompany the prototype of the technology, a 3-D model of a Magnox can was constructed in SolidWorks to perform eigenfrequency and modal analysis.

## Outcome

Elizabeth joined UKNNL in 2024 where she has continued advancing work on the technology. Collaboration with industry and university partners on the technology has allowed for the development of capability in this area through Elizabeth, harnessing the skills and knowledge established thus far. The technology was successfully deployed at Central Laboratory, where it was applied to real Magnox packages for the first time. The results were validated against existing destructive pressure measurement methods, showing good correlation with the established technique.

## Status

Following this successful demonstration, research is now underway to adapt the technology for use with Thorp packages, which are a higher priority for the customer. The overarching goal is to enable the use of EMAT technology for package pressure measurement at the Sellafield site. By eliminating the need for destructive testing, the technology reduces operator radiation exposure, allowing personnel to safely handle and analyse materials for longer periods.



UKNNL delivery team (from left to right) Doug Offin, Elizabeth Sharp, Neil Cockbain

## Core Science Theme:

# Disposal

## Summary

Launched in April 2023, the Disposal Core Science Theme is establishing an impactful R&D portfolio and leading the development of critical 'sovereign capabilities' to support the UK Government's mission, led by Nuclear Waste Services (NWS) to dispose the UK's higher activity radioactive waste in a geological disposal facility (GDF).

## Core Science in Focus

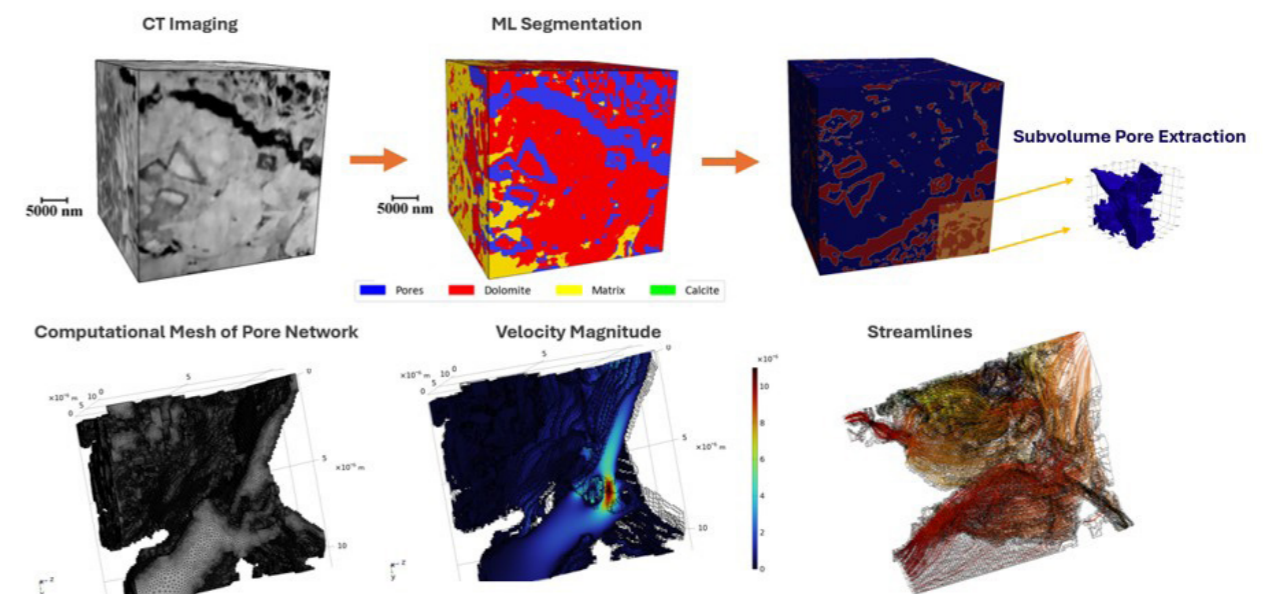
Currently, the UK's most hazardous radioactive waste is stored in ageing nuclear fuel storage ponds and waste silos which were not designed to store waste indefinitely.

Key challenges include safety, environmental impact, security, cost, deliverability and a shortage of both technical and non-technical critical skills. Aligned to international best practice, the UK Government's plan

is to immobilise and dispose higher activity radioactive waste without further human intervention (known as passive containment). It will be contained in a GDF between 200 metres and 1000 metres deep underground for hundreds of thousands of years.

The Disposal Core Science Theme leverages UKNNL's unique facilities and modelling expertise, in collaboration with UK and international organisations, with

the ambition to become world-leading experts in the two core components of the GDF 'multi-barrier' safety concept - engineered barrier systems and the geosphere. In collaboration with our academic and industry partners, the novel workflows showcased below can be easily modified and implemented across the wider NDA Group, using the latest digitalisation and modelling advancements to support in-situ, near-surface, and deep geological disposal.



Framework established for multi-physics modelling at the pore-scale.

# Case Study :

## The Future of Encapsulants and Engineered Barrier Systems

### Challenge

The UK Government is committed to the safe disposal of highly radioactive waste deep underground in a GDF. This facility will be comprised of a series of engineered barriers in addition to the host rock environment which will maintain the safe isolation of the waste for hundreds of thousands of years. Cementitious materials are likely to be integral to the engineered barrier system. However, the cement industry is changing rapidly in response to security of supply demands and sustainability, moving towards next generation, lower carbon cements with Limestone Calcined Clay Cement (LC3), Calcium Sulfoaluminates (CSA) and geopolymers as possible future alternatives to traditional cement formulations. In addition, the potential host geologies in the UK include some very high ionic strength porewater which could have an impact on both chemical and physical properties of any backfill material.

### Solution

To address this key knowledge gap, UKNNL teamed up with The University of Manchester and Lancaster University, on two projects funded by the National Nuclear User Facility (NNUF):

- Project 1 - The effect of different groundwaters to understand the interaction with different cements
- Project 2 - Encapsulation of uranium metal in traditional and lower-carbon cement formulations

### Technology

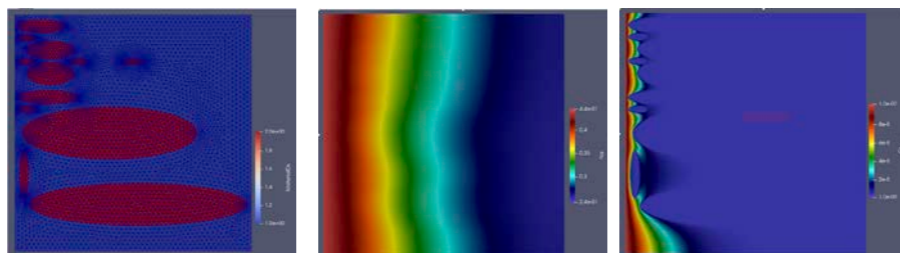
To assess the effect of different groundwaters, various low-carbon and traditional cement forms were exposed to three groundwater compositions (high salinity, high sulphate and high carbonate) to investigate the behaviour of low-carbon cements and advance knowledge of how different cements work, both as encapsulants and as part of the wider engineered barrier system. Project 2 will use advanced three-dimensional imaging to investigate the corrosion of uranium, when encapsulated in different low-carbon cements over time.

### Outcome

Early results from Project 1 have highlighted critical knowledge gaps, particularly in predicting the behaviour and compatibility of next generation cements in hypersaline groundwaters. Maximising the compatibility of cementitious materials to these environments is something that UKNNL are currently working on in a new experimental programme.

The results are building our understanding of the behaviour of low carbon cements compared to traditional cement formulations when exposed to different geochemical conditions. This work supports Nuclear Waste Services to better understand the impact of salinity on future cementitious materials. Project 2 is currently underway, and we look forward to sharing results soon.

Ongoing investigation linking OpenGeoSys with PHREEQC, focusing on the implementation of a surface complexation model for caesium. Left: Computational domain and mesh, with two materials explicitly represented: clay lenses (red) and sand/gravel (blue). Middle: Sodium concentration profile. Right: caesium concentration profile, illustrating sorption into the clay lenses



## Strategic Modelling Capability

Since its launch, the Disposal CST in close collaboration with the Environmental Radiochemistry CST, has been instrumental in establishing and implementing state-of-the-art strategic modelling capabilities. These are closely aligned with the R&D needs of the UK's Disposal Programme, while also maintaining an outward-looking vision to support and engage with international programmes. Beyond disposal, these capabilities provide a critical foundation that can be applied across the Environmental Restoration Focus Area and the wider UKNNL portfolio, strengthening delivery, enhancing UKNNL's strategic positioning, and enabling long-term impact.

Our overall strategy for modelling capability is structured around the integration of the following pillars:

- Multi-scale, multi-physics, and uncertainty quantification modelling – spanning nanometres to kilometres and integrating fluid flow, reactive transport, mass and heat transfer, mechanics, chemistry, microbiology, corrosion, and geological processes
- Next-generation predictive modelling – leveraging machine learning and AI to complement and integrate with physics-based approaches, enhancing efficiency and enabling robust uncertainty quantification.

- Advanced data management and interpretation – next generation data analysis, visualisation, and post-processing through machine learning/artificial intelligence (ML/AI) driven techniques. Ongoing key modelling initiatives include:

#### Next-generation mechanistic reactive transport modelling:

UKNNL's one-dimensional (1D) geochemical modelling capability is unparalleled. This work package, carried out in collaboration with the Environmental Radiochemistry CST, aims to extend this capability into three-dimensional (3D) multi-physics numerical platforms. Such an extension will allow the explicit representation of chemical and mineralogical heterogeneity, while also incorporating and coupling additional physical processes, including thermal, hydraulic, and mechanical interactions.

#### Pore-Scale Reactive Transport Modelling and Machine Learning-Based Image Segmentation:

This collaborative R&D framework builds on the Disposal CST's ongoing work within the GeoSafe programme and strengthens partnerships with the University of Manchester (UoM) and Heriot-Watt University (HWU). The focus is on establishing state-of-the-art pore-scale modelling capability using HWU's GeoChemFoam platform and linking it with UKNNL's main simulation environments, including OpenGeoSys

and COMSOL Multiphysics

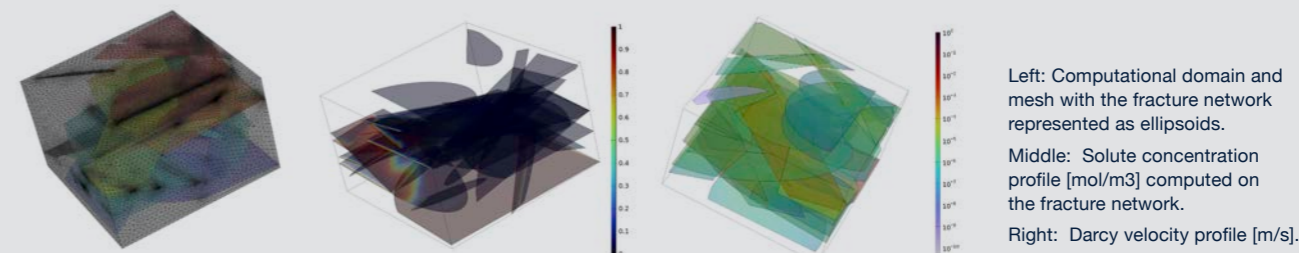
In parallel, collaboration with UoM is advancing next-generation machine learning image segmentation methods at the pore-scale. These methods enable accurate representation of pores and minerals at micro and nano-scales, thereby improving reactive transport flow calculations and supporting the development of novel upscaling approaches.

#### Discrete Fracture Network (DFN) Modelling:

The Discrete Fracture Network (DFN) concept provides a robust computational framework for representing fractured rock systems, where individual fractures are explicitly modelled as planes with defined characteristics such as size, transmissivity, and orientation.

By integrating DFNs into site descriptive models, fractured rock systems can be represented more realistically than with conventional continuum models. This leads to improved predictions of groundwater flow and contaminant transport.

In Phase 1 of this R&D program, the foundations were established for a multi-physics DFN modelling capability within the COMSOL Multiphysics simulation environment. This included the integration of site-specific fracture characterisation data into numerical models, enabling a more direct link between field observations and predictive simulations.



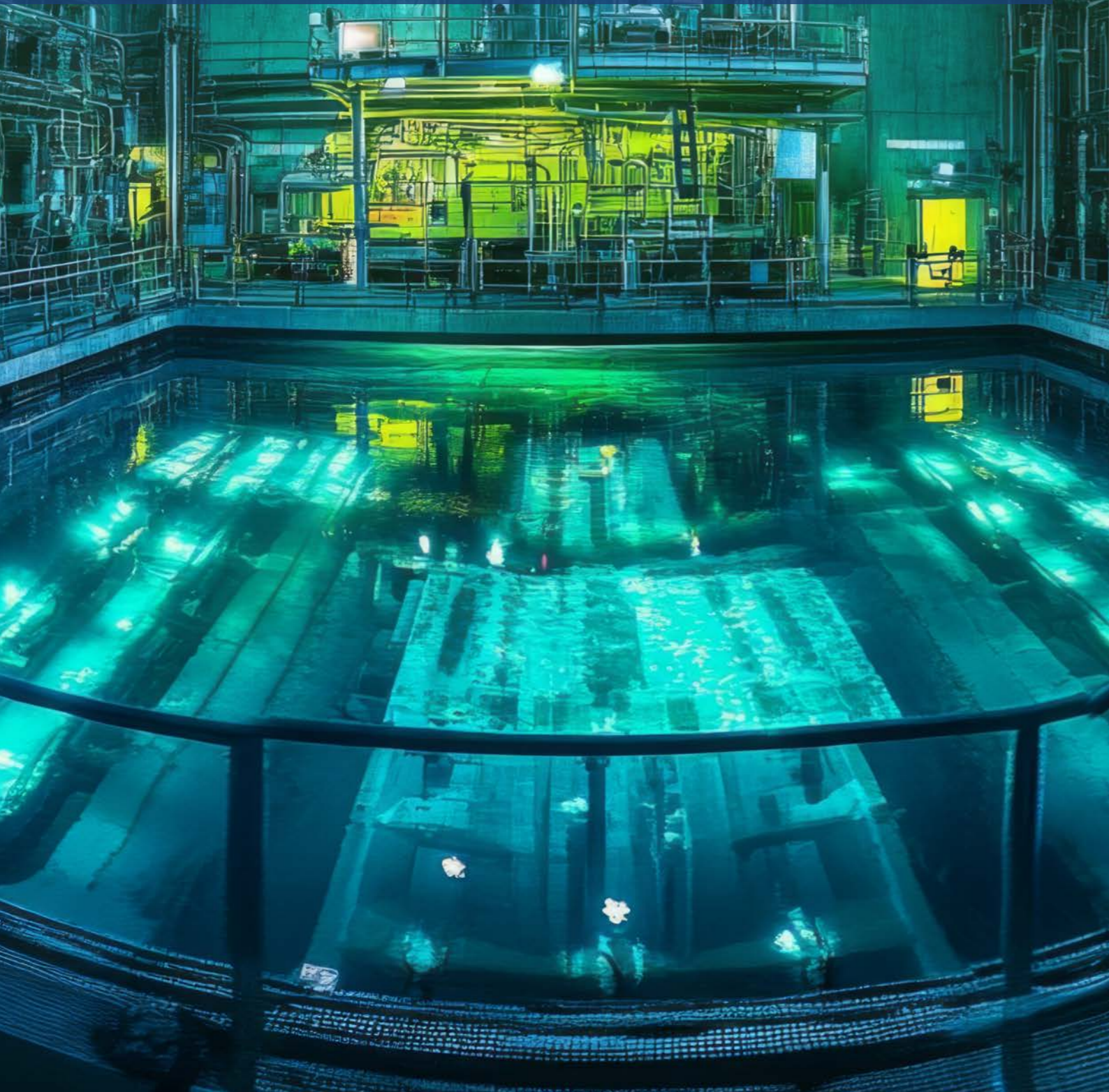
Left: Computational domain and mesh with the fracture network represented as ellipsoids.

Middle: Solute concentration profile [mol/m<sup>3</sup>] computed on the fracture network.

Right: Darcy velocity profile [m/s].

Core Science Theme:

# Environmental Radiochemistry



## Summary

The Environmental Radiochemistry theme is aligned with the high hazard risk reduction missions for legacy ponds and silos at Sellafield, identifying methods to reduce our environmental impact and supporting better-informed decisions on the management of legacy wastes.

## Core Science in Focus

Our work focuses on understanding how radionuclides behave across a range of environments. This is a critical aspect of safely decommissioning nuclear facilities, treating effluent streams, and managing waste storage, treatment and disposal. Such knowledge is essential for safeguarding the environment from the hazards posed by radiotoxic elements.

Experimental work is currently concentrated in two areas:

### 1) Radionuclides in engineered environments

We are continuing experiments to improve our understanding of uranium corrosion products (UCP) and their interactions with magnesium species found in legacy waste environments. These interactions can influence the mobility of the UCP and associated alpha-bearing actinides in effluent streams.

### 2) Radionuclides in natural environments

Looking to longer-term environmental solutions, we are developing skills and methods to study the interaction of radionuclides with natural sediments, with relevance to contaminated land and ultimately, geological disposal of radioactive wastes. We are working with the British Geological Survey to select and source materials of interest.

We are investing in our analytical capabilities to support studies in challenging environments – including improvements to our time-resolved laser fluorescence spectroscopy (TRLFS) instrument to enable actinide speciation measurements under relevant alkaline conditions.

Staff training and development remains a core objective of the theme and we are planning our programme so that it contributes to the professional development and accreditation of early career researchers, helping to develop the next generation of subject matter experts.

To complete the experimental work, the Environmental Radiochemistry theme also supports a modelling programme to translate our understanding into predictive tools. This ranges from mechanistic chemical and microbiological processes to larger-scale reactive transport simulations.

# Case Study : Developing the Central Laboratory Time-Resolved Laser Fluorescence Spectroscopy (TRLFS) Capability

## Challenge

UKNNL currently provides support to Sellafield Ltd in effluent and environmental radiochemistry.

This includes understanding how radionuclides behave in challenging environments, a critical aspect of safely decommissioning nuclear sites, treating effluent streams, and managing waste storage, treatment, and disposal.

Robust knowledge of radionuclide chemistry underpins efforts to protect the environment from radiotoxic hazards, and maintaining and developing our environmental radiochemistry capabilities is essential to address a range of environmental challenges at the Sellafield site.

## Solution

To strengthen these capabilities, UKNNL has invested in re-establishing the time-resolved laser fluorescence spectroscopy (TRLFS) capability in the active laboratories at Central Laboratory. This has included upgrading both the laser system and spectrometer, with further enhancements planned.

TRLFS is a highly sensitive technique that uses pulsed laser excitation to probe the chemical environment of metal ions by measuring their fluorescence over time.

It is particularly effective for studying reactions between radionuclides and coordinating ligands (the chemical species in solution that bind to a metal and control its behaviour), even at very low concentrations.

For certain species, TRLFS offers unparalleled detection limits for examining chemical interactions. The installation of the system within a fume hood at Central Laboratory provides a unique capability for analysing high-activity samples safely.

## Technology

The TRLFS system at Central Laboratory uses an optical parametric oscillator (OPO) to tune the excitation wavelength across a broad range, enabling the selective study of different elements and species. Laser light is delivered into the fume hood via a mirror system, with the emission detected by an intensified CCD detector coupled to a spectrometer, providing high spectral and temporal resolution.

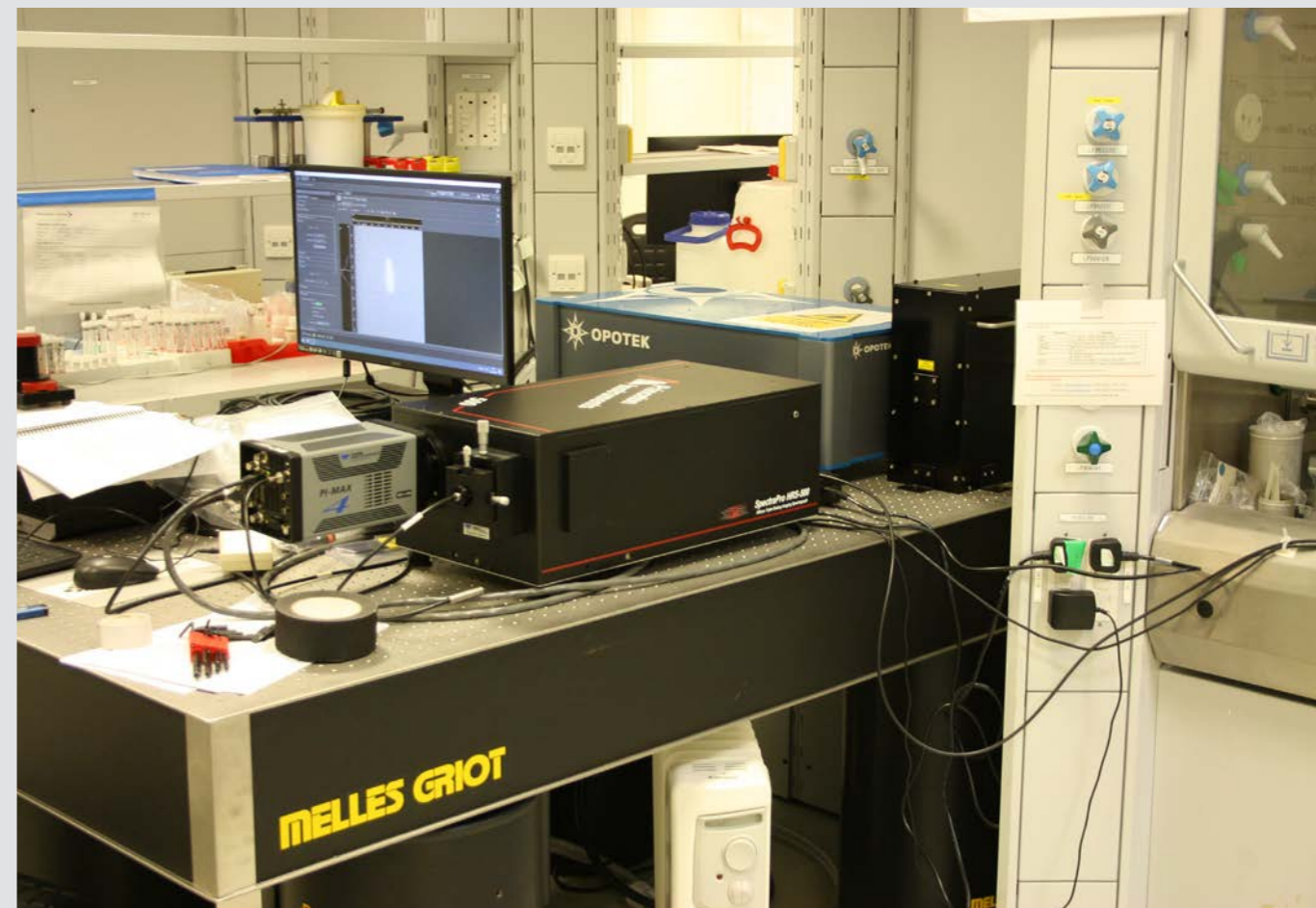
The spectra and fluorescence lifetimes obtained give us insight into the atomic coordination environment of radionuclides – for example, the number of ligands bound under specific conditions, in both solution and solid phases. This information can be used to determine thermodynamic properties such as stability constants. Due to its sensitivity, TRLFS is widely regarded as one of the most powerful techniques for deriving such data.

## Outcome

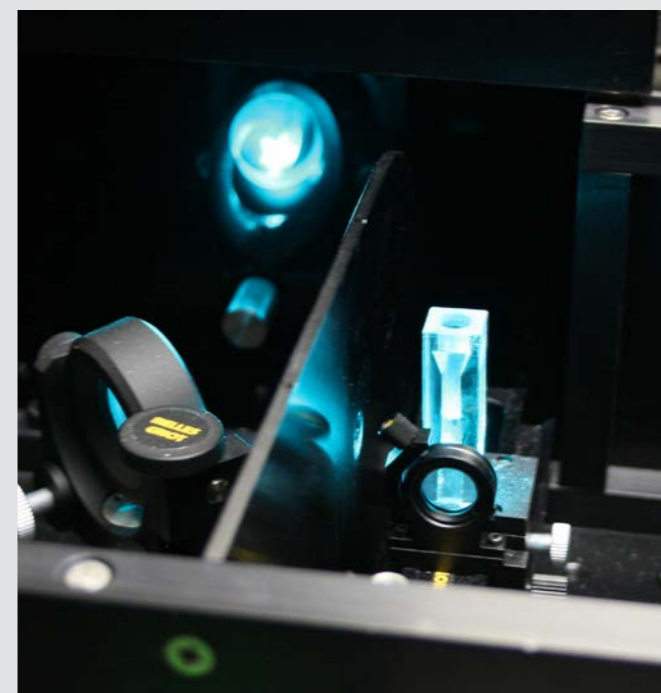
This year, work within Environmental Radiochemistry theme is focused on studying the Am(III) ion in solution to refine the method and derive stability constants relevant to effluent treatment and other environmental systems.

Future work could extend to other radionuclides such as uranyl(VI), Cm(III), and explore applications other technical areas, including thermal science.

Planned upgrades include replacing the current mirror-based beam delivery with fibre-optic cabling, which will improve detection limits and support analysis of more challenging samples.



The TRLFS Capability at UKNNL Central laboratory.



Examples of different excitation wavelengths enabled by the inclusion of the OPO in the UKNNL TRLFS capability.

Core Science Theme:

# Materials Performance

## Summary

Recognising that materials issues are often life-limiting for reactors, this theme targets the delivery of world leading scientific programmes to understand the behaviour of materials in an irradiation environment. Driving the theme's purpose are three key objectives:

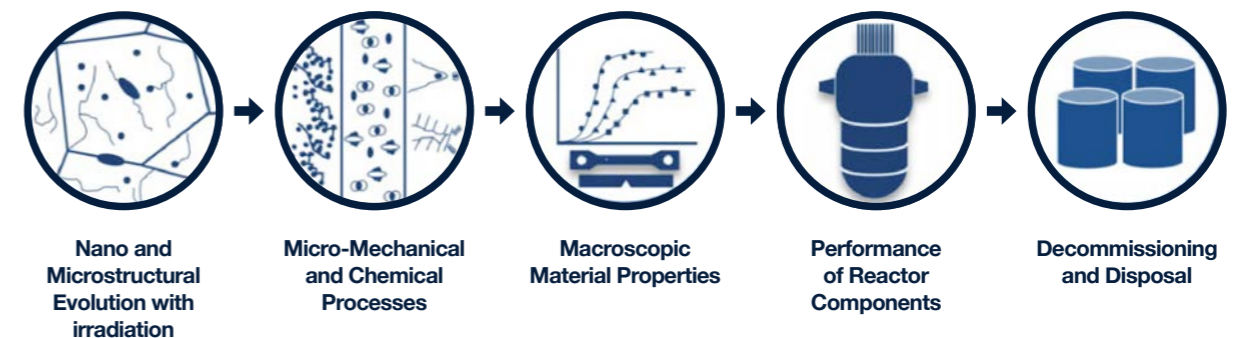
- to improve mechanistic understanding of in-reactor materials performance
- to support safety cases for plant operation, life extension and decommissioning strategies
- to develop capabilities to support reactor operations

The importance of this theme is highlighted by the knowledge that many components are non-replaceable and safety critical.

## Core Science in Focus

The work carried out under this theme is essential in helping to understand materials issues to ensure safe reactor operation, reduce conservatism to maximise plant lifetimes, maximise fuel usage, enable new reactor technologies, and reduce costs with innovative materials and manufacturing methods. Research performed by the theme is

directly relevant to a wide range of our collaborators and customers, including Sellafield Ltd, NDA, the MOD, ONR, and EDF Energy. Contribution from materials performance has demonstrated UKNNL's expertise in these areas and breeds a positive consideration towards continued collaborative work.



# Case Study :

## Minimisation of Graphite Waste Volume using the Nibble and Vacuum Technique

### Challenge

There are over 96,000 tonnes of irradiated graphite waste in the UK, most of which remains in the reactor building it served in. The current accepted method of removal is by keeping the graphite intact in the form of full bricks. However, this approach is limited as some bricks are deformed and due to significant reactor design differences, there is no universal full brick tooling. An improved method is therefore required for efficient and safe retrieval in the graphite decommissioning field, which can then inform future disposal options.


### Solution

A Nibble and Vacuum Retrieval method offers a potential route to addressing this graphite core removal challenge and is currently being investigated by PhD student Nathalie Edwards, co-funded by the University of Manchester and the Centre of Innovative Nuclear Decommissioning (CINDe). Following investigation of the retrieval method, integration of the Nibble and Vacuum Retrieval method with Hot Isostatic Pressing (HIP) as a combined disposal and immobilisation method was also explored.

### Outcome

Variables found to impact breaking down and collection of graphite during experiments included sample shape and mass, graphite type, vacuum distance, and angle from the graphite source. Encapsulating the particulate nibbled during earlier phases of the experimental work also enabled simulation of the full decommissioning process. Whilst ideally the volume of graphite being disposed of will be reduced through treatment, recycle or reuse (processes which require the graphite to be particulate), most contaminated material will have to go to a GDF. HIP was identified as an option to reduce the excess volume of waste to be stored, through using glass to immobilise the graphite pore network, reducing the risk of leaching during long term storage.

So far, the results have been encouraging. They indicate that high-density immobilised graphite and glass wasteforms can be successfully produced using nibbled material, without the need for any post-processing of the graphite particulate. Furthermore, this has been done with only 20% excess volume of encapsulate material required.



**My project is focused on the retrieval and disposal of reactor core graphite. The British Carbon Group Meeting was a great opportunity to share my work and get input from the wider graphite and carbon community.**

**Nathalie Edwards**  
University of Manchester

### British Carbon Group Meeting

The British Carbon Group hosted an Early Careers Researchers Meeting at the Royce Hub in Manchester on June 4th, 2024. As part of the event, presentations and posters were presented on carbon research, particularly graphite and graphene technologies. Nathalie attended this meeting and presented a poster

regarding the work undertaken as part of her CINDe PhD. Attending this meeting allowed Nathalie to meet other early-career researchers within the field of carbon-based research. It gave Nathalie the opportunity to ask questions to the wider research community about aspects of the project they deem to be

important which has helped to refine Nathalie's future experimental aims. The poster presentation sessions involved answering questions regarding the poster and Nathalie's PhD project and her poster won the Early Careers Researchers Meeting Poster Competition.



Graphite and glass HIP can at various processing stages: packing; bakeout; crimping; post HIP.

Core Science Theme:

# Nuclear Safety

## Summary

Across the nuclear industry, we work with inherently hazardous materials, making it essential that all operations are carried out with the highest safety standards to protect our colleagues, the public, and the environment. Achieving UKNNL's environmental restoration goals and delivering impactful nuclear science to benefit society demands innovative approaches.

To enable such work, robust and fit-for-purpose safety cases are essential. This underscores the importance of our nuclear safety specialists continually developing their expertise and influencing industry best practices to ensure these safety cases support progress without compromise.

Through UKNNL's Core Science investment, the Nuclear Safety Theme focuses on thought leadership and

advancing research in areas where improvements in safety assessment deliver the greatest impact on risk reduction and operational efficiency. As the industry moves toward the use of novel fuels and addresses complex challenges within geological disposal, improved validation of the codes and nuclear data underpinning criticality safety assessments is of growing importance.

To drive best practice in this area across the sector, UKNNL is leading the UK Working Party on Criticality's (WPC's) dedicated sub-group on sensitivity and uncertainty (S/U) tools and techniques, helping to shape national capability and confidence in this essential area.

## Core Science in Focus

Ensuring risks are as low as reasonably practicable (ALARP) is the cornerstone of UK health and safety law. Whilst the flexibility of the ALARP principle offers many benefits, its non-prescriptive nature can sometimes lead to inconsistent interpretations, overly cautious assessments, and challenges in defining clear thresholds for acceptable risk, potentially complicating decision-making.

The Nuclear Safety CST is addressing this challenge by building an internationally recognised capability, focused on delivering fit-for-purpose nuclear safety solutions with approaches that are proportionate and evidence-based, and commensurate with the ALARP principle.

This leadership is demonstrated through the development of new standards, guidance and methodologies; through targeted research that reduces conservatism; and through investment in the next generation of nuclear safety Subject Matter Experts (SMEs), to ensure sustained excellence across the sector.

# Case Study :

## Leading a UK Expert Group on Criticality Code Validation

### Challenge

Criticality safety assessments based on computational modelling must account for any uncertainty or bias in the code and nuclear data with an appropriate safety margin.

Safety margins are well established for routine fuel materials; however, a significant challenge is posed by novel fuel materials which are not as well-validated (given the paucity of real-world criticality experiments).

It is therefore essential that any uncertainties and bias are well understood to prevent potential over-conservatism in the safety margin, not least because this may have a significant impact on the facility design and throughput. There are various techniques for determining an appropriate safety margin for less well-validated systems, some of which are relatively recent developments (particularly emerging S/U tools). However, there is a lack of consensus across industry on good practices relating to these tools.

### Solution

For conventional fuel systems such as uranium oxides moderated by water, a substantial library of critical benchmark experiments exists, enabling accurate and confident calculation of the safety margin using criticality safety codes.

However, as the nuclear industry progresses toward advanced fuel compositions like silicides, carbides, and nitrides; novel fuel forms such as High Assay Low Enriched Uranium (HALEU) and TRI-structural ISOtropic (TRISO) fuels; and increased crediting of burn-up in applications such as geological disposal, the lack of relevant real-world benchmark experiments becomes a significant challenge. In the absence of applicable experimental validation, an additional bias is incorporated into the safety margin.

Yet there is growing concern that traditional approaches of calculating that bias may lead to overly conservative and potentially limiting criticality safety cases, underscoring the need for a more balanced and fit-for-purpose validation approach (particularly for new industry developments).

In recent years, with advances in computing power, there has been an emergence of S/U tools in both national and international criticality safety codes. These are powerful automated techniques that can enable a deeper understanding of how input uncertainties (e.g. in nuclear data) affect the reactivity of the system, enabling more robust quantification of the required bias.

However, there has been some reticence in the adoption of these techniques in the UK; the quality and reliability of the results are heavily dependent upon the appropriateness of the underpinning models and datasets (potentially undermining the confidence that such techniques are meant to enhance) while S/U tools can be complex to implement and interpret (with a risk of over-reliance on the quantitative outputs without sufficient consideration of the broader context).



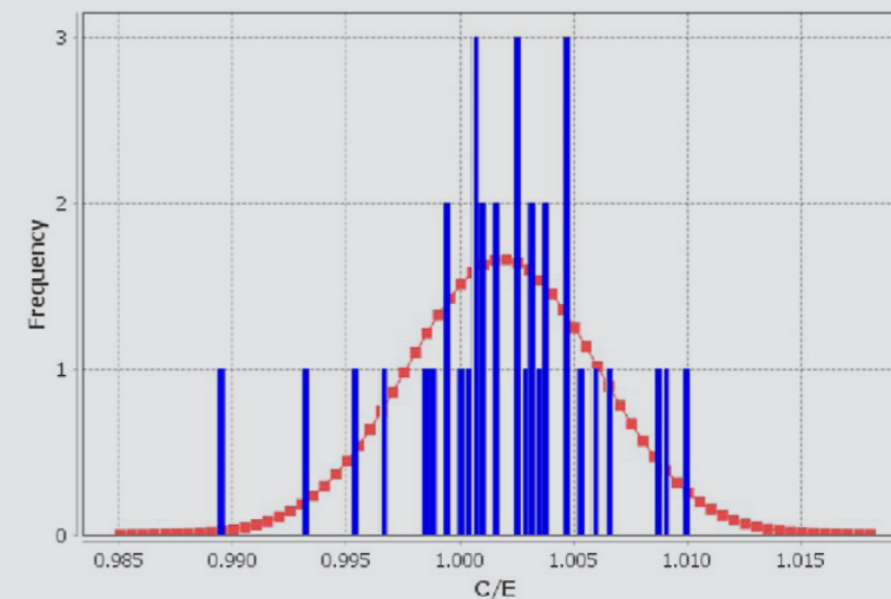
### Outcome

To address these concerns, UKNNL is leading a UK WPC sub-group to harness the collective expertise of SMEs from across industry, in collaboration with regulatory stakeholders. The group is undertaking a comparative review of the various validation techniques available to criticality safety assessors, evaluating the strengths, limitations, and appropriate application of each.

This work will culminate in the development of a Good Practice Guide (GPG) to support consistent, defensible, and efficient use of validation tools across the sector.

Recognising the limited pool of expertise in this area, the group is also focused on education and knowledge transfer – helping to build capability, share learning, and ensure sustainability of this niche criticality safety skill.

Ultimately, appropriate use of these tools will ensure that safety margins are evidence-based and proportionate, minimising unnecessary operational constraints while maintaining high safety standards.



Example output of ANSWERS® Visual Workshop 5A Validation Database Viewer comparing calculated (C) and experimental (E) results for a set of benchmarks.

Core Science Theme:

# Robotics



## Summary

The Robotics CST aims to develop scientific underpinning that enables safe and effective adoption of innovative robotic technologies for cross-cutting applications within nuclear through a strategic focus on solving current and emerging nuclear decommissioning challenges.

## Core Science in Focus

Nuclear decommissioning is a key priority both within the UK and internationally. Robotics has been identified as a key enabler to the completion of these activities due to the need to remove humans from harm and the challenges associated with remote access into highly hazardous environments.

The rapid advancement of robotic technologies introduces new ideas and solutions for their use in nuclear operations, spanning activities such as remote inspection and characterisation, waste sorting and segregation, nuclear waste management, dismantling and decommissioning.

UKNNL's robotics capability draws upon its extensive nuclear experience to deliver integrated robotic solutions that stretch across the full TRL domains, from fundamental research to full plant deployment, through the provision of supporting functions in safety case, engineering, modelling and software development etc.

UKNNL's Robotics CST supports this capability through applied research, primarily across TRLs 3-6, to address current and future needs of the nuclear industry.

A key focus is on carrying out scientific analyses for the development of tools, techniques, and methods that support the integration and deployment of digital technology (including aspects of machine learning and AI) and novel robotics solutions (such as mobile, collaborative, soft, and continuum robots) in a safe and reliable manner given the hazards and security requirements associated with operational nuclear facilities.

The programme balances investment across internal research projects, collaboration with academic/industry partners, funding of PhD research projects, development of talent, and dissemination of learning to the UKNNL robotics community.

Skills and capability development within the theme deliver direct benefit to industry stakeholders through commercial projects, transfer of R&D outputs to capability (with support from the Environmental Restoration Focus Area) and wider strategic, research, and collaboration initiatives.



# Case Study :

## Chairing of the National Committee on Robotics Regulations and Standards (NCRRS)



### Challenge

Robotics and Autonomous Systems (RAS) are crucial throughout the nuclear industry for tasks which must take place in hazardous environments, including inspection, maintenance, and decommissioning.

However, the deployment of RAS solutions within the industry can be hampered by systemic challenges which prevent their development, particularly for emerging technologies.

Robots can come in many different shapes and sizes, with widely varying behaviours and capabilities. Many of the most successful robots are hiding in plain sight in the form of Smart Machines - intelligent, semi-autonomous systems that integrate seamlessly into the physical world with people, such as washing machines, connected smart cars and drones. Those with embodied intelligence and mobility can exhibit behaviours such as autonomy, collaboration and swarming; and as such the future narrative is shifting from "RAS" to "Smart Machines".

Smart Machines have the potential to revolutionise diverse sectors of the UK economy; and as such a requirement existed to establish a UK national capability to accelerate knowledge exchange, drive regulatory reform, enhance skills, and share best practice that can ensure lessons are shared and used cross-sector to benefit the national agenda.

### Solution

Representing UKNNL's Robotics Capability, Howard Chapman co-chairs the National Committee on Robotics, Regulations and Standards (NCRRS) alongside the Health and Safety Executive (HSE) and University of Birmingham, enabling the collaboration of regulatory bodies and public infrastructure organisations. This is supported by a cross-sector industry working group of organisations driving RAS implementations.

The NCRRS was formed as a direct response to a priority recommendation of the UK Cross-Sector RAS Development Task Force, which is an EPSRC UK-RAS Network funded project that brought together a cross-section of public and private organisations investigating or investing in smart machines and RAS.

In March 2025, the NCRRS published a report "Compliance Pathways: Robotics, Autonomous Systems and Smart Machines" detailing their work on behalf of the Department for Science Innovation and Technology (DSIT) into the development of the compliance pathway for Smart Machines in the UK.

This work took the form of an extensive consultation with a range of regulators, end users and developers on their experience of Smart Machine deployment under the UK's existing regulatory framework.

It followed precedent work by the NCRRS on "Transforming the Route to Market", a UK-RAS White Paper which documented experiences with the NCRRS's community of interest covering 16 areas of economic activity. This work highlighted regulation as a barrier to progressing deployment of Smart Machine technologies, citing a lack of consistency and clear guidance that inherently invokes a risk-averse response.

The work documented in the UK-RAS White Paper was deemed unique due to the range of regulators and end users engaged in the consultation, therefore was seen as having the potential to set a precedent in the way Smart Machines are deployed. The experiences of those contributing to the consultation aligned with the findings of the UK Government expressed by HM Treasury (HMT) and the Regulatory Horizons Council; that the regulatory landscape inhibits innovation, specifically in the deployment of Smart Machines.

Both end users and developers reported that they struggled to understand which regulations or combination of regulations may be relevant, and that there was little or no guidance, best practice, or experience to guide their journey. In those cases where Smart Machines have reached full deployment it has often been as a result of special dispensations or unique regulatory environments.

### Outcome

The consultation found that if the full economic benefit of Smart Machines is to be realised, as set out in the "Robotics Growth Partnership (RGP) Smart Machines 2035 Strategy", then transformation of the compliance pathway for smart machines is an essential prerequisite.

The report recommended that a detailed regulatory scan be conducted to identify where and how legislation and regulatory barriers are inhibiting smart machine adoption; and to identify how regulation can be used to enhance uptake.

The report highlighted two key barriers: specific statutes and associated regulatory mechanisms that directly or indirectly limit or prohibit the operation of Smart Machines in public spaces and in the workplace; and incompatibility and misalignment between different statutes and regulatory mechanisms that can create obstacles that are insurmountable or severely limiting.

The support of the Environmental Restoration Focus Area has enabled me to fulfil my lead role as the co-chair of the NCRRS allowing my expertise in Compliance and Assurance to be recognised across a wide range of industries; and has resulted in a number of collaboration opportunities being identified for UKNNL with ONR/HSE, Cranfield, York University and other leading organisations.

**Howard Chapman**  
Principal Safety Consultant,  
Safety Engineering & Assessment



Attendees at the National Committee on Robotics Regulations and Standards Workshop (courtesy of University of Birmingham)

Core Science Theme:

# PARIS (Plutonium, Advanced Recycle and Isotope Separation)

## Summary

PARIS aims to develop internationally recognised capabilities and generate impact by integrating customer and internally funded R&D projects. Key areas of interest include advanced reprocessing of spent fuel and recycling of actinides for future closed nuclear fuel cycle options, plutonium characterisation and storage science, and separations of other isotopes of potential value for non-fuel cycle applications.

## Core Science in Focus

The theme has key objectives to:

- Extend measurement and analysis capabilities for actinides in solution
- Understand the characteristics of long-stored plutonium under conditions relevant to the UK stockpile
- Support PhD and PDRA projects based at strategic universities, supported through PARIS and national funding bodies
- Provide opportunities for earlier career researchers to develop towards SME status and develop their practical "alpha skills"

The theme supports key industry challenges:

- Building capability and knowledge of advanced nuclear technologies with enhanced safety and sustainability by virtue of fuel recycling and reducing wastes for disposal
- Understanding routes to production/ isolation of key isotopes/elements using non-reactor-based technologies
- Safe and secure storage of plutonium
- Disposition of UK plutonium

PARIS is strongly aligned to key customers including Sellafield Ltd for the safe and secure storage of plutonium and the NDA for plutonium disposition. PARIS has also been very successful in participating in European programmes from FP5 to Horizon 2020.

Some of the key collaborators for the PARIS Theme include the Universities of Manchester, Lancaster and Leicester; the French CEA; US national labs PNNL and INL; EU Joint Research Centre at Karlsruhe; German labs Jülich and KIT; ANSTO, Australia; and OECD-NEA.

# Case Study : Modelling of a PuO<sub>2</sub> Can in the Presence of Moisture Using a Method of Manual Discretisation

## Challenge

Plutonium packages at Sellafield have the potential to contain residual moisture. This can then adsorb onto the powder and under certain conditions can be subject to radiolysis, leading to production of hydrogen and less commonly oxygen.

The challenge here was to develop techniques in modelling this effect, to determine the extent of moisture uptake by PuO<sub>2</sub> during plant operations and its implications for the behaviour of the sealed packages in subsequent storage.

This information can support the safety case defining conditions that will avoid potential pressurisation and/or formation of flammable atmospheres.

## Solution

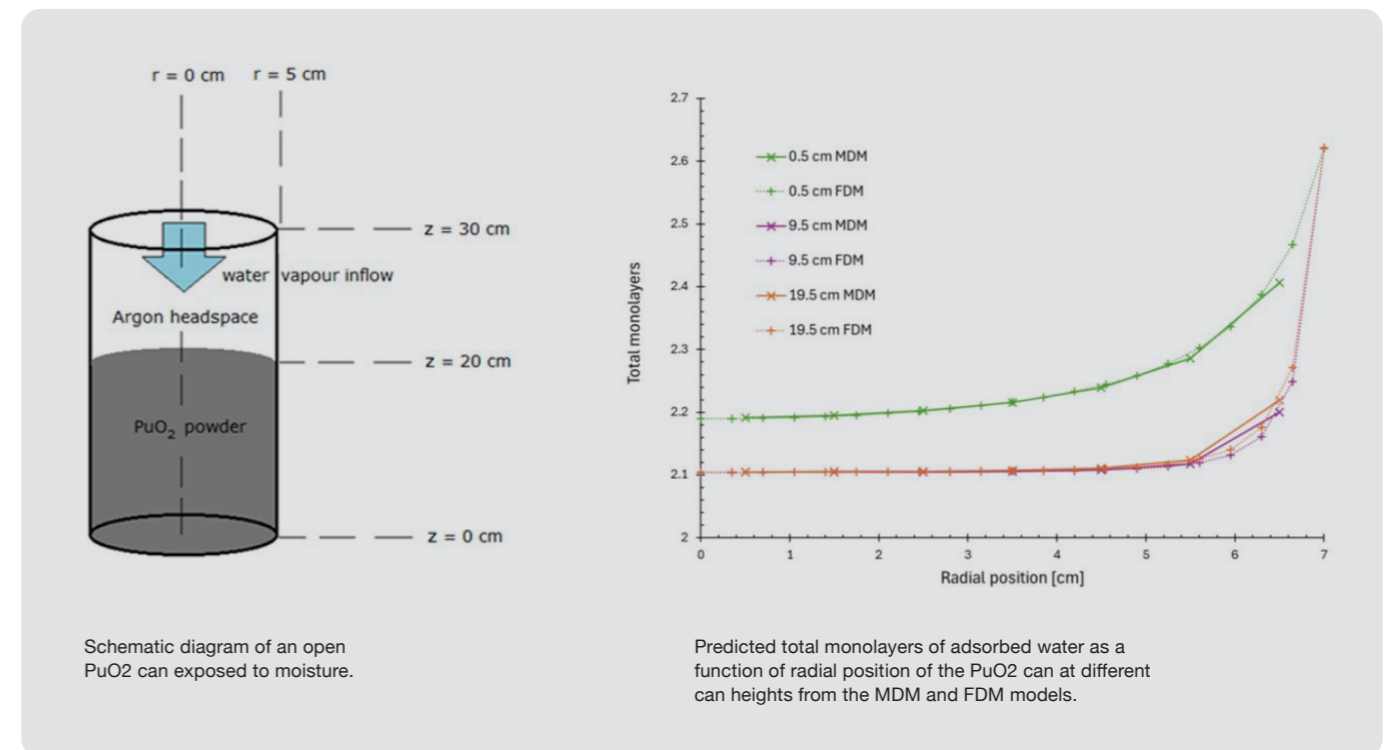
The scope of this work included modelling of an open PuO<sub>2</sub> can in the presence of moisture using a method of manual discretisation (MDM model) and comparison of results to those from a previous model which used finite difference methods (FDM model) in order to develop modelling technique in this area.

Both the MDM and FDM models represent an open inner PuO<sub>2</sub> can in an Ar atmosphere, exposed to ~21% relative humidity. Simulations were run until equilibrium, with a range of can properties predicted including adsorption of water, temperatures, relative humidity and partial pressures of water vapour, oxygen and hydrogen.

## Outcome

Generally, there was good agreement between results from the MDM and FDM models. With relatively coarse discretisation (2400 nodes for the FDM model and 210 cells for the MDM model), both models ran at modest computational expense. However, the MDM model predicts faster diffusion of moisture through the powder bed, slightly greater relative humidities and higher adsorbed water at can boundaries.

This work has expanded UKNNL's capabilities in modelling PuO<sub>2</sub> cans to support potential future work, upskilled early career modellers and is facilitating discussions with Sellafield Ltd.



Core Science Theme:

# Thermal Treatment

## Summary

The Thermal Treatment CST has a key role to play in nuclear waste clean-up and nuclear material management and disposal. Thermal treatment uses elevated temperatures to alter the chemical and physical properties of a waste material to reduce its volume and improve its safety and stability for storage and disposal, whilst reducing the costs associated with waste management. Ultimately, the strategic goal of this CST is to develop capability to support the development of this transformative technology and perform thermal wastefrom research and development to underpin its disposal.

## Core Science in Focus

UKNNL's Thermal Treatment theme carries out essential work involving thermal product fabrication, characterisation, and analysis to support wastefrom thermal technology.

Thermal technologies are flexible in the production of a range of products including glass wastefroms, ceramics and glass ceramics.

UKNNL has leading materials experts in both glass and ceramic science and the theme is driven to expand our capabilities and knowledge transfer to early career colleagues.

Existing thermal technologies operated by UKNNL include hot isostatic pressing (HIPing), Geomelt®, cold-press and sinter (CPS), MOx fabrication and the Vitrification Test Rig (VTR) in support of Waste Vitrification Plant (WVP).

Both within the UK and internationally, UKNNL's collaborative work enables a boost in the expertise held to continuously improve the capability.

In turn, this area of work significantly helps us to align our research to the needs and priorities of our key customers such as Sellafield Ltd.

### The key objectives for this theme are:

- Develop a future UKNNL workforce with the necessary skills and experience in the fabrication, characterisation, analysis and modelling of thermally treated materials and products (especially active)
- Align our research with the priorities of our customers and regulators to demonstrate the significant benefits of thermal treatment to realise future opportunities for the business
- Create long-term and productive collaborations with academic and other strategic research partners to influence the UK (and global) agenda

# Case Study : Impact of Hot Isostatic Pressing (HIP) canister preparation on the Canister-Ceramic Interface Region

## Challenge

Zirconolite is one of the potential ceramic wasteforms currently being considered for plutonium immobilisation and disposal. Therefore, work must be carried out to underpin the potential effects that the manufacturing process, i.e. hot isostatic pressing (HIP), can have on wasteform quality.

One potential impact on quality highlighted in the literature is the formation of secondary phases at the interface between the ceramic material and the stainless steel canister. However, the literature exploring this area is sparse and the overall impact of the effect is unknown.

## Solution

This work investigated whether the HIP canister preparation route influences the growth of this interfacial layer. Additionally, it served as a test bed for sample preparation methods to improve confidence in conducting similar analyses on active samples.

The thickness of the interfacial layer was estimated using a new image analysis technique. This method requires a binary map of an BSE (back scattered electron) SEM image; this image is then binarised via a thresholding function.

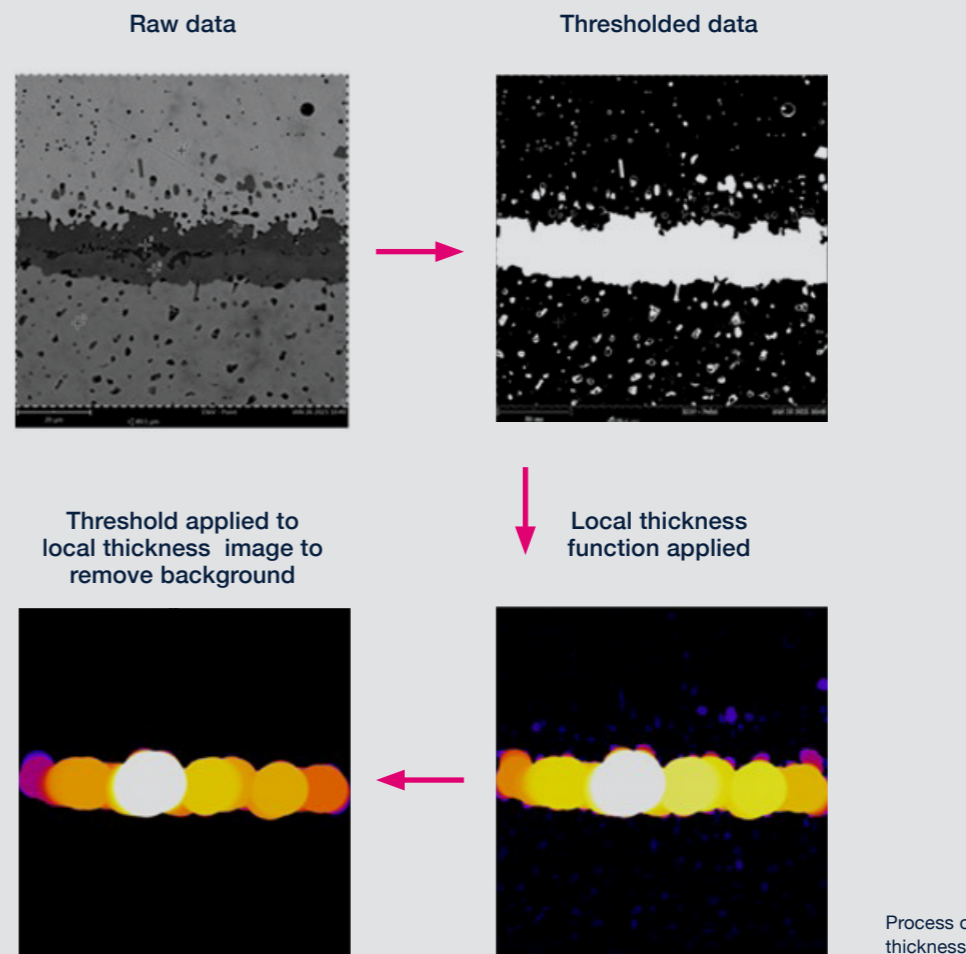
Once a binary map is produced, the local thickness package is used to calculate a thickness distribution. This plugin works by finding the largest diameter circle that fits inside the object.

Data smoothing is required, which used another thresholding stage to remove the small diameter pores. The full process is illustrated in the Figure opposite.

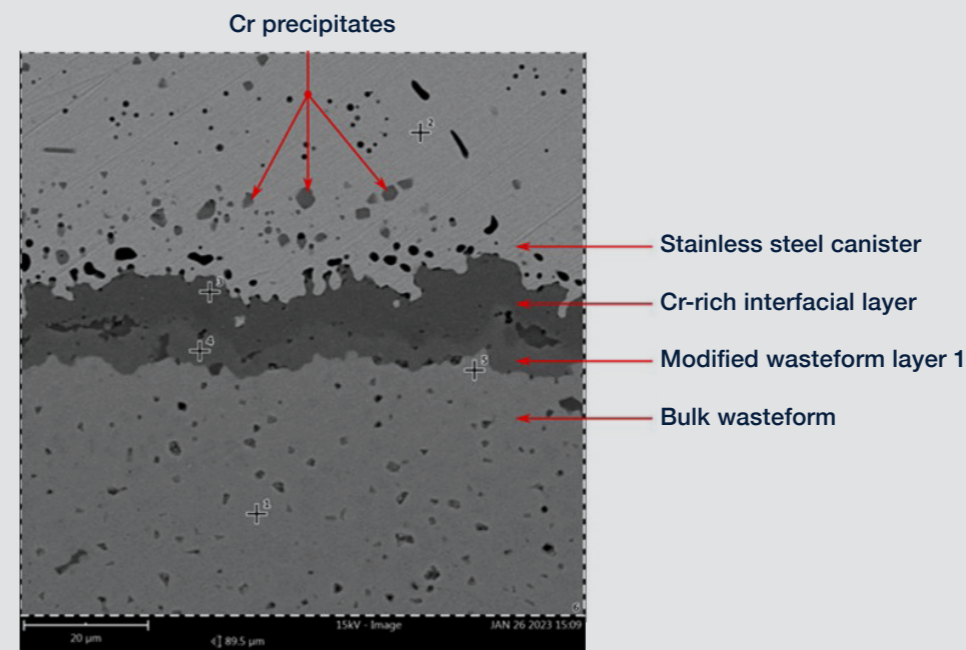
## Outcome

The work carried out confirmed the structure of the interface region and reaction layers reported in the literature and as shown in the SEM image below. However, it also showed that the thickness of the interfacial layer remained constant across a range of canister preparation conditions indicating no link between parameters.

Work revealed that samples processed at ambient conditions resulted in the ineffective removal of isopropyl alcohol that destabilised local phase equilibrium. This indicates that canister preparation must be completed at higher temperatures to ensure equilibrium phase conditions are achieved.



Process of extracting thickness values



SEM image of the various reaction layers forming at ceramic-canister interface

# Innovation



## Summary

Innovation continues to be one of the fundamental pillars underlying the foundation of the Science and Technology Agenda at UKNNL. There is an enthusiastic culture to create and encourage an environment in which our people feel inspired to innovate. Innovation at UKNNL has a constant aim to explore new ideas and interests for developing new solutions.

Aiming to create a space to think and provide access to funding through a clear process that takes ideas through technology readiness levels to product delivery, the Innovation programme was created to construct a productive and broad-ranging innovation portfolio, addressing the needs of our customers, the industry, and UKNNL as an organisation. In 2024/25 the number of ideas at each stage has increased over the previous year.

The Innovation team uses a proven, clear process to take ideas through the technology readiness levels to product delivery. This provides an optimistic environment to really assess the merit of ideas for commercialisation.

There are three distinct funding levels:

- **Innovation Primer** – supporting early stage ideas with up to **£2,500** funding to allow a review of scientific material to validate the proposed idea
- **Innovation Builder** – supporting initial proof of concept trials, prototypes with awards of **< £25,000**
- **Innovation Delivery** – enabling commercialisation through product development with awards of **> £25,000**

### Approved and funded Primer applications

**19** **26**  
FY23/24 FY24/25

### Approved and funded Builder applications

**7** **10**  
FY23/24 FY24/25

### Approved and funded Delivery applications

**0** **1**  
FY23/24 FY24/25

### Overview of the innovation programme's funding streams

	Primer	Builder	Delivery
Purpose	Idea stimulation	Prototype	Commercialisation
Award size	< £2,500	< £25,000	> £25,000
Duration	2 months max	12 months max	Unlimited
Review time	1 week	4 weeks max	6 weeks max

# Case Study : Ultrasonic Decontamination Technology

## Challenge

Decontamination is a crucial tool to enable the progress of decommissioning at nuclear facilities. Several facilities will require reduction in the radiological hazard prior to access, with decontamination also providing a pathway for waste reclassification lightening the burden on final disposal.

Decontamination requirements vary significantly between scenarios, which necessitates an equally diverse range of methods and techniques to address these needs. Conditions where deposits may arise, for example through use of grease, solvent, or paint, can be a particular challenge.

In such cases the solids need to be broken up to enable them to be displaced and removed from the area. This can often be time-consuming process which may take several different methods, or application cycles to fully decontaminate.

## Solution

Alongside collaborators, UKNNL carried out research to explore the use of low-frequency ultrasound equipment to aid in the displacement of deposited solids and have since developed a device suitable to be used in the harsh chemical and radiological environments found on nuclear sites.

The device applies ultrasonic frequencies (20 kHz – 2 MHz) to produce small bubbles which readily collapse, generating localised high pressures and temperature to accelerate chemical reactions and enhance decontamination. This is a technique is referred to as ultrasonic cavitation.

## Outcome

This ultrasonic material has the potential to accelerate decontamination of wastes in much shorter time scales, reducing decontamination process from days to minutes, reducing both hazard and cost.

Work is continuing to demonstrate the technology at the UKNNL Preston Facility on a variety of challenges, including technology advancements in its for scenarios requiring submersion under water.

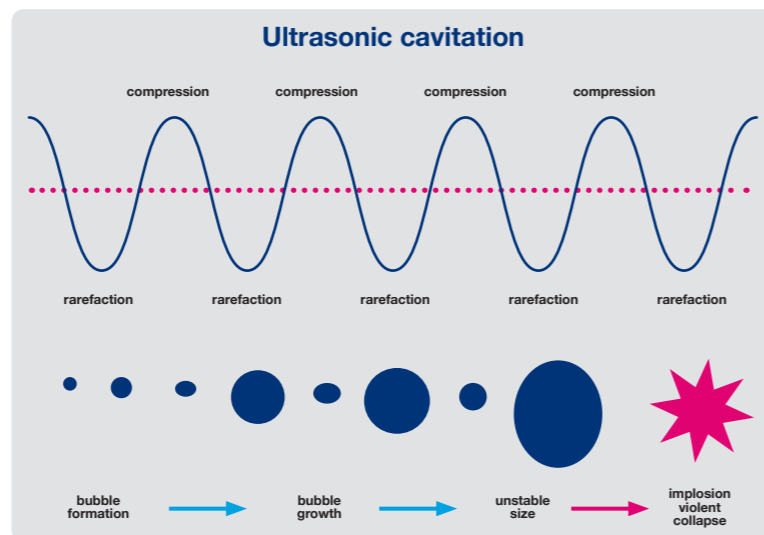


Diagram showing the Ultrasonic cavitation technique



# Strategic Research

## Summary

Strategic Research delivers programmes aimed at collaborative interventions to sustain skills and develop capabilities needed to address national nuclear technology challenges. It aims to implement large scale research programmes which provide training and development of nuclear scientists and engineers across the sector, whilst enabling strategic collaborations, maintaining national infrastructure and supporting growth of new capabilities.

In collaboration with our partner organisations, we currently help deliver two Strategic Research programmes which align with Environmental Restoration – Advanced Nuclear Fuel Cycle Research and Alpha Resilience Capability (ARC).

## Advance Nuclear Fuel Cycle Research

UKNNL is working to develop skills, knowledge, and capabilities in the areas of advanced nuclear fuels, recycling and waste management. This involves development of new technologies and processes which contribute towards a reduction in the whole lifecycle costs of nuclear energy. The programme also aims to ensure international co-operation with an emphasis on promoting and maintaining the position of the UK as a global leader in areas advanced nuclear fuel cycle research.

In 2024 the International Atomic Energy Authority (IAEA) redesignated UKNNL as its sole Collaboration Centre on Advanced Fuel Cycles. This will enable continued collaboration for a further four years (2024-2028) on future fuels and sustainable fuel cycles and contribute to the recycling of nuclear fuel for advanced and innovative reactors,

UKNNL have also continued to play a key role in the Working Party on Scientific Issues of Advanced Fuel Cycles (WPFC) Expert Group on Fuel Recycling and Waste Technology (EGFRW). The EGFRW focuses on the separation processes relevant to recycling technologies for spent nuclear

fuel and helps to drive collaborative international efforts to progress their deployment.

Research has also continued on within UKNNL facilities following the success of the Advanced Fuel Cycle Programme (AFCP), particularly in areas of Recycle and Waste.

An electrochemical oxidation process, ELENDRES (Electrochemical Enhancement of Nuclear Decontamination Solutions) has been under development within UKNNL for the treatment of decontamination solutions and destruction of contaminated organics (e.g. solvents, oils, complexants). Routes to dispose of these types of materials have traditionally been difficult to access and are also potential blockers for the use of innovative and novel solvents for future recycling flowsheets. So far the technique has been trialled on inactive organic materials, however the ELENDRES technique is currently being recommissioned in the Decontamination and Decommissioning Laboratory at UKNNL Preston to allow for active testing to be conducted.

## Alpha Resilience Capability (ARC)

The ARC programme is a partnership between government, nuclear operating companies, and the wider nuclear industry. It ensures the UK has the capability and capacity to enable Alpha related programmes. This allows for the de-risking of the UK current Alpha programmes and sustains growth in UK's leadership in managing complex Alpha projects.

ARC-DARTS (Development of Alpha Resource Technical Skills), a sub-project, supports the development of future Subject Matter Experts (SMEs) in a fragile skills area. This has enabled SME development within UK through training, knowledge sharing, and networking.

A specific programme of work which UKNNL is delivering is focused on Decontamination Technology, with the aim of developing new technology for the sector, driving forward hazard and waste volume reduction, and allow for cross-organisation technology insertion.

# Case Study : Benchmarking of Decontamination Techniques to Facilitate On-site Deployment

## Challenge

Nuclear facilities require decontamination and decommissioning at the end of their usable lifecycle. A commonly encountered challenge is the down-selection of the best available decontamination techniques given the varied plant hazards, operational constraints and secondary waste routes available.

The performance of the available techniques is not always easy to compare, due to the range of scenarios in which they've been used. There is also scope to expand the number of available techniques to address the full spectrum of challenges found on nuclear sites through exploration of new innovative techniques which have the potential to out-perform established methods.

## Solution

Down-selection of the most effective technologies for each decontamination challenge can be aided by benchmarking assessment. Using standardised testing methodologies and datasets, a shared multi-discipline stakeholder understanding can be gained about each technology and its relative performance.

The SIMCON (simulated contamination) methodology was originally developed by Idaho National Laboratory and provides a means to assess different techniques in a non-radioactive environment on a 'level playing field'.

This methodology was utilised in a recent benchmarking assessment which compared 10 different decontamination technologies, inclusive of techniques utilised and not currently utilised on the Sellafield nuclear site. Following this assessment, the best performing techniques were then selected for specific 'active trials' on the nuclear site.

This work was carried out by Rob Mayhew, in collaboration with Sellafield Ltd, as part of the UK Alpha Resilience & Capability Programme (ARC) under the project DARTS (Development of Alpha Resilience & Technical Skills), to develop Subject Matter Experts (SMEs) for the UK Nuclear Sector.

## Technology

The SIMCON methodology of simulating contamination was used as a means of obtaining standardised non-radioactive test material for comparative decontamination trials. The methodology uses caesium and zirconium salts deposited on steel and can be tailored to simulate both loose and fixed contamination.

A range of established decontamination techniques commonly used at Sellafield Ltd were tested including Detex, Protectapeel E105, Decongel Sure, Radwipes, Decon90 and Internal Glovebox Cleaner (IGBC). Innovative techniques not currently used on site were also included in the benchmark trials – three cerium based chemical decontamination reagents supplied by FEVDI Nuclear (Aspigel 100, FevdiRad Ox5 and Cerimouss), and EASD (Electrolytically Assisted Surface Decontamination) Gel which is been developed within the D&D CST.

Coupons were analysed by electron dispersive X-ray fluorescence (ED-XRF) to obtain quantitative data on the contamination remaining on each coupon follow treatment with each decontamination technique. This data, in corroboration with stakeholder engagement with Sellafield Ltd, was used to down-select techniques that showed improved performance relative to established techniques and ease of deployment on-site.



Sellafield worker receiving training from UKNNL SME on use of decontamination techniques

## Outcome

Using the ED-XRF data, it was possible to rank the assessed techniques from most to least effective for both loose and fixed contamination. Benchmarking trials showed the majority of techniques were relatively effective at removing simulated loose contamination, but fixed contamination was overall more difficult to remove.

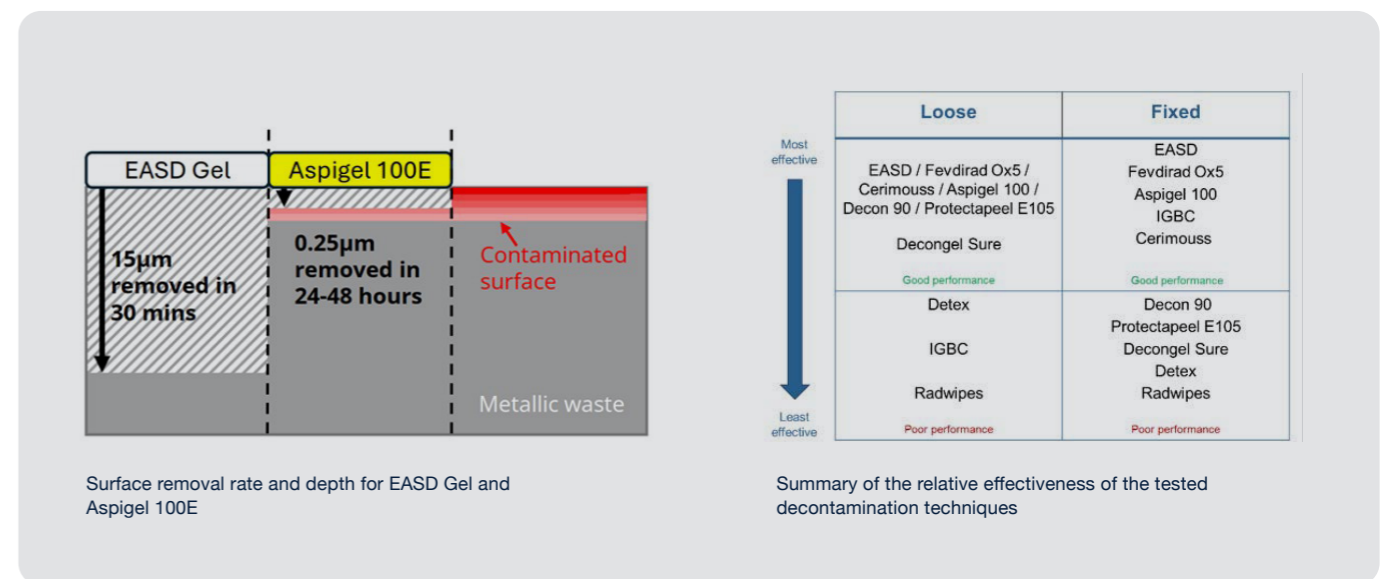
EASD Gel and Aspigel 100 were selected for further deployment testing based on the observed enhanced decontamination performance. Waste conditioning routes for both EASD Gel and Aspigel 100 have been developed, with cured solid gels being relatively easy to collect and encapsulate.

## Status

Technology 'scale-up' testing has been completed prior to an 'active trial' on Sellafield Ltd site within the First Generation Reprocessing Facility. Training sessions with operators from Sellafield Ltd were conducted by Thomas Carey, Theme Lead for Decontamination and Decommissioning CST, and Rob Mayhew who has been trained through the collaborator ARC-DARTS programme.

Sellafield operators gained valuable hands-on experience using both EASD gel and Aspigel 100 for treatment of metals, directly encapsulating the resulting solid waste form, and gaining an appreciation of waste volumes resulting from scaled up decontamination trials.

Active trials are planned for Winter 2025 which is anticipated to accelerate the use of both techniques to support on-going decontamination challenges across site.



# Collaboration



A core value of UKNNL, collaboration, continues to be fundamental in the way the organisation operates, aiming to nurture and develop efficient and successful partnerships by bringing together customers, researchers, academia and government.

Successful collaboration helps to drive progress towards the intention of delivering a global step change in environmental restoration.

UKNNL demonstrates taking responsibility for ensuring a safe and clean environment for generations to come, by committing to the development of novel technologies and the people who work with them.

This is enabled and enhanced through pursuing additional funding opportunities through routes such as UKRI both directly\* and via our network of engaged partners. This has been highlighted by UKNNL's success in being awarded funding for collaborative research with universities across our Science and Technology Agenda.

\* Since UKNNL became eligible for UK research and Innovation (UKRI) funding as a Public Sector Research Establishment in 2022.

# International Collaborations

## Summary

International collaborations are crucial to accelerate progress in tackling industry-wide challenges, both in the UK and further afield. UKNNL uses its investment into Science and Technology to support continued international collaborations in areas relevant to Environmental Restoration. Such collaborations allow a pathway to capturing the best available techniques, tools and science which is fundamental for faster and safer decommissioning.

On-going international collaborations which intersect with Environmental Restoration are the European Partnership on Radioactive Waste Management (EURAD2) and the Natural Environment Research Council (NERC) GeoSafe Project.

EURAD2 is the follow-on project from EURAD and PREDIS, and involves collaboration between UKNNL and several UK and international organisations. It is a European collaboration on safe radioactive waste management and covers all phases of the waste lifecycle. UKNNL is involved in multiple work packages focused on Sustainable Treatment and

Immobilisation of Challenging Waste (STREAM) and Radionuclide Mobility Under Perturbed Conditions (RAMPEC). Both work packages are closely linked to our CSTs – Decontamination and Decommissioning, Environmental Radiochemistry, and Disposal.

UKNNL is part of the NERC GeoSAFE project 'Towards Safe Geological Disposal of Radioactive Waste in Lower-Strength Sedimentary Rocks', that is led by Imperial College London, in collaboration the British Geological Survey, and universities of Heriot-Watt, Leeds, Manchester, Liverpool, and Helsinki. The aim of the GeoSafe project, which is part of the GeoDraw

programme (Derisking Geological Disposal of Radioactive Waste), is to undertake fundamental research that will advance our understanding of the potential effects that the introduction of a GDF might have on lower strength sedimentary host rock. Furthermore, results of this project will be used as part of a knowledge exchange programme in EURAD2 (RAMPEC).

# Case Study : GeoSafe

**UKNNL's Disposal and Environmental Radiochemistry CSTs cover all three challenge areas:**

- **Challenge 1:** Characterisation and conceptualisation of geological complexity and heterogeneity at multiple length and time scales within Lower-Strength Sedimentary Rocks (LSSRs)
- **Challenge 2:** To develop a mechanistic understanding of retention and transport within LSSR, for radionuclides, longer-lived fission products, and non-radioactive contaminants
- **Challenge 3:** Mathematical modelling of thermal effects from waste and damage caused by excavation process, deformation processes within the host rock, and overall geochemical evolution of the system

In relation to challenge 1, the Disposal CST has been supporting the multi-scale and multi-dimensional characterisation of LSSR heterogeneity, including funding two associated PhD projects based at the University of Manchester (Holly Mills) and University of Liverpool (Jonathon McEvoy).

In relation to UKNNL's investment in additional PhD studentships to complement challenge 1 Professor Kevin Taylor (NWS Research Support Office Geoscience-lead and professor of Geoscience at the University of Manchester) provided the following commentary "This work, which links the Universities of Manchester and Liverpool with UKNNL, is developing integrated approaches to understanding the characteristics, properties and predicted subsurface behaviour of key rock units in the UK. The collaboration between

academia and industry brings unique capability across geosciences, materials characterisation and modelling".

Within challenge 2 UKNNL is building the mechanistic models of radionuclide behaviour in LSSRs, working closely with UoM to translate experimental results into models which can be applied at larger scales.

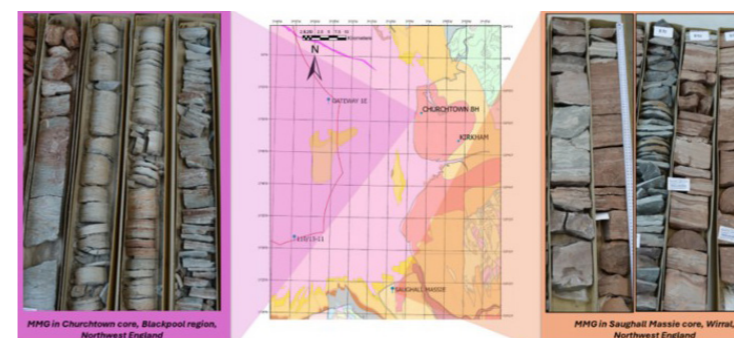
In relation to challenge 2, one potential host-rock under consideration for a UK Geological Disposal Facility (GDF) is the Mercia Mudstone Group (MMG). The MMG is comprised of mudstones, siltstones, sandstones, as well as evaporitic rocks (e.g. gypsum, anhydrite, halite). The GeoSafe project is studying how radionuclide behaviour may change depending on the proportion and mineralogy of the clay, silt, and sand sized fraction.

However, despite being a significant component of the MMG there are currently no studies ongoing that will assess how interlayered evaporitic rocks may impact radionuclide behaviour in the subsurface. To address this, UKNNL's Disposal CST led a successful submission to the NNUF successor scheme, in partnership with the UoM to undertake a novel experimental programme to assess how uranium behaviour varies throughout the evaporite-bearing MMG sections of the Churchtown borehole, Blackpool, Northwest England.

The objective is to determine bulk partitioning and sorption mechanisms of uranium to mixed mudstone-evaporite rock units within the MMG.

In relation to challenge 3, the Disposal CST is working alongside Heriot-Watt University to investigate the interactions between chemical reactions, fluid flow and mass transport phenomena like advection, diffusion and dispersion in the mathematical modelling part of the GeoSafe project.

Furthermore, the Disposal CST is working in partnership with NWS and Imperial College London to develop large-scale geological models to assess how damage caused by excavation and thermal effects of waste may impact radionuclide transport at the GDF scale.



Photographs of core material located at the British Geological Survey from wells which penetrate the Mercia Mudstone Group in the NW of England.

# University Collaborations

## Summary

As the UK's lead civil nuclear laboratory for nuclear fission, UKNNL has a responsibility to support development of new technologies and future subject matter experts to contribute to the sustainability of the nuclear sector. UKNNL has several successful partnerships with Universities across the UK. The geographical locations of UKNNL facilities allow us to work collaboratively and take a proactive role in addressing some of the biggest challenges for environmental restoration.

### University Collaborations

- Universities
- 1 University of Aberdeen ●
- 2 University of Cumbria ▲
- 3 University of Lancaster ▲
- 4 University of Central Lancashire ■▲●
- 5 University of Manchester ■▲●
- 6 University of Liverpool ▲●
- 7 University of Leeds ■●
- 8 University of Sheffield ■●
- 9 University of Birmingham ●
- 10 University of Warwick ●
- 11 University of Oxford ●
- 12 University of Bristol ■●
- 13 Queen Mary University of London ●
- 14 University College London ●
- 15 University of Surrey ■
- 16 University of Southampton ■
- 17 Bangor University

- UKNNL facility locations
- 18 Workington
- 19 Sellafield
- 20 Preston
- 21 Warrington
- 22 Stonehouse
- 23 Abingdon

- Key**
- ▲ CINDe
  - TRANSCEND
  - Core Science R&D



**Centre for Innovation in Nuclear Decommissioning (CINDe)**  
The first CINDe programme enabled researchers to work closely with industry by co-locating their workspace at UKNNL's Workington Laboratory. The programme has funded 16 PhD students across five cohorts in Cumbria with three subsequently joining UKNNL. Eleven journal articles and one book chapter have been published over the last year. The success of the joint UKNNL, Sellafield and NDA programme has been recognised by the NDA. A second programme, CINDe 2, has an expected duration of nine years.

**TRANSCEND**  
TRANSCEND (Transformative Science and Engineering for Nuclear Decommissioning) is a £9.4m collaborative research consortium of 11 universities and eight industry partners (including support from public interest reinvestment), it comprises 40 PhD and post-doctoral projects. The programme aims to unite academic and industrial research communities to enable the adoption of a comprehensive approach to decommissioning and waste management. This programme has now entered its final year.

**Core Science Theme PhDs**  
Core science themes play a key role in supporting projects that have direct relevance to Sellafield challenges. The flexibility provided by each theme enables projects to be created that target relevant issues and ensure that critical skills are developed and maintained.

# Case Study : Simulating Contamination on Stainless Steel

## Challenge

Following closure of the THORP and Magnox reprocessing plants at Sellafield, a strategy is required for the decontamination of aged vessels and pipework. Reducing the radioactivity is necessary to enable dismantling, but effluent plant has limited capacity for the secondary waste from decontamination.

Due to limited access to plant sample material, there is currently no direct information about the depth of contamination which is needed to underpin the R&D requirements for innovative decontamination techniques that can reduce secondary waste and make dismantling safer.

## Solution

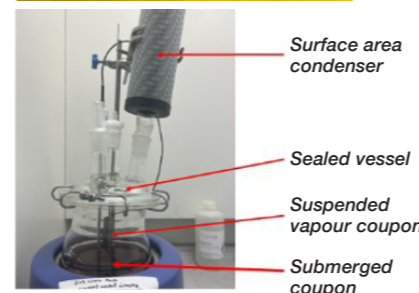
This experimental project has focused on using surrogate material to examine the depth and nature of contamination generated in a nitric acid environment. Simulated contamination was generated in the CINDe laboratory at UKNNL Workington, by corroding stainless steel sample material in nitric acid solutions containing non-radioactive elements found in a Magnox reprocessing liquor. Some of the tests have used the UTGARD laboratory at the University of Lancaster to spike solutions with uranyl nitrate and thorium nitrate.

High-resolution characterisation is being carried out on the samples using Atom Probe Tomography (APT) in collaboration with the UKAEA's Materials Research Facility (MRF) and the University of Oxford NucLEAP to visualise and quantify the contamination in the surface of the stainless steel. The project has also used electrochemical techniques to investigate the corrosion behaviour in the presence of various elements to understand whether the same elements are responsible for both corrosion and contamination.

## Technology

Following successful experimental work, this project has been able to visualise the oxide layer penetrating to depths of around 100 nm. Using the quantitative information from APT, it will be possible to estimate the amount of radioactive material that may be present within real contaminated surfaces.

The work has also demonstrated an effective characterisation route that can now be applied to real radioactive material, which has been obtained from the Magnox northside dissolver and is currently at UKNNL's Active Handling Facility.



A coupon of 304L stainless steel heavily corroded in simulant Magnox reprocessing liquor spiked with thorium nitrate (top), generated using a reaction vessel set-up (bottom).

I was keen to find a PhD which had strong industrial links and tackled a real-world problem, so being able to be part of CINDe has been ideal. Spending the first two and a half years of my PhD working out of the UKNNL's Workington office gave me direct insight into how the nuclear industry runs which will be invaluable going forward into the start of my career. The mixture of academic support from Lancaster University and the industrial experience gained from UKNNL has made my PhD a brilliant experience.

**Hannah Lane**  
PhD Student

# Enablers

At UKNNL we continually invest in our people, facilities and infrastructure to deliver globally recognised nuclear science and technology to benefit society.

We are a team of world-leading scientists, engineers, technologists and experts across multiple fields, focused on nuclear research and driving forward advancements to support the industry.

Our investment in facilities and infrastructure enables us to maintain our unique offering to our partners and customers and continue to push the boundaries of science and innovation.

## Facilities and Infrastructure

### Summary

The work undertaken in 2024/25 through UKNNL's capital investment agenda remains key in addressing some of the biggest challenges faced in the restoration of UKNNL nuclear facilities. This work is funded via the reinvestment of earnings that UKNNL generates through customer focused projects.

UKNNL continues to strive towards the vision for a cleaner, safer environment whilst observing that this would not be possible without the commitment, innovation, drive, and delivery of the Project Management Authority (PMA).

The capital investment has supported the transformation of the UKNNL landscape, removing shadows of the past, restoring and modernising facilities, whilst creating new capabilities. Investment has allowed a programme of growth for the PMA within UKNNL, which has been collaborative with the supply chain, forming a partnership approach to meet customer needs and enhance delivery expectations.

Collaboration was vital to ensure that the improvement of UKNNL facilities was delivered efficiently and effectively, providing value for money

#### Capex key facts


Number of team members – 25

Number of live projects – 52

Investment - £38m+

Social value – **Over 100 winter warmer packs donated to elderly in the local community**

Geographical locations – **Windscale, Central Laboratory, Workington Laboratory, and Preston facility.**



Delivery of projects to support Science and Technology is a challenging task that requires innovation, creative thinking and the unique project management skills. UKNNL recognises that sustained investment is required to support the nuclear mission and to deliver infrastructure that is world class as the UK's National Laboratory.

2024/25 has been a successful year for project delivery, we are continually investing to lay the foundations for transformational projects ranging from nuclear cave refurbishment programmes to major decommissioning projects on the Windscale site. I am extremely proud to lead a team who deliver a challenging portfolio and do this with nuclear professionalism.

**Gail Willis-Smith**  
Capex Portfolio Lead

**Capex has delivered over £30m of improvements to Windscale, Central, Workington and Preston laboratories, including the following:**

- Enhancing welfare and safety standards within laboratories including new epoxy flooring, engineered safety solutions, chiller replacements and glovebox enhancements
- Improving UKNNL's sustainability by lowering the carbon emissions
- Enhancing emergency preparedness through IT infrastructure and new logistics
- Increasing capability by bringing new technology into service including microscopes and gloveboxes
- Building defence in depth by replacing outdated machinery and refurbishing nuclear caves
- Completing security upgrades to facilities and infrastructure in the design and delivery major projects including state of the art security enhancements
- Reducing operational risk by enhancing asset availability



Central Laboratory C2 Duct repairs (before [left] and after [right])



# IT

Our vision is to be a **trusted business partner and strategic enabler.**  
Our purpose is to **provide proactive IT for sustainable delivery and growth.**



Having a safe, secure, reliable and fit-for-purpose IT estate is essential in underpinning our delivery of nuclear outcomes for Government, and to support the growth of the entire UK nuclear sector. The IT strategy has already provided a focus and direction to stabilising how we operate, reducing our risk profile and, ensuring we are ready for the opportunities ahead.

I'm proud of what we have achieved during the last 12 months, from the introduction of our brand-new superfast broadband, to achieving accreditations essential to us contracting with our customers, to migrating key applications to the cloud, and I'm excited for what is still to come.






**Jonathan Mason**  
VP of IT, UKNNL

## Key IT Improvements

- Significantly improved our corporate risk profile through the implementation of full offline backups, data cloud migration, and the planned migration of our core IT infrastructure to a secure, reliable and resilient off site Data Centre
- Improving user experience, through a combination of the delivery of our new superfast, best-in-class Software Defined network (SDWAN), LAN infrastructure upgrades, secure corporate Wi-Fi and modern end user devices
- Retained ISO27001 and Cyber Essentials Accreditations, essential certifications for UKNNL to contract with our customers
- Successfully supported our transition to a formal Arms Length Body, a key component of the HMGs Strategic Review of UKNNL

## Our Strategic Objectives and Outcomes

At the core of the IT Strategy are five key objectives. They set the direction for everything we do, provide clarity on what we aim to achieve, and align with UKNNL's corporate strategic imperatives. Below is a summary of our key achievements against each objective.

				
Investing in our people to unleash their potential	Always stable, resilient, secure, and compliant	Operationally and strategically aligned to the business	Enabling business value through data	Efficiency through technology innovation
Our capability is always growing and our colleagues role model UKNNL behaviours because we have a strong sense of purpose and belonging.	The business can depend on our IT services every single day; we are confident in our security and compliance as they are considered hygiene factors in everything we do.	Through trusted relationships we work collaboratively, providing solutions that enable UKNNL strategic delivery and end to end customer to operations technology and data.	Data is timely, accurate, meaningful and easy to consume, it is used every day at every level to inform decision making across UKNNL.	We use our knowledge, expertise, and industry insight to deliver innovation that enables UKNNL to work smarter and continue to grow.
25 new starters resulting in improved services and response times, reducing single points of failure across all IT departments.	Completed our upgrade to a superfast, best in class network (SD WAN), providing an average increase of x40 in wired network speed across all our sites.	Launched a new Business Engagement function ensuring business and IT strategic alignment and building trusting and meaningful relationships.	Accreditation of our all our Cloud based productivity applications up to Official-Sensitive:SN1 permitting online collaboration	Development of a framework for the assessment and deployment of Artificial Intelligence
New Continuous Improvement function created to drive internal IT change.	New Testing function created to improve quality and ensure successful project delivery.	Upgraded from Microsoft Project to Primavera P6, supporting delivery of our defence related programmes to MoD and Rolls-Royce.	Successfully migrated to SharePoint Online, ensuring we stay compliant and providing enhanced functionality.	Delivered business process efficiencies using newly deployed Microsoft Power Apps and Forms.
New Service Transition function created to ensure smooth implementation of changes into Business As Usual.	Commented our rollout of secure Wi-Fi across all our sites, including our active areas, providing a foundation to new ways of working, improving efficiency and reducing costs.	Commented the migration of our Enterprise Resource Planning (Business World) to the cloud, providing enhanced functionality and process efficiencies.		

# Technical Skills and Capability

## Summary

As a National Laboratory, UKNNL has a responsibility to maintain and develop skills to sustain the sector over the long-term. The complexity of operations in nuclear facilities requires highly specialised knowledge in a range of areas to support safe and efficient practices, while driving forward innovation.

A commitment to technical excellence enables nuclear facilities to meet safety and operational standards, progress technologies and foster public trust in nuclear to contribute to the long-term sustainability of the industry.

At UKNNL, we offer tailored professional development programmes for early careers through our Apprenticeship, Graduate and Postdoctoral programmes which provide valuable hands-on experience alongside our team of experts to support their transition into the nuclear industry. Continued professional development opportunities beyond the early career programmes allows us to continue nurturing talent to help deliver on nuclear science to benefit society.

Started in September 2023

**10** Postdocs

**17** Graduates

**14** Apprentices

## Apprenticeship Scheme

Our apprenticeship scheme provides an embedded training and development programme for those with an interest in science, technology, engineering, mathematics and business administration.



Being on the Degree Apprenticeship scheme has provided me with a range of valuable opportunities. I have been able to work on customer projects which have helped develop my technical knowledge.

I have also been given many developmental opportunities both for my personal and professional development. These opportunities have helped me gain a greater understanding of the work completed at UKNNL as well as the wider nuclear sector.

**Laura Graham**  
Scientific Apprentice

## Graduate Programme

The two-year programme provides an opportunity to work on cutting-edge projects with a development plan tailored to the needs and ambitions of each graduate.



The Graduate scheme at UKNNL has been an incredibly transformative experience, enabling me to grow both personally and professionally while contributing to meaningful, forward-looking work. I have been given amazing opportunities to get involved with lots of exciting projects such as the AMR Fuels Programme, supporting with key customer work such as the new EDF contract as well as ground-breaking initiatives within health and nuclear medicine, including cancer treatment research.

Overall, the scheme has deepened my understanding of the nuclear industry and further highlighted the vital role it plays in our society, both now and in the future.

**Lucy Bate**  
Commercial Graduate

## Postdoctoral Development Programme

The STLP is a collaborative programme delivered by UKNNL and the University of Liverpool and delivered as part of UKNNL's Continuing Professional Development (CPD).



The Post Doc scheme at UKNNL has allowed me to transfer my skills and knowledge from academia to the nuclear industry. During my time on the scheme, I have worked on a variety of projects whilst developing my own research concepts.

The scheme has provided me with multiple opportunities to network with a range of enthusiastic people all around the business and wider sector.

**Sidrah Hussain**  
Chemist

## Scientific Technical Leadership Programme (STLP)

The STLP is a collaborative programme delivered by UKNNL and the University of Liverpool and delivered as part of UKNNL's Continuing Professional Development (CPD).



STLP offered the opportunity for me to hear from academics, fellow industrial colleagues and world-leading scientists on various aspects of technical leadership, including evidence-based writing, influencing technical decision-makers and approaching the ethical challenges associated with being a technical leader.

Coupling interactive sessions with coursework assignments enabled me to reflect on my technical strengths and weaknesses in a constructive environment and provided me with a platform to continue my professional development and produce high quality technical work.

**Chris Foster**  
Research Technologist

## Graduate Programme

Embedded two-year projects at UKNNL designed to attract talent to the UK's Alpha community to develop future subject matter experts (SMEs) in a fragile skill area.



The ARC-DARTS programme introduced me to some of the challenges the industry faces and the technologies being explored to address them. It involved practical experience at the UKNNL Workington rig hall, the chance to present at international conferences, and close working with Sellafield staff through a secondment.

The experience I have gained has increased my scientific understanding and helped me have a broader perspective of the issues faced in waste management and decommissioning.

**Rob Mayhew**  
Effluent Rig Operations Technical Support

## NuClear Leaders

In combination with the Leadership Framework, NuClear Leaders helps to develop the inspiring leaders for all levels of the organisation.



The NuClear Leaders Supervisor's programme introduced several leadership tools and concepts which I often apply in my work. In particular the different tools to develop ideas, and evaluate options have been incredibly useful when designing and implementing work programmes.

The 360 feedback received from colleagues was really beneficial and the associated change/improvement project enabled me to embed learning throughout the programme in real time.

**Aislinn Boylan**  
Senior Research Technologist



United Kingdom  
National Nuclear  
Laboratory



United Kingdom  
National Nuclear  
Laboratory

**United Kingdom National Nuclear Laboratory**

5th Floor  
Chadwick House  
Warrington Road  
Birchwood Park  
Warrington WA3 6AE

**+44 (0)1925 289 800**  
**[customers@uknnl.co.uk](mailto:customers@uknnl.co.uk)**