CHALLENGE: Modelling and Knowledge Management
<table>
<thead>
<tr>
<th>Section Number</th>
<th>Section Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Overview</td>
</tr>
<tr>
<td>4</td>
<td>What Do We Mean by Innovation?</td>
</tr>
<tr>
<td>5</td>
<td>The Modelling and Knowledge Management Vision</td>
</tr>
<tr>
<td>5</td>
<td>The Business Benefit</td>
</tr>
<tr>
<td>6</td>
<td>Real Time Monitoring of Waste Treatment and Clean Up</td>
</tr>
<tr>
<td>8</td>
<td>Communication With Remote Devices, Plus Tools and Sensors That Can Be Deployed in Harsh Environments</td>
</tr>
<tr>
<td>10</td>
<td>Characterisation, Data Management and Optimised Planning</td>
</tr>
<tr>
<td>12</td>
<td>Monitoring of Buildings: Interconnected Array to Provide Real-time Monitoring and Surveillance of Buildings</td>
</tr>
</tbody>
</table>
OVERVIEW

Sellafield is the most complex industrial site requiring remediation in western Europe. Comprising approximately 700 acres, the site consists of more than 2,200 buildings including 170 major nuclear facilities.

As reprocessing operations cease, the major focus will shift to Post Operational Clean Out (POCO), waste management and decommissioning activities.

Due to the variety of complex operations performed at Sellafield a wide range of challenges will need to be addressed, some of which might be solved with the introduction of innovative digital solutions, including:

- Real time monitoring of waste treatment and clean up
- Communication with remote devices, plus tools and sensors that can be deployed in harsh environments
- Characterisation, data management and optimised planning
- Monitoring of buildings – interconnected array to provide real time monitoring and surveillance of buildings

The Modelling and Knowledge Management Challenge Statements (right) introduce the challenges associated with the dismantling, size reduction and decommissioning of the legacy nuclear plants on the Sellafield site.

Sellafield Ltd seeks to work with industry, SMEs, academia and larger organisations to create a diverse tool-kit of smart technology and digital solutions to support the decommissioning programme. The document has been created to provide information on:

- The identified high-level challenges which could immediately benefit from smart technologies and digital solutions
- Current baseline technologies which are available for use today
- Limitations of current baseline technologies, that could potentially be addressed with innovation
- Perceived gaps with the existing approaches and suggestions on areas where there is an opportunity for innovative solutions
Sellafield Ltd and Game Changers are inviting enquiries and applications from companies who are focused in smart technologies and digital solutions, typically in the fields of:

- Real time radiometric measurement of gaseous effluent
- Aerial gas sensor specialists
- Detectors and sensor networks
- Big data, analytics, data mining
- Legacy dataset conversion
- Augmented Reality / Virtual Reality
- Imaging and modelling
- Automated monitoring and testing
- Robotics
- Remote asset care and monitoring
- Reducing energy / raw material consumption

**WHAT DO WE MEAN BY INNOVATION?**

We are seeking to engage with companies with the knowledge, experience, ideas, solutions and/or early stage technologies which might help accelerate the decommissioning programme at Sellafield. These can be SMEs or large corporations, academia or individuals.

Rather than limit the scope to only those with experience in the nuclear and decommissioning arena, innovation in this instance might be the technologies and approaches successfully deployed and proven in other sectors. The transfer of knowledge and technologies from other industries is something we wish to actively encourage.

We know, for example, that commonalities exist in the decommissioning of large and complex oil and gas facilities, many with similar dependencies and cost and safety considerations.

Sellafield Ltd also welcome completely novel ideas and concepts: the early stage and emerging technologies that will truly be ‘game changers’.
THE MODELLING AND KNOWLEDGE MANAGEMENT VISION

Imagine if we had access to all the information we required to make accurate, informed decisions about the full scope of the decommissioning challenges in front of us; we could put that information into tools that would allow us to run, or even evaluate, scenarios from which we can make detailed plans and commit resources accordingly.

This would enable us to tackle our challenges with a much higher degree of confidence and with the assurance that we know what to expect; that we’ve been able to practice in a highly realistic synthetic environment, so when humans or our remote tools are deployed they are able to carry out operations in a safe, efficient and optimal way with respect to a health, environment, costs and time.

Sellafield's vision is to challenge the baseline and determine optimised Post Operational Clean Out (POCO) and decommissioning strategies. The objective is to provide mechanisms to enable optioneering and scenario modelling in support of strategy development and decision making for POCO and decommissioning.

THE BUSINESS BENEFIT

The old adage is that knowledge is power: in the case of the clean-up and decommissioning at Sellafield, lack of knowledge can lead to:

• additional or extended operations where situations encountered are not as assumed or anticipated;
• increased risk to human operators if they encounter unexpected hazardous materials;
• increased risk to operators having to exit and re-enter harsh environment due to new information.

Furthermore, where uncertainty exists, in order to maintain the highest level of safety there is a tendency to assume worst case scenarios leading to solutions that might be over-engineered.

Over-engineering, re-work and manual operations add cost and time to the Sellafield programme and can impact on operator dose uptake and environmental discharges, as well as the ‘knock-on’ effect to subsequent decommissioning activities.

Being able to access appropriate and accurate measurements, and/or make judgements in real time from remote locations, provides Sellafield with the ability to make informed decisions and make significant improvements to their baseline cost, time, health and environmental performance.

Due to the challenging nature of the environments this will only be achieved through innovative solutions in deployment, information transfer, management and presentation.
REAL TIME MONITORING OF WASTE TREATMENT AND CLEAN UP
The Situation

Thermal treatment solutions provide an option for the immobilisation of Intermediate Level Waste (ILW) and Low Level Waste (LLW). The treatment solution will need to accommodate varied feeds and will typically be used to:

• destroy organics;
• destroy passivate reactive metals;
• and produce a monolithic material suitable for ultimate disposal.

A good understanding of process relating melt behaviour and its response to feed variability can greatly reduce the need for intrusive characterisation of feeds and final product analysis.

Key aspects of the thermal process include melt REDOX condition, specific radionuclide volatility and partitioning to the off gas and variation of melt stability, all against changes in feed characteristics.

Real time monitoring of specific aspects of the process could enable the responses to feed changes to be managed in such a way that the final product can be guaranteed for final disposal without the necessity for ‘destructive’ analysis.
COMMUNICATION WITH REMOTE DEVICES, PLUS TOOLS AND SENSORS THAT CAN BE DEPLOYED IN HARSH ENVIRONMENTS
The Situation
The widely accepted definition and attributes of Industry 4.0 leans towards the world of advanced manufacturing, yet many of the associated technologies are those which, it is anticipated, may achieve positive results in remote decommissioning operations. This includes, but is not exclusive to, developing:

- intelligent tools through integrating sensors / feedback / complex control;
- automated or tele-operated systems;
- using real-time computer models to inform processes / decisions;
- autonomous operations;
- and information recording.

The Challenge
In decommissioning nuclear facilities, tools are deployed in sensory deprived conditions. In beta gamma decommissioning, high radiation fields require remote solutions which can be difficult to interrogate and in alpha decommissioning, the sensory and situation awareness of operators is reduced by Personal Protective Equipment (PPE) and the general working environment.

There is a great potential in smart technologies and digital solutions to revolutionise the deployment of tools in nuclear decommissioning.

Real time, in-situ feedback can allow:

- the advanced control in semi-remote, collaborative tools or autonomous intelligent systems;
- the monitoring of live operations through data mining and information (rather than data) generation and dissemination;
- tool interrogation for on-line maintenance, graceful degradation and fail-safe operations;
- continuous re-planning for optimised operations and the analysis of success criteria.

Updating traditional tools with feedback utilising advances in smart technology will give significant benefits in all measurable aspects of nuclear decommissioning.
CHARACTERISATION, DATA MANAGEMENT AND OPTIMISED PLANNING
The Situation
The clean-up and decommissioning of the Sellafield site is a complex process with significant challenges presented by the interconnectivity and hazardous nature of the environments involved.

The Challenge
Advances could be made if clean-up and decommissioning plans could be made on comprehensive, robust datasets.

Unfortunately, human access to many facilities is limited or not possible; furthermore, datasets that have been generated have been archived in many different formats over decades of operation.

The use of smart technology and digital solutions to generate new or compile existing information into an accessible, tangible format to permit formulation of robust plans would drive down costs and accelerate timescales.

The Constraints
• Installing sensors/instrument in complex contaminated environments where human access is limited.
• Communication through large reinforced concrete structures.
• Analysis of real-time heterogeneous data to give insight into performance and prediction of future performance.
• Exploitation of intelligent systems with some levels of autonomy in safety-related decision making.
• Maintaining security of information where there is the opportunity to aggregate information.
• In some cases, the instruments will be in regions of higher radiation levels and may deteriorate.
• Systems will need to remain capable, dependable and sufficiently accurate for several decades.
MONITORING OF BUILDINGS: INTERCONNECTED ARRAY TO PROVIDE REAL-TIME MONITORING AND SURVEILLANCE OF BUILDINGS
The Situation

The programming of decommissioning activities on the complex and interconnected Sellafield site includes a number of ageing buildings remaining in quiescent states for the foreseeable future. Some buildings will be storing waste for decades until a suitable repository becomes available. This presents a need to monitor the condition of these facilities, the waste containers housed within and the contaminated waste itself.

Most of these buildings have substantial ventilation systems to prevent contamination of operators and the wider environment. As the buildings move into dormant states, we need to find more appropriate ways of managing the risk from residual contamination.

This may include combinations of monitoring and low-throughput conditioning systems.

The Challenge

The challenge is to apply pervasive, low cost multi-sensor arrays to monitor quiescent buildings and equipment in order to reduce the number of unnecessary, expensive, complex and potentially hazardous interventions into these structures.

The Constraints

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- Communication through large reinforced concrete structures.
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- Exploitation of intelligent systems with some levels of autonomy in safety-related decision making.
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- In some cases, the instruments will be in regions of higher radiation levels and may deteriorate.
- Systems will need to remain capable, dependable and sufficiently accurate for several decades.
Get involved.

Should any of the challenges presented be of interest to you and your organisation, and you feel that you have the innovative technologies or techniques to help deliver the desired solutions, then we’d like to hear from you.

Visit [www.gamechangers.technology](http://www.gamechangers.technology) to download or complete an application form online, or you can request an application form by email at [apply@gamechangers.technology](mailto:apply@gamechangers.technology)

The decommissioning of the Sellafield site is anticipated to take over 100 years, cost in excess of £50bn and creates challenges never encountered before. These challenges require investment in innovative technologies, concepts and methods.

Sellafield Ltd actively seek to engage with Game Changers - businesses, academia and individuals who can bring their innovations into the nuclear arena and help achieve the goals of accelerating the decommissioning programme whilst also reducing costs and upholding Sellafield’s commitment to human and environmental safety.

Game Changers could also be technologies and methods which are already used in other industries which could be developed for use in the nuclear sector.

Funding for proposals is available to support development of these technologies: we invite proposals which clearly articulate the innovative technology development needed to meet Sellafield’s decommissioning challenges.

Successful applicants are eligible for an initial £5,000 of funding and commercialisation support to present their innovations to Sellafield Ltd.

Further proof of concept and prototype development funding will be made available to any innovations identified by review panels to have significant commercial and operational potential.

Information about this initiative is available on the Game Changers website at [www.gamechangers.technology](http://www.gamechangers.technology) or you can contact us by email at [apply@gamechangers.technology](mailto:apply@gamechangers.technology)

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