



Decommissioning Capability Development

END OF YEAR REPORT 2016-17

Future Decommissioning Project

Decommissioning Sellafield nuclear site is a significant undertaking, expecting to take over 100 years and cost an estimated £85billion – a large cost to the UK taxpayer. Through challenging current assumptions and delivering improved capabilities, there is an opportunity to make substantial savings to these long-term predictions.

“This year the Future Decommissioning Project Team has strengthened and made a step change in performance and delivery. The Team have increased both the number and complexity of active demonstrators performed, including the award winning LaserSnake2. The team are also working in collaboration with the NDA and Innovate UK to deliver a major innovation competition with the aim of encouraging organisations (both nuclear and non-nuclear) to innovatively solve a significant decommissioning challenge.”

Decommissioning Capability Development has established the Future Decommissioning project which is responsible for delivering Research and Development activities to enable decommissioning to be safer, faster, and cheaper.

Focussing primarily on near-term (up to 5 years) development, the project addresses challenges spanning the full lifecycle of decommissioning; from characterisation and Post-Operational Clean Out (POCO), through to dismantling and waste assay.

Future Decommissioning’s activities fall into five key areas:

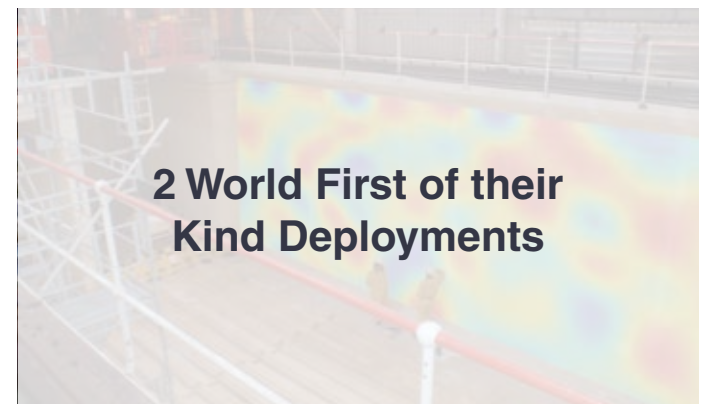
- Assessment of COTS equipment for suitability to provide benefit
- Support development of fit for purpose technologies in the supply chain by providing end user or intelligent customer guidance (market pull)

- Collaborative working within Sellafield Ltd to communicate the decommissioning challenges and ‘pipeline’ lower TRL technologies through to active deployment
- Active demonstration and integration of technologies to prove capability in an active environment and determine benefits
- Industrialise technologies and techniques where appropriate and communicate the learning to enable the greatest potential for the business to realise the benefits (facilitate business as usual).

This 2016/17 report details the key activities and successes this year, identifying the progress towards improving capabilities for the decommissioning of Sellafield site.



Key Achievements



- Legacy Ponds & Silos
- Spent Fuel Management
- Special Nuclear Materials
- Remediation

In the next four years, Sellafield Limited will undergo a historic change. The reprocessing operations at THORP and Magnox Reprocessing Plants will cease, and the site will transition to a business focussed on decommissioning and long-term remediation of the Sellafield site.

To best align with this transition, the business has introduced the Value Stream model.

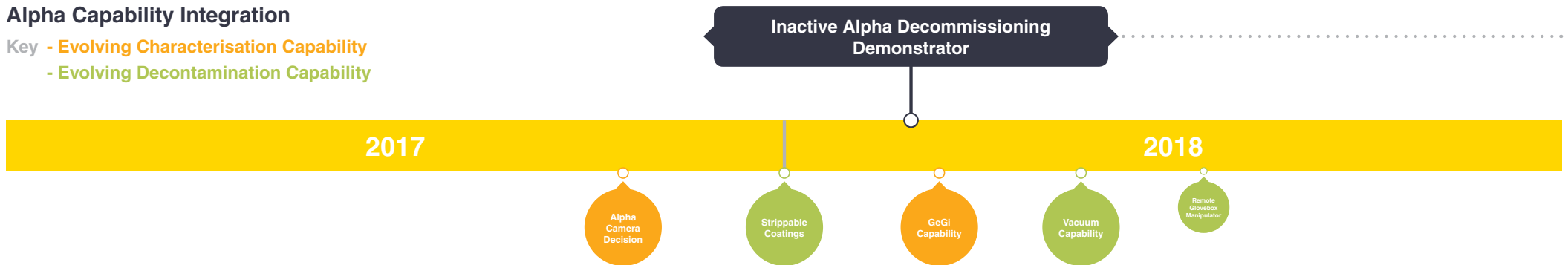
The four streams identified are: Legacy Ponds and Silos, Spent Fuel Management, Special Nuclear Materials, and Remediation. The purpose of this model is to ensure

current and future activities are aligned to bring real benefit to Sellafield Limited long-term mission.

Decommissioning Capability Development, and Future Decommissioning, is aligned primarily to the Remediation value stream.

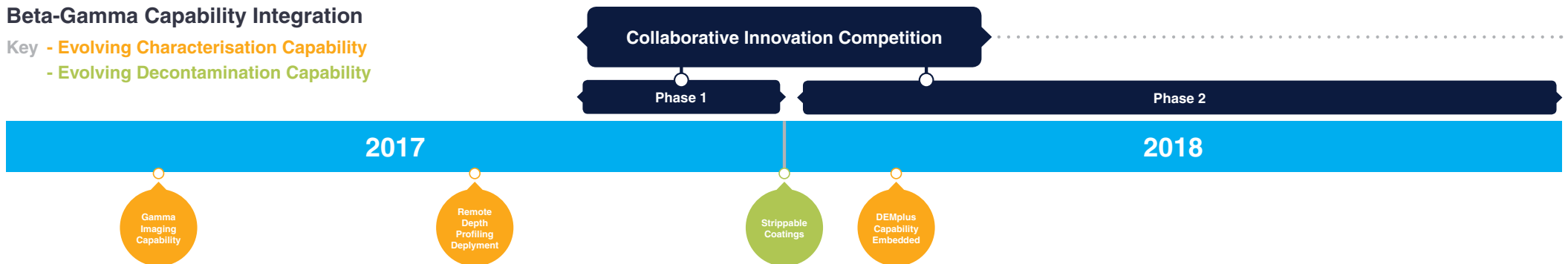
Alpha Capability Integration

- Key - Evolving Characterisation Capability
- Evolving Decontamination Capability



Beta-Gamma Capability Integration

- Key - Evolving Characterisation Capability
- Evolving Decontamination Capability



Value Streams & Capability Development

Remediation Value Stream

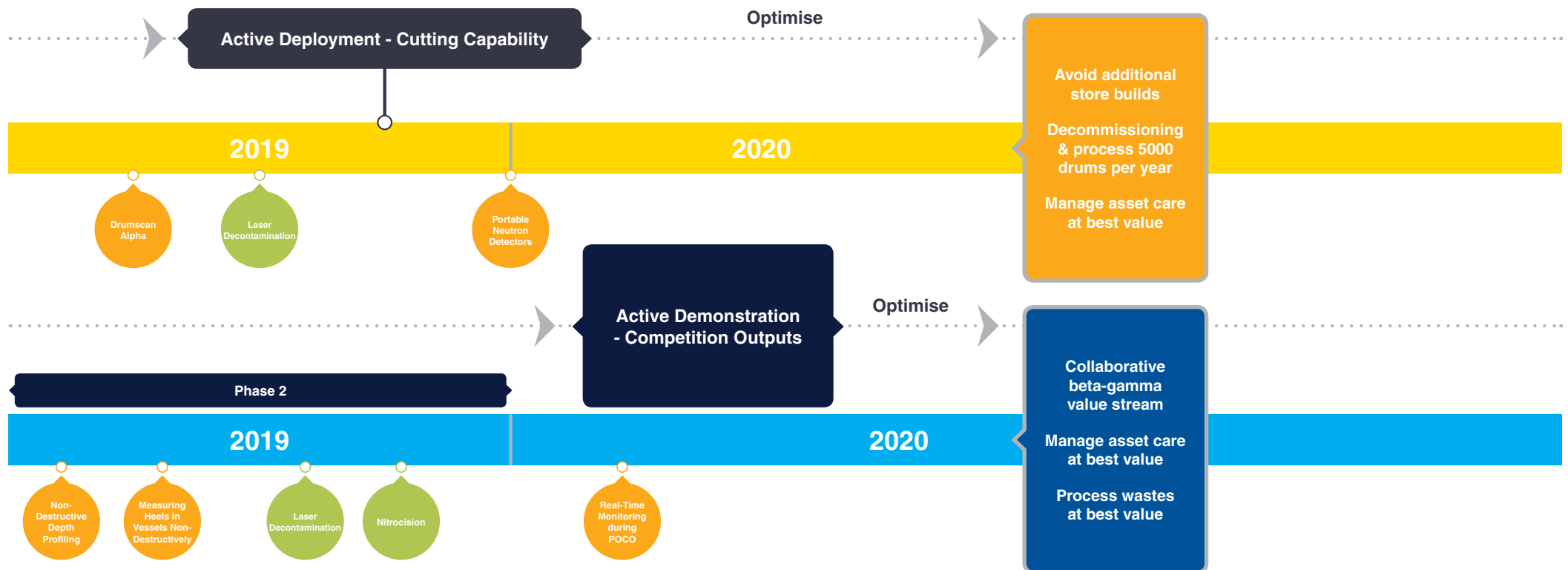
From active decommissioning through to ground remediation and possible delicensing of the Sellafield site, the Remediation value stream covers the whole range of activities that will take place over the next 100+ years.

The vision of this value stream is to “remediate Sellafield with commercial efficiency”, delivering best value while reducing intolerable risks.

Alpha and Beta-Gamma

Within the Remediation portfolio, there is a whole range of different challenges, and the business has sub-divided them into two areas; alpha, and beta-gamma, depending on the predominant radiological challenge present.

This year’s key development projects are on the timelines below – showing the likely date each technology will be mature for business use, compared with the key milestones for both areas.



Decommissioning Challenges

Decommissioning Theme:

Plant Characterisation

Modelling, Knowledge Management & Procedures

Post-Operational Clean Out (POCO)

Surveillance & Maintenance

Decommissioning Infrastructure & Enablers

Decontamination

Plant Dismantling / Decommissioning

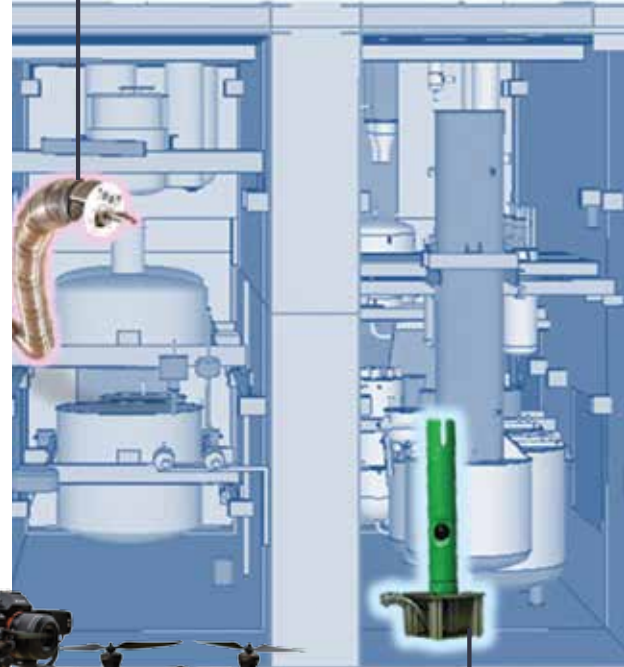
Waste Characterisation & Conditioning

Waste Handling & Storage

The challenges faced with decommissioning a complex nuclear site such as Sellafield site are many and varied. In order to aid development, Decommissioning Capability Development broke this overall task down into ten Decommissioning Themes (left) which can be seen throughout this report. These themes cover the whole lifecycle of decommissioning, front upfront characterisation and POCO, through to final demolition and waste assay. Within each Theme, one or more Decommissioning Challenges have been identified. These Challenges address specific needs where targeted development could bring significant improvements to current capabilities. Creating these decommissioning challenges began in 2015/16, with this year seeing updates and additional challenges added. The total number of individual Decommissioning Challenges identified is currently 37. However, as decommissioning progresses, this list may evolve.

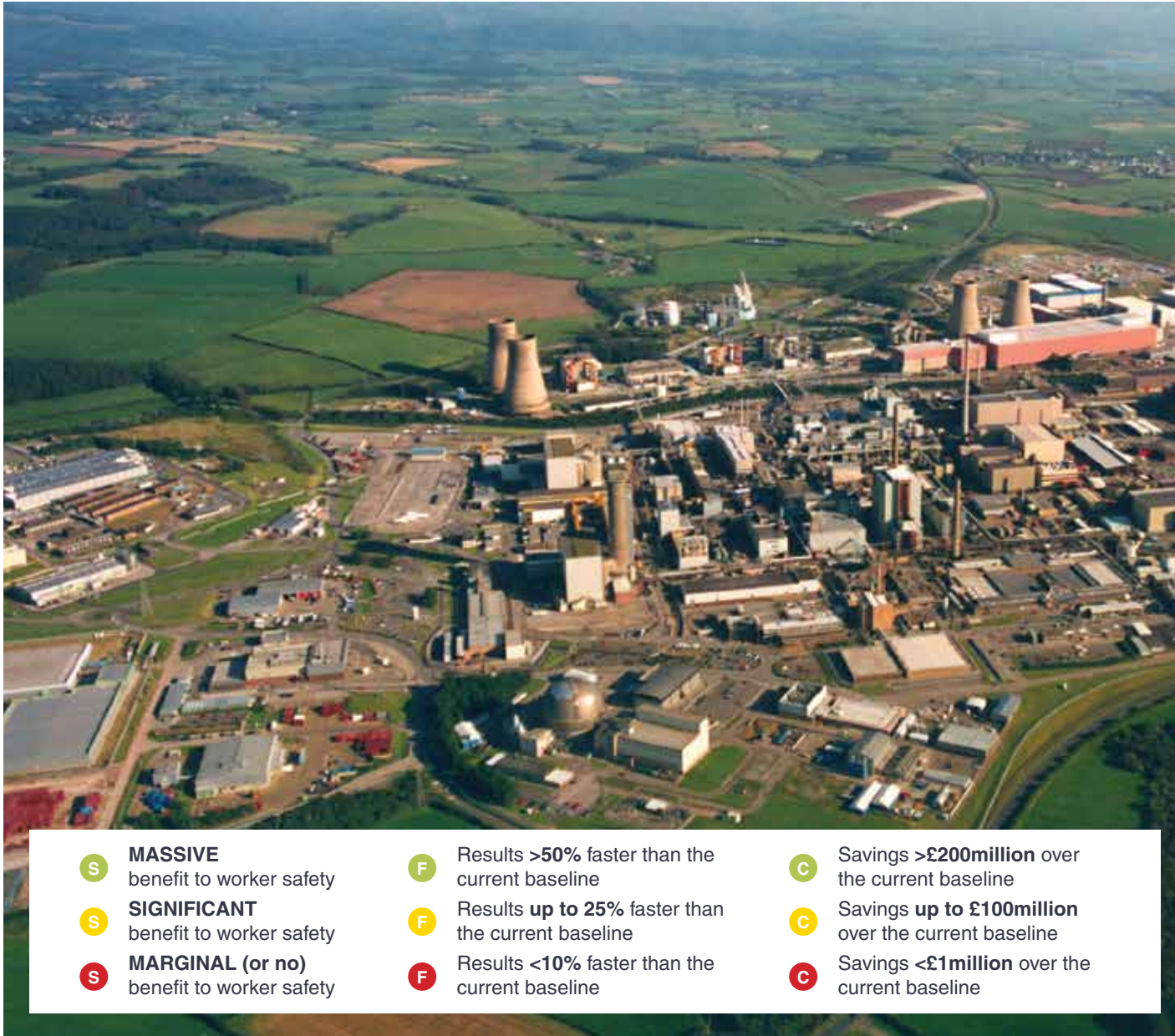
These 37 challenges, along with further descriptions and information have been collated into a single document – for sharing to enable innovation. Copies of this Challenge Statement document are available on request, and have been handed out at various conferences and events – including the NDA Supply Chain Event in November 2016. In addition, this year a benefits assessment has been made for each Decommissioning Challenge to estimate the possible savings achievable from innovation in each area.

7.01 Plant Dismantling / Decommissioning
Tank, Vessel, Pipework & Steelwork Decommissioning



1.02 Plant Characterisation
Waste Estimation

Projects this Year



Waste Estimation	S F C	08
DEMplus	S F C	09
Lasersnake 2	S F C	10-11
Gamma Imaging	S F C	12
UAVs	S F C	13
Alpha Cameras	S F C	14
Strippable Coatings & Fixings	S F C	15
Depth Profiling	S F C	16
ViridiScope	S F C	17
Challenge the Baseline		18-19
Collaborative Innovation Competition		20
Other Achievements		21-22
Meet the Team		23

S **MASSIVE**
benefit to worker safety

S **SIGNIFICANT**
benefit to worker safety

S **MARGINAL (or no)**
benefit to worker safety

F Results **>50%** faster than the current baseline

F Results **up to 25%** faster than the current baseline

F Results **<10%** faster than the current baseline

C Savings **>£200million** over the current baseline

C Savings **up to £100million** over the current baseline

C Savings **<£1million** over the current baseline

Plant Characterisation

Understanding the volume and expected classification of waste that may arise is a key requirement when planning decommissioning operations at Sellafield Site. Intermediate Level Waste (ILW) vs Low Level Waste (LLW) can vary in treatment and disposal costs by a factor of 30. Also, as ILW is kept in interim storage on site, an estimation of ILW arisings determines the number and size of storage facilities required.

Currently, estimations for these waste volumes are based off operational experience / provenance often with a pessimistic approach. In some cases, limited characterisation may be performed – this consists of taking core samples from items of interest and sending for laboratory analysis. This destructive process is unfeasible in many cases and introduces significant pessimisms.

“Waste volume estimates form a critical part of the Sellafield Ltd. future strategy.”

A number of gamma imaging systems have the capability to estimate activity in an object non-destructively. However, there have not been any tests to confirm the accuracy of these quoted values. Without this information, assessing the suitability of these systems for the purpose of waste classification estimation is a challenge.

This year, the First Generation Reprocessing Plant (FGRP) hosted an active demonstration intended to address this issue. An area of the Medium Active South (MAS) cell was made available for gamma imaging technologies, with six vessels identified as being of known activity / waste classification.

In collaboration with Sellafield’s Radiometric Systems Group (RSG) five systems were deployed. The results from these deployments will form an Active Demonstrator Report with the aim of better informing decision making

on future applicability of these detectors.

CHALLENGE

Determine the relative quantities of ILW and LLW in-situ

SOLUTION

Benchmark gamma imaging systems in a known environment to increase stakeholder confidence in the approaches

BENEFITS

Some current expected ILW volumes may be five times higher than reality. This has a significant cost / timescale impact

CURRENT STATUS

Five technologies deployed in MAS cell used to underpin vessel activities

FUTURE ACTIVITIES

Active Demonstrator Report, business-as-usual use of technologies, increased characterisation capability and programme of characterisation



COMPANIES INVOLVED:

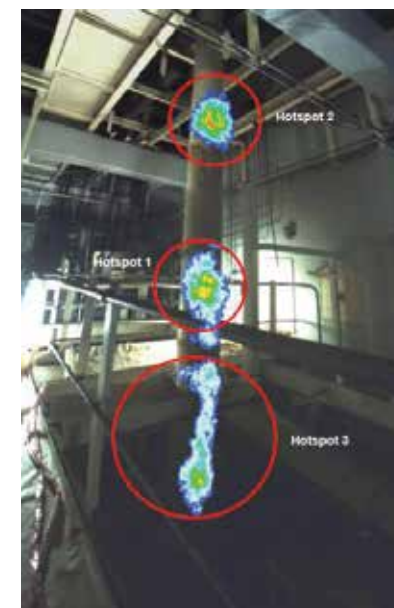


Benefit Realised from 2017



KEY MILESTONE ACHIEVED

March 2017
- All active deployments complete



Modelling, Knowledge Management, & Procedures

Decisions made during the decommissioning planning stage of projects have significant impact in terms of timescales and costs. That's why the current planning operations involve large numbers of stakeholders, processing vast amounts of information, in order to determine the most appropriate approach for the specific challenge.

DEMplus is a software tool which is intended to aid this process. By combining operational data (working times, waste routes etc.), with a geometric and radiological 3D model, alternative approaches can be visualised and quantitatively compared.

The benefits from improved scenario planning include:

- Improved decommissioning & dismantling strategies
- Ability to see the effects of in-situ decontamination
- Optimised working and dose reduction
- Waste forecasting (future store needs)

- Reduction in cost through more efficient planning and scenario modelling software.

In 2015/16, this software was first demonstrated at Sellafield, taking real data from three cells on site to determine the impact of different decommissioning strategies.

This year, those models have been completed and a number of other tasks have begun, utilising this software. These other tasks include the first use of DEMplus at Sellafield in a study phase of a decommissioning project.

In addition, Sellafield Ltd has taken the decision to procure DEMplus and embed it within the business. Utilising the Sellafield Operational Research Group (SORG) as the Intelligent Customer, a set of licences has been purchased to enable some support in-house.

“DEMplus gives Sellafield Ltd the capability for easier optimisation of decommissioning

strategies, potentially improving: conventional and radiological safety, waste management, and a cost saving for decommissioning operations.”

CHALLENGE

Determining optimal decommissioning approaches

SOLUTION

3D visualisation of decommissioning schemes with quantified benefits over alternative approaches

BENEFITS

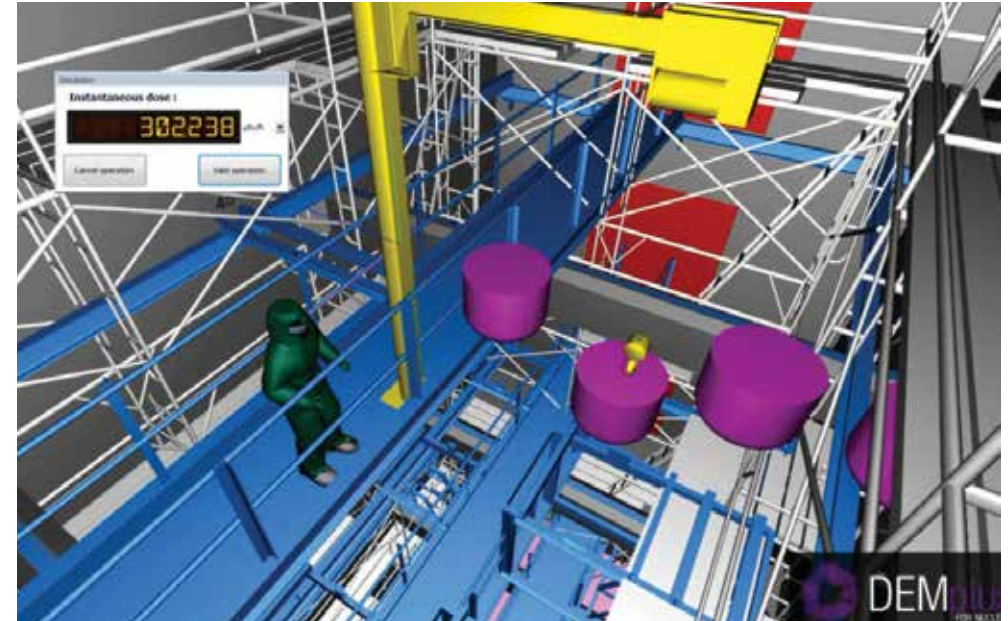
Most appropriate decommissioning strategy chose enabling best use of resources with balancing time, cost and dose

CURRENT STATUS

Multiple Sellafield Site environments modelled, alternative schemes developed and compared and the supply chain capability developed

FUTURE ACTIVITIES

Decommissioning study using DEMplus due to complete in 2018/19



COMPANIES INVOLVED:



Benefit Realised from 2017



KEY MILESTONES ACHIEVED

- Make/ buy decision resulting in purchase of DEMplus licences and completion of operator training
- Supply chain capability delivered

Plant Dismantling / Decommissioning

Decommissioning Sellafield site will involve a large number of operations in hazardous and restricted environments. A significant number of these operations will be cutting / size reduction tasks- either to free an object for handling and removal, or to fit into a waste container.

Previous decommissioning work has relied on human intervention to perform the majority of activities. Only where human access is prohibited (e.g. radiation, physical access, high levels of contamination, etc.) have remote approaches been taken. Historic experience with using robotics for decommissioning has shown large uncertainties in costs and productivity.



Increasing productivity in remote decommissioning is estimated to save up to £2billion over the lifetime of the site. In addition, there are potentially further savings from utilising remote solutions to do activities previously thought of as manual operations.

Lasersnake 2 is an NDA/ Innovate UK/BEIS-funded project which combines two relatively mature technologies high power laser cutting, and a multi-jointed “snake arm” manipulator. The resultant system is a remotely operated device capable of reaching awkward locations and performing size-reduction activities.

As the majority of the electronics / high value equipment are situated outside of the area, it is ideally suited to working in areas of high dose rates and high contamination.

The Innovate UK project is a collaboration of several industrial partners: OC Robotics, The Welding Institute (TWI), Laser Optical

Engineering (LOE), ULO Optics, and the National Nuclear Laboratory. Sellafield Ltd provided end user support and delivered an active and inactive demonstration opportunity.

The environment chosen for the active demonstration was a redundant dissolver in the West Dissolver cell in the First Generation Reprocessing Plant. This vessel presented multiple challenges:

- Double skinned
- Stainless steel thicknesses from 9mm to 50mm
- Access possible through only one port into cell

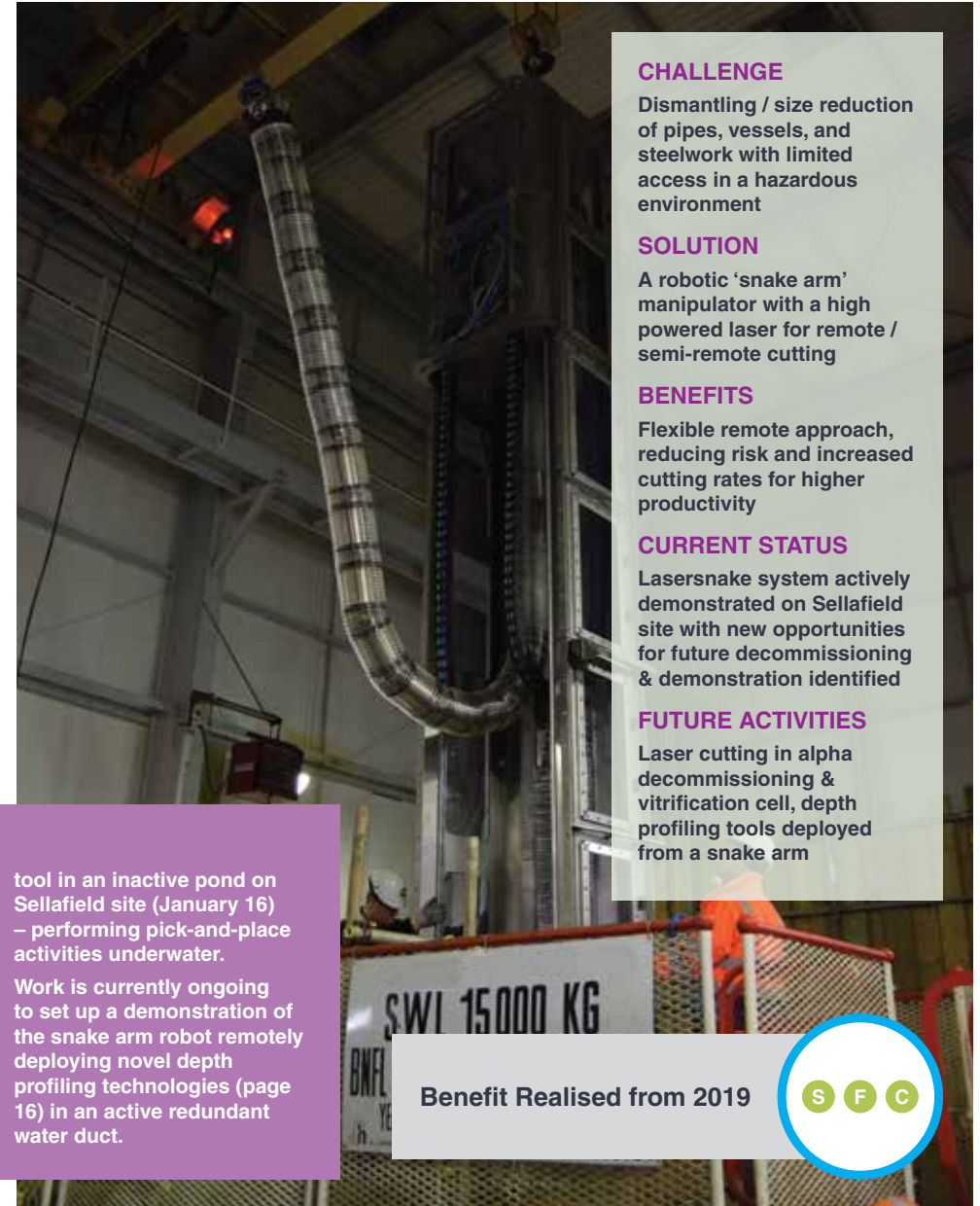
OTHER APPLICATIONS

In addition to the success of the Lasersnake 2 active demonstration, Sellafield Ltd recognises the benefits from both the snake arm manipulator and from laser cutting.

Prior to the active demonstration of Lasersnake, the snake arm robot was deployed with a gripping

tool in an inactive pond on Sellafield site (January 16) – performing pick-and-place activities underwater.

Work is currently ongoing to set up a demonstration of the snake arm robot remotely deploying novel depth profiling technologies (page 16) in an active redundant water duct.



CHALLENGE

Dismantling / size reduction of pipes, vessels, and steelwork with limited access in a hazardous environment

SOLUTION

A robotic ‘snake arm’ manipulator with a high powered laser for remote / semi-remote cutting

BENEFITS

Flexible remote approach, reducing risk and increased cutting rates for higher productivity

CURRENT STATUS

Lasersnake system actively demonstrated on Sellafield site with new opportunities for future decommissioning & demonstration identified

FUTURE ACTIVITIES

Laser cutting in alpha decommissioning & vitrification cell, depth profiling tools deployed from a snake arm

Benefit Realised from 2019



Plant Dismantling / Decommissioning

Preparations for this demonstration, required input from a large number of Sellafield Ltd stakeholders including: operations team, safety case, health physics, system engineering, and others. Some of the required preparations included:

- Creating a light-safe cell – with access hole for the snake arm
- Infrastructure installation (ventilation, compressed, electrical supply, CCTV, lighting, etc.)
- Plant Modification Proposals, Risk Assessments, and Operator Instructions
- Training and site access for suppliers

The demonstration began in June 2016, and so successful was the trial that the time on site was extended to complete more size reduction. In total, over 10 weeks were spent on site, cutting over 200m (42 hours of cutting) and completely size reducing the dissolver vessel for future disposal.



The success of the trial has been recognised by across the industry with the receipt of both the NDA Supply Chain Award (Technology / Innovation Implementation) and the Sellafield Ltd Business Excellence Award (People's Choice). This work has also opened opportunities for the technologies involved as well, with future deployments planned for both laser cutting and snake arm-deployed tooling.



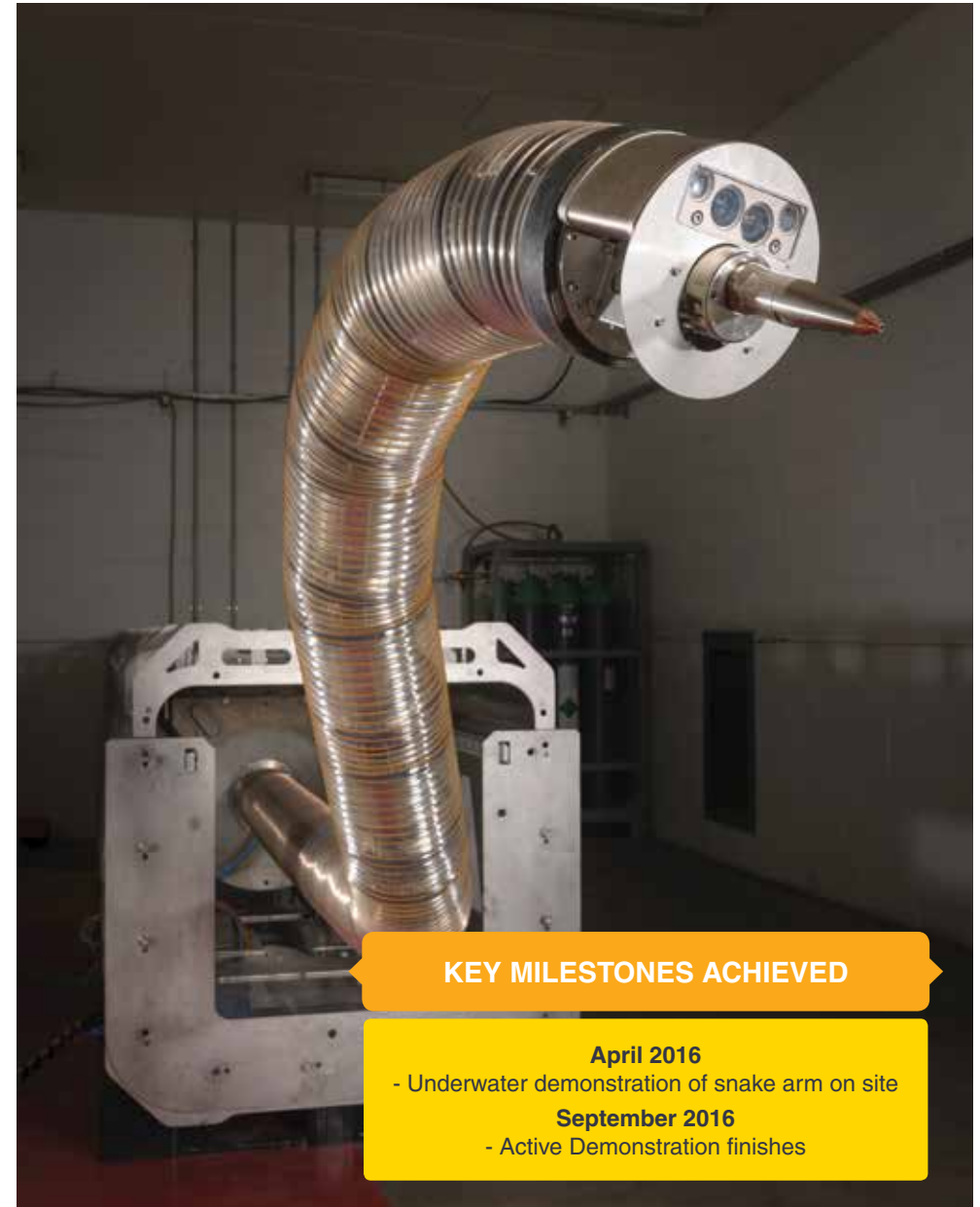
Business Excellence Award



NDA Supply Chain Award



COMPANIES INVOLVED:



KEY MILESTONES ACHIEVED

- April 2016**
- Underwater demonstration of snake arm on site
- September 2016**
- Active Demonstration finishes

Plant Characterisation

Understanding the radiation environments is important in order to best determine if any remediation (decontamination, shielding etc.) or controls need to be put in place to protect people.

Current methods to do this involve simple, manually deployed probes which gives limited information about the location and type of any sources.

Advancements in detector technology indicate that new systems may be able to measure not only the dose rate, but also the location, quantity and key sources contributing to the overall dose environment.

“The ability to effectively characterise environments is becoming increasingly important, as the business transitions towards decommissioning operations”

Over the past 2-3 years, Sellafield Ltd has facilitated the demonstration of nine different gamma imaging systems. These technologies

varied from small handheld systems, to large, remotely operable, collimated devices. The purpose of these demonstrations was to understand the performance of each system, and which were most appropriate for Sellafield’s challenges. This is shown in a report in which future decisions can be made.

The Decommissioning Capability Development team purchased two systems following this report. This included the N-Visage gamma imager and **GeGI Gamma-ray imaging spectrometer.**

The N-Visage gamma imager, this detector is utilised in high dose environments where there is restricted access and can fit through access holes.

The second system purchased is the GeGI Gamma-ray imaging spectrometer – better suited to fast results in low dose rate areas.

With projects lining up to make use of these new

systems, the coming months will see multiple deployments of the new devices. The report also enabling other Sellafield teams to further make vs buy decisions. These systems will be demonstrated all across Sellafield site enabling benefit realisation, with a potential saving of £50k a task with the new technologies.

KEY MILESTONES ACHIEVED

- Active demonstration of two gamma imaging systems
- Internal evaluation report endorsed by the Remediation technical committee
- N-Visage and GeGI gamma imagers purchased

COMPANIES INVOLVED:



CHALLENGE

Measuring the dose environment and the location of radioactive sources

SOLUTION

A range of Fit-For-Purpose gamma imaging systems

BENEFITS

Faster acquisition of results and improved deployment options could save >£100million over the lifetime of the site

CURRENT STATUS

Nine systems tested and evaluated, with two devices purchased

FUTURE ACTIVITIES

Utilising Sellafield’s new internal capability and a “watching brief” for additional systems of interest and a program of characterisation so a state of business a usual can be reached

Benefit Realised from 2018



Decommissioning Infrastructure & Enablers

Accessing areas of interest on site, both indoors and outside, can be a real challenge. Especially in high dose or contaminated environments, constructing scaffolding to perform simple monitoring tasks is a lengthy and costly process. Often the balance of cost / practicality vs benefit means that inspections do not take place and instead pessimistic assumptions have to be made.

With the emergence of small Unmanned Aerial Vehicles (UAVs) for low-cost visual and radiometric monitoring, these pessimistic assumptions can be challenged with minimally intrusive activities.

Over the past 4 years, the decommissioning capability development team has overseen the implementation of UAVs on the Sellafield site. The first flight at Sellafield site was carried out in April 2014, with subsequent active demonstrations in the Solvent Recovery Plant and the Windscale Chimney.

As a result of these activities, the supply chain has built up a UAV capability to meet Sellafield's Ltd needs. This project has now reached sufficient maturity to begin realising benefit for Sellafield Ltd.

This year, decommissioning capability development has produced the Sellafield Ltd Procedure – standardising the use of UAVs on site.

Following this, a key objective this year was to deliver this capability for Business-As-Usual operation by the rest of site. In this way technical support has been provided for several flights in Sellafield Ltd airspace. Including: monitoring the local beaches (The first business as usual flight off site), Calder Hall's turbine hall roof (The first business as usual flight on site) and the civil inspections of FGRP chimney (The first business as usual flight in separation).

Now that the use of drones is a standard practice on site, future development work may include more

novel UAV platforms to increase the possible applications for these systems.

“Sellafield now has the appropriate procedures in place to enable the use of small unmanned aircraft on site, paving the way for the future”

CHALLENGE
Viewing structures without the need for scaffolding / infrastructure

SOLUTION
Unmanned Aerial Vehicles with tools for visual / radiometric monitoring

BENEFITS
Reduced time, cost, and dose for inspections (indoors and outdoors)

CURRENT STATUS
Active demonstrations and the first Business-As-Usual activities carried out through engagement with the supply chain

FUTURE ACTIVITIES
UAV capability delivered to the business




KEY MILESTONES ACHIEVED

- April 2016**
- Underwater demonstration of snake arm on site
- September 2016**
- Active Demonstration finishes

COMPANIES INVOLVED:



Benefit Realised from 2017



Plant Characterisation

There are over 350 alpha gloveboxes on Sellafield site. Each box has its own operational history, and the levels of alpha contamination within will be similarly varied. Identifying this contamination is a particular challenge in these environments as alpha particles are typically shielded by thin layers of material, or a few centimetres of air.

As the site comes to decommission these gloveboxes, understanding the contamination present before opening the glovebox (and breaking containment) is important. The risks present will define the contamination control requirements and any additional safety measures that need to be in place.

Current techniques for assessing alpha contamination involve worst-case neutron measurements, and visual inspections. Through more accurately understanding the environment, fit-for-purpose controls can

be put in place during operations, and upfront decommissioning planning activities can be better informed.

A potential solution identified is “Alpha Cameras”. These devices measure the ultraviolet radiation produced when alpha particles collide with nitrogen in the air. As these collisions take place within the first few centimetres, the source of this UV light closely matches the source of alpha contamination.

Sellafield Ltd is aware of a number of different alpha camera systems. In 2015, the first alpha camera system was active demonstrated in the Mixed Oxide Fuel Demonstration Facility (MDF). This year, a second system was trialled in the same facility.

Learning and comparisons between the two systems will now be collated

This will better inform the future requirement for alpha cameras and future developments to be shared with companies involved.

The trials have demonstrated that further development/ deployment work is required to enable a usable system to realise business benefits, with this being reviewed in 2017/18”.

CHALLENGE

Identifying alpha contamination without intrusive measurement, or significant pessimism

SOLUTION

“Alpha cameras” that detect UV light produced by alpha particles in air

BENEFITS

Ability to visualise and target clean out and carry out large area assessment without the need for extensive surveys

CURRENT STATUS

Two alpha camera systems demonstrated on site

FUTURE ACTIVITIES

Define future development requirements and other suitable technologies

KEY MILESTONE ACHIEVED

July 2016

- Active Demonstration of second system

COMPANIES INVOLVED:



Benefit Realised from 2019



Strippable Coatings & Fixings

Decontamination

In support of current operations and decommissioning of the Sellafield site, fully understanding decontamination methods and products is essential. Historic plants were not built with decommissioning in mind, and the risk of making loose contamination airborne delays advancements in Post Operational Clean Out (POCO).

There is current work looking at base lining fixatives and strippable coatings. The applicability of the coating and fixings is plant specific, as some chemical coatings may react differently in varying environments.

To counteract this issue, a set list of approved products is needed. Various waste management routes can then plug-and-play with a specific coating to suit a particular environment. This will allow for smart deployment of coatings which will lead to increased efficiency and a thorough

understanding of which product is acceptable for every scenario.

Fixatives and strippable coatings are chemicals in the form of a liquid or a gel that can be either painted, rolled or sprayed onto a substrate (concrete, brickwork, metals etc.), and left to cure over a period of time (nominally 24hours). The fixatives remain in place on the substrate; in contrast, the strippable coatings can be peeled off once cured and disposed of as a solid waste form.

This financial year various stakeholders were engaged from several waste management streams with question sets taken to build up a baseline of acceptable chemicals.

Following this, products were irradiated in their cured state are being tested at the University of Manchester's Dalton Cumbria Facility; to determine the products tolerability to high radiation fields and how they potentially degrade.

Active trials have also taken place in the First Generation Magnox Storage Pond area to look into: ease of application, coverage, adhesion, ease to peel, and resistance to tearing, alongside the ability to pick up contamination, and the retention of the loose contamination within the products.

The goal is to get a prescribed list of approved products that have been formally assessed for use across the Sellafield site and the NDA estate, with an agreed list of approved products that, in their rawest form, are accepted by a number of waste routes.

“Assessing and benchmarking a variety of strippable coatings & fixings to fully understand their performance and disposability.”

KEY MILESTONE ACHIEVED

March 2017
- Active Demonstration



COMPANIES INVOLVED:



CHALLENGE

The need to create a set standard for the use of Strippable coatings and Fixings across site to fix and remove contamination

SOLUTION

A prescribed list of approved products that have been formally assessed for the use across Sellafield Site and the NDA estate

BENEFITS

Correct use of strippable coatings and fixings can lead to possible reclassification of C5 areas, with Reductions in cross contamination, easier clean up and faster recovery after operations

CURRENT STATUS

Trials completed, with a review of the findings underway

FUTURE ACTIVITIES

Formal assessment and approved list of products completed. Assessment of any gaps in trials i.e. Alpha specific environments so it becomes normal practice

Benefit Realised from 2018



Plant Characterisation

At Sellafield Site, there are a number of areas where concrete surfaces have become contaminated. Due to concrete's porous nature, this contamination can permeate beneath the surface. A consequence of this is that activity contained within the first few millimetres of the surface may impact the waste classification of the entire bulk material. To reduce the over-classification of an entire structure, the depth of this contaminated layer needs to be understood. The current procedure for measuring the activity profile in a material involves extracting core samples and off-site laboratory analysis. This destructive analysis process has several limitations:

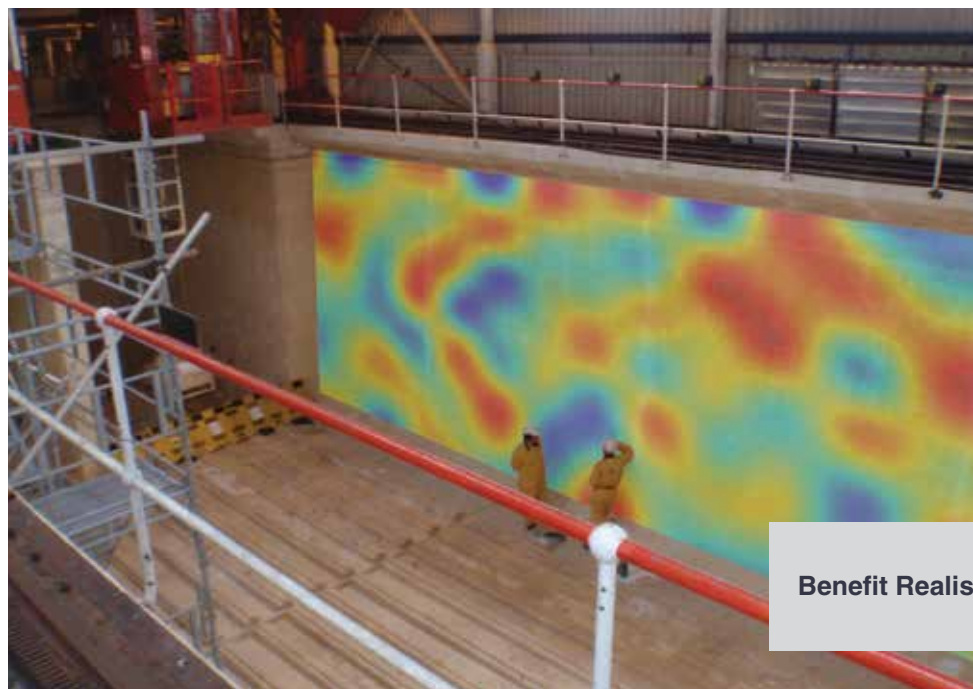
- Coring is time consuming and involves operators working in potentially high dose environments
- Laboratory analysis can take several months before receiving results

“Removing the active surfaces of concrete structures can lower the overall waste classification; huge savings in cost and waste volumes can be realised.”

Through faster and less dose intensive techniques to acquire this activity depth profiling could lead to significant schedule and cost savings across site of up to £30million. Additionally, more accurate measurement of these profiles may enable more effective segregation of Low Level Waste and Intermediate Level Waste. As ILW costs approximately 30 times more than LLW to dispose, this is a key opportunity.

Sellafield Ltd has become aware of several potential non-destructive solutions for measuring activity depth profiles – at varying stages of development. Previous years have seen several supply chain technologies tested in two active environments on site, with core samples also taken to provide a known result for comparison.

This year, the results from both active demonstrations have been analysed, with recommendations for future development / use identified for each system. In tandem with this, the first “real” use of the systems has taken place in the Pile Fuel Storage Pond.



KEY MILESTONE ACHIEVED

Analytical results analysed and recommendations for future use identified

COMPANIES INVOLVED:



CHALLENGE

Determine the activity profile in porous substances as a function of depth

SOLUTION

Non-destructive techniques which can produce accurate depth profiles of activity, without the need for core samples

BENEFITS

Faster analysis & more effective segregation of Intermediate Level Waste and Low Level Waste

CURRENT STATUS

Active demonstrations in FGRP and in Pile 1 water duct complete with first deployment in the Pile Fuel Storage Pond

FUTURE ACTIVITIES

Transition to Business-as-Usual with several deployment opportunities under consideration including remote deployment

Benefit Realised from 2019



Plant Characterisation

Waste Characterisation & Conditioning

Surface sampling is a common activity on Sellafield site. Swabs and scrapings of concrete walls, ceilings, and floors are taken in order to understand any contamination that may be present. This information forms part of the process for characterising and disposing of concrete wastes.

Current processes involve collecting samples for off-site analysis, which can take weeks or even months to receive results from. Reducing these timescales can improve the efficiency of this waste assay process.

ViridiScan® is an Innovate UK project, sponsored by the Nuclear Decommissioning Authority. The project uses a laser to ablate a small sample off the surface, for collection on a filter paper and in-situ analysis. The sampling head would be small, either handheld, or deployed from a Remotely Operated Vehicle (ROV).

The samples required by ViridiScan® may be as much as 1000 times smaller than needed for laboratory analysis. This could also reduce the risk associated with generating airborne contamination during sample operations.

Throughout this project, Sellafield Ltd has been offering end-user support. In April 2016, the sampling-end of the ViridiScan was demonstrated in an inactive area at Sellafield Site. This front end, ViridiScope®, extracts the sample and collects it on a filter paper for analysis.

Following this demonstration, an active trial of ViridiScope was setup in November 2016 to directly compare the ViridiScope® sampling process with current baseline techniques. The generated samples were sent for off-site analysis and the results will provide valuable learning for the ViridiScan development.

“This was the first deployment of ViridiScope in an active environment; the learning gained will be invaluable for this project.”

The output from this active demonstration will help quantify the benefits the ViridiScope®/ViridiScan® tool will bring Sellafield Ltd.



CHALLENGE

To enable the sampling of a wide range of decommissioning wastes for characterisation

SOLUTION

Easily deployable technique which can produce results in-situ

BENEFITS

Potential to reduce timescales for characterisation results by months

CURRENT STATUS

Active and inactive demonstrations carried out this year on Sellafield site

FUTURE ACTIVITIES

Possible further deployments of ViridiScan in 2017/18



COMPANIES INVOLVED:



Benefit Realised from 2019

KEY MILESTONES ACHIEVED

- April 2016**
- Inactive Demonstration
- November 2016**
- Active Demonstration

Challenge the Baseline

The greatest improvements to time, cost, and safety for decommissioning operations on Sellafield site will come from step-changes in how we tackle our challenges. With the decommissioning mission at Sellafield site expected to take over a 100 years to complete, by identifying these step-changes now, £billions can be saved

from the expected lifetime costs. Decommissioning Capability Development has termed this process “Challenging the Baseline” and has begun projects in three distinct environments: alpha-contaminated gloveboxes, beta-gamma decommissioning in a man-access cell, and beta-gamma decommissioning in a remote-access cell.

Challenge the Baseline Approach

Integration into the Business

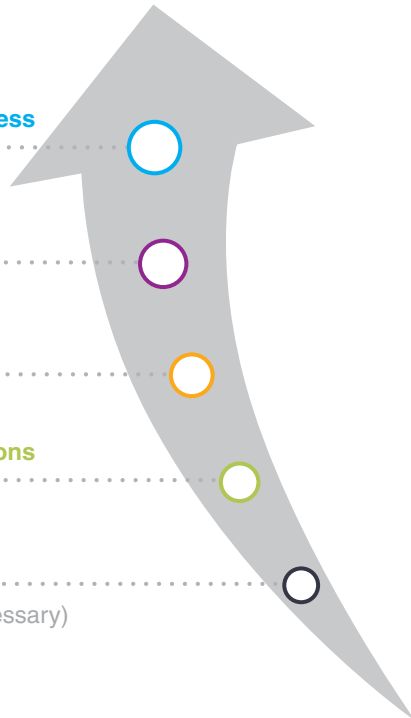
Active Demonstrations

R&D Roadmap

Assess Alternative Solutions

Baseline Approach

- Characterise area (if necessary)
- Update Baseline



BASELINE APPROACH

A pre-existing plan for decommissioning is identified. This is naturally conservative and does not account for potential technology developments.

ASSESS ALTERNATIVE SOLUTIONS

Using DEMPlus, the baseline approach is compared against alternative solutions to identify the significant factors future R&D should be targeting.

R&D ROADMAP

These identified opportunities form a roadmap that is then used to inform the sites Research and development plan.

ACTIVE DEMONSTRATIONS

Appropriate technologies can then be demonstrated in this representative environment to assess suitability against decommissioning challenges.

INTEGRATION INTO THE BUSINESS

Tools and techniques: underpinned with clear benefits to the business, tested in active environments, and ready for industrialisation / business-as-usual use.

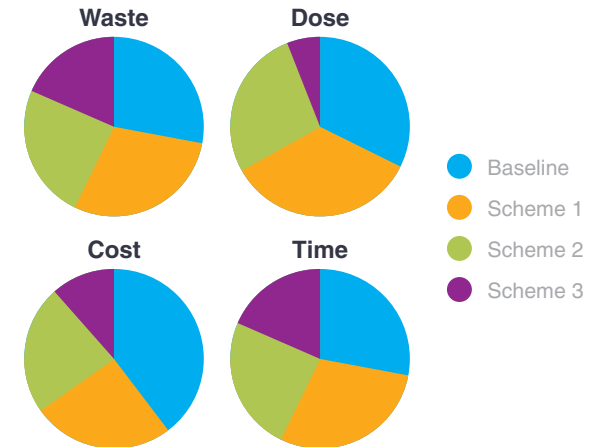
Beta-Gamma Manual Decommissioning

Initiated in 2015/16, this project considered the challenge of a beta-gamma cell, where man access is achievable. The cells chosen were the Medium Active South (MAS) and Medium Active North (MAN) cells in FGRP. These big cells, spanning several floors, contain large volumes of steel vessels and pipework – accessible by a single walkway on each floor.

The baseline scheme for these cells consists of size-reducing these vessels using manually deployed power tools from a scaffold platform erected from the ground floor. Due to the protective equipment required, operator working conditions are harsh and limit productivity.

In 2015/16 three alternative schemes were identified:

1. Manual approach using dancefloor scaffolding
2. Semi-remote tooling, decommissioning top-down in MAS and bottom-up in MAN
3. Fully remote deployment using a high power laser cutting system



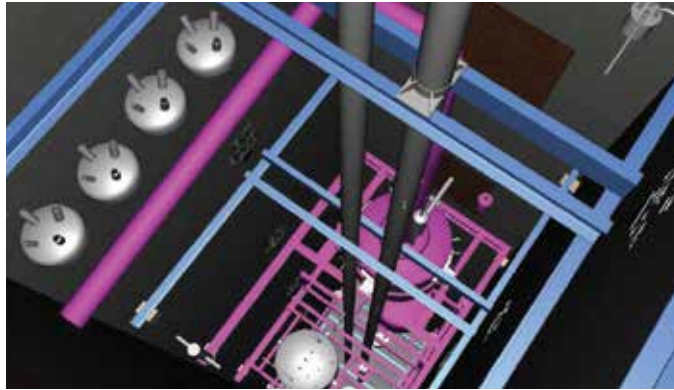
PROGRESS THIS YEAR HAS INCLUDED

- Quantifying the relevant benefits between schemes and sensitivities within schemes
- Final report and R&D roadmap issued
- Outputs feeding into MAN/MAN decommissioning study

Challenge the Baseline

Beta-Gamma Remote Decommissioning

In some of the highest hazard environments at Sellafield Site, all access has to be carried out remotely. This may be due to high activities and radiation posing a risk to human operators, or because physical access is too restrictive. With remote decommissioning at Sellafield Site estimated to cost £3 billion, highlighting relevant development opportunities could result in significant cost savings. The High Active South Inner cell in the First Generation Reprocessing Plant was chosen as a case study for this project. This large, open cell poses challenges with limited access and potentially high dose rates. As the current baseline approach is based off very limited knowledge of the cell's status, one of the key stages in this project is to better understand this cell environment.



HASI Cell Baseline Decommissioning Scheme

7 YEAR OPERATION
OVER £30 MILLION
>170 TONNES OF ILW

PROGRESS THIS YEAR:

- Produced 3D Cell Environment
- Modelled Baseline Scheme in DEMplus
- DQO Workshop to define characterisation requirements
- Characterisation plan developed

Due to the variety of challenges the HASI cell poses, the solutions generated through this project will be applicable to other remote access environments. In particular, the reprocessing facilities THORP (Thermal Oxide Reprocessing Plant) and Magnox Reprocessing Plant, which are due to finish operations in 2018 and 2020 respectively.

FUTURE WORK:

- Characterisation of HASI cell
- Update of DEMPlus Baseline
- Generate Alternative Schemes
- Assess Potential Benefits
- Produce R&D Roadmap

Alpha-Contaminated Gloveboxes

There are over 350 alpha-contaminated gloveboxes on Sellafield site. These boxes (which vary in size, shape, and contents) act as the primary containment for the various powders and residues left behind from their operational use.

These aged units now require a considered approach to safely decommission, containing any contamination and reducing the site's overall hazard. It is estimated that the decommissioning of alpha-contaminated facilities will cost £billions.

This project identified two gloveboxes which, together, demonstrate a range of characteristics associated with different boxes. In addition, a mapping exercise carried out identified the various different schemes that might be required, given different glovebox properties.

Although the two case study boxes may not be the next to decommission, the learning from this project is being utilised in current decommissioning projects.



PROGRESS THIS YEAR:

- Two case study gloveboxes chosen and 3D models produced
- Six alternative schemes generated
- Alternative schemes and baseline modelled in DEMplus

Work undertaken next year looks to establish an inactive demonstrator area for alpha decommissioning which will serve as a route for future technology integration.

FUTURE WORK:

- Review the surveillance and maintenance benefits for plants entering into POCO to realise significant cost savings
- Develop a system for laser cutting on a robotic arm to offer Remediation projects more efficient methods of glovebox dismantling
- Demonstration of alpha - contaminated re-cleanable filter systems on site to lessen the burden of hands-on filter changes and to minimise the amount of PCM waste produced

Collaborative Innovation Competition

VISION:

“A transferable integrated decommissioning toolkit which minimises the interface between the decommissioning operator and the hazard, whilst achieving a significant increase in productivity and a reduction in lifecycle cost”.

In January 2017, the integrated innovation for Nuclear Decommissioning competition opened. This £3 million call (funded by the Nuclear Decommissioning Authority and Innovate UK) is seeking, **integrated** solutions for tackling decommissioning of reprocessing cells with limited man access. Any developed system will need to be **transferable** and **scalable** to address the range of process cells on site.

The following step change is being driven by:

- **Safer - minimise human intervention**
- **Faster - increase productivity**
- **Cheaper - waste optimisation**

Decommissioning Capability Development has been acting on Sellafield Ltd's behalf as the end user for this competition, providing key scope definition and a route to market for suitable outputs. The final stage of the competition is inactive demonstration at an offsite location around September 2019. Successes at this point will likely lead to active demonstration on Sellafield site, with a suitable cell environment already identified.



These solutions need to provide safer, faster, and cheaper approaches across the full decommissioning lifecycle, including:

- Characterisation
- Planning
- Decontamination
- Contamination Management
- Cutting
- Holding
- Moving

Due to the complexity of the challenge posed. It is expected that submissions to the competition will be made by collaborations of companies. To aid the forming of consortia, Innovate UK, NDA, and Sellafield Ltd have worked with KTN (the Knowledge Transfer Network), to host a series of events:

- **BRIEFING EVENT, LONDON, 14TH FEB**
- **BROKERAGE EVENTS AT**
 - Aberdeen** - 28th February
 - Birmingham** - 2nd March
 - Penrith** - 7th March
 - Bristol** - 9th March

In total, around 300 people from within the nuclear industry and external to it have been engaged. The deadline for submissions was April 2017 with successful applications beginning in July 2017.



Plant Characterisation

In-Situ Capabilities for Hazardous & Chemotoxic Assessment

In order to dispose of potentially hazardous / chemotoxic wastes, the concentration of various compounds needs to be measured. Currently, each sample collected is transported for laboratory analysis; this can be a significant task when hundreds of samples may be required to cover a representative area. A market review was conducted to identify any potential systems that can work in-situ and provide analysis of the compounds of interest. Future development / active demonstration work will then follow this project.

Benefit Realised from 2020



Plant Status Monitoring for Neutron Detectors

Current detection of fissile material in-situ involves the deployment of bulky neutron detectors. These systems need to completely surround the object of interest in order to reduce uncertainty in the results gained.

This feasibility study investigated the suitability of a new detector which would reduce these limitations, allowing for neutron survey of a large area with greater ease. Following this initial success, further development is to take place to bring the system to be demonstrated on site.

Benefit Realised from 2020



Measuring Heels in Vessels

The decommissioning of reprocessing cells on Sellafield site will commonly include size reduction of inter-connected pipes and vessels. Due to the harsh chemicals involved during reprocessing operations, appropriate safety precautions need to be in place to prevent any unintended releases.

The focus of this project was to assess what options are available to detect the presence of liquor heels without intrusive operations. The results from this work will identify any potential active demonstration opportunities.

Benefit Realised from 2019



Surveillance & Maintenance

Optimisation of Facility Surveillance and Maintenance

When a facility finished operations on Sellafield site, it typically goes through a phase of Post-Operational Clean Out (POCO). Following this depending on resource / site priorities, the building may be left in a state of Surveillance and Maintenance for several years. Keeping facilities in this state for extended periods of time is expected to cost £billions over the site's lifetime.

This project set out to underpin the possible lifetime savings by performing more hazard reduction before entering S&M. Recommendations from this work will go towards the site strategy and identify any R&D activities that could be beneficial.

Benefit Realised from 2020



Plant Dismantling / Decommissioning

Remote Glovebox Manipulator

Characterising and cleaning out historic gloveboxes is a challenging task. Over time, glovebox windows become opaque; this makes operator intervention through gloveports undesirable and less effective.

The Remote Glovebox Manipulator is a small robotic arm for deployment through a gloveport, capable of carrying out characterisation and clean out operations. This concept, developed by Sellafield Ltd graduates, is maturing with a first active demonstration planned for 2017/18.

Benefit Realised from 2019



Generic Vent Duct Cutting Tool

The technology currently available for removing and decommissioning redundant ductwork are either bespoke, or requires intensive manual operations. Given that across Sellafield site, there are kilometres of ductwork that will need to be decommissioned; a generic tool capable of size reducing clean and contaminated ductwork could bring significant benefit.

The purpose of this project was to understand how a more generic vent duct cutting tool might look like, and what benefits it may offer over the current baseline approaches.

Watching Brief



Post-Operational Clean Out (POCO)

Real Time Plant Monitoring

POCO involves washing out plant and equipment in order to reduce the hazard prior to decommissioning. This project investigates the possibility of monitoring the effectiveness of POCO in real-time.

Through real-time monitoring, a specified end state for the system can be reached efficiently – saving time and money, and potentially reducing volumes of waste generated.

Benefit Realised from 2020



Waste Characterisation & Conditioning

Characterisation of Dense Materials

Radiological characterisation of dense materials (such as lead) is a significant challenge at Sellafield Site. Self-shielding combined with the limitations of current tools produce large uncertainties which limit available waste routes.

This project investigated what commercially available techniques could be used in the future.

Watching Brief



Improvements to Fissile Waste Segregation & Sentencing

Decommissioning operations in alpha-contaminated environments is likely to generate large volumes of Plutonium Contaminated Material (PCM).

This project looked to understand if improving on current pessimisms and technology developments could increase segregation of PCM and Low Level Waste. The final report will inform future active demonstration activities and any broader challenges need to be addressed (e.g. culture change).

Benefit Realised from 2020



MIKE GUY

**Technical Capability
Development Manager**



What I have been involved in: 'By 2020 we will have demonstrated a set of tooling that can meet the majority of challenges to deliver 'General Decommissioning'. Beyond 2020, as plans mature and decommissioning gets started, we will continue to develop this capability to make our delivery safer, faster, cheaper and look to address specific challenges aligned to decommissioning and waste management projects.'

CHRIS HOPE

**Decommissioning
Capability Dev Lead**



What I have been involved in: 'As well as the team achieving some fantastic 'world's first' demonstrations of new technology, I have had the great pleasure of providing 'end-user' input and steering the exciting new collaborative innovation competition - Integrated Innovation for Nuclear Decommissioning. Working with the NDA and Innovate UK has been very rewarding and the supply chain response has exceeded all our expectations.'

GRAEME ASKEW

**Decommissioning Capability
Dev Team Member**



What I have been involved in: 'Main project focus this year was the DEMplus capability and its implementation within the SORG. The DEMplus software has a number of applications which greatly enhance the way we currently carry out Studies and Scenario planning for decommissioning operations. Ensuring that DEMplus is widely available within the supply chain will ensure the software is used to its best advantage.'

BILL JOHNSON

**Decommissioning Capability
Dev Team Member**



What I have been involved in: 'I have been involved with the team since I joined the nucleargraduates graduate scheme back in 2013. Since starting at Sellafield Ltd. full-time, the majority of my work has been focussed around the development of new tools for our characterisation challenges.'

DAVID PROCTER

**Decommissioning Capability
Dev Team Member**



What I have been involved in: 'During my previous role in Alpha Decommissioning Projects I had the opportunity to work alongside the Future Decommissioning Team on a number of projects and challenges. Since transferring into the team earlier this year I have had the opportunity to be involved in a number of exciting new technologies that with further development will enable value for money for the taxpayer.'

ALAN CARDWELL

**Decommissioning Capability
Dev Team Member**



What I have been involved in: 'The challenge set was to remotely decommission complex environments with access being restricted to existing penetrations. This was successfully achieved with the deployment of Lasersnake, the technology was proven with the dismantling of the dissolver vessel and will now be used to springboard future developments.'

JAMES MOORE

**Decommissioning Capability
Dev Team Member**



What I have been involved in: 'Getting the small unmanned aircraft (drone) procedure launched within the company now means that Sellafield is in a position to really make this technology take off.'

JAMES SANT

**Technical Specialist
Trainee**



What I have been involved in: 'I joined the team in January 2017, as part of the TST Degree apprentice scheme. Myself and Bill have created this document to highlight some of the exemplary work that goes on in our team. Next year I am looking forward to getting stuck in to some projects of my own.'

OTHER PROJECT LEADS

Liz Ostle - Decontamination Technical

Jen Rochford - Facility Characterisation Technical Delivery Team

Alex Jenkins - Decontamination Centre of Expertise

Xavier Poteau - Technical Manager

Tom Robinson - Research Technologist

Useful Documents

<https://www.gov.uk/government/publications/nuclear-decommissioning-research-and-development-brochures>

http://www.sellafieldsites.com/wp-content/uploads/2017/03/Technology-Development-and-Delivery-Summary_2015-16_LoRes.pdf

More Information about the Lasersnake 2 Project

<http://www.sellafieldsites.com/2016/11/arm-in-arm-approach-wins-awards-for-nuclear-companies/>

<http://www.ocrobotics.com/lasersnake2--news--a-world-first--laser-cutting-for-nuclear-decommissioning-at-sellafield/>

Special Mentions

Simon Candy

- Head of Technical

Sue Brown

- Future Characterisation Development Lead

Stephen Balmforth

- Studies & IT Capability Dev Lead

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