Advanced Nuclear Skills Innovation Campus

GAMECHANGERS
DELIVERING NUCLEAR INNOVATION

Department for Business, Energy & Industrial Strategy

Challenge: Digital technologies to support development, deployment, operation and decommissioning of Advanced Nuclear Technologies

Digital Technology has been recognised as an exciting topic within the nuclear industry. It has the potential to overcome challenges that currently impact negatively on the cost of nuclear including siloed working, loss of fidelity of information during handover and a digitally aware culture that embraces the benefits of digital and drives change across business practices in the nuclear sector.

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Summary

Advanced Nuclear Technologies (ANTs) could play an important role as a low-carbon energy source to support a secure, affordable decarbonised energy system. Success in achieving these objectives could be achieved in part by adoption of Industry 4.0 to support the whole life-cycle management of assets through design, construction, operation, decommissioning and remediation. However, it is recognised that digital integration and Industry 4.0 approaches have so far had limited traction in nuclear, whilst having revolutionised other sectors. Understanding the connection between the stages of the lifecycle and the management of digital assets is essential if the nuclear industry is to realise the benefits of digitalisation.

On behalf of the Department for Business, Energy, and Industrial Strategy (BEIS) and the National Nuclear Laboratory (NNL), Game Changers are seeking innovative approaches to overcome barriers to the adoption of Industry 4.0 technologies in the nuclear sector. Topics for proposals could include, but are not limited to:

- **Digital twins and smart sensor networks**
  Specifically, application within a nuclear environment, role with project delivery and quality assurance, asset management maintenance and operability, standards for sharing of digital information, off-site modular manufacture, and digitalisation of design-build-operate.
- **Collaboration and security of digital assets**
  Specifically, secure sharing of information, collaboration involving sensitive data sharing. Establishing a common cross industry approach to digitisation and an exploration of blockchain and cybersecurity technologies to support the establishment of a collaborative cross-industry digital ecosystem.
- **Cloud technologies and large-scale computing**
  Specifically nationally significant digital infrastructure to support new nuclear build.
- **Artificial intelligence and high-fidelity computer simulation**
  Specifically, application of AI to nuclear safety and operations, uncertainty in numerical simulation, credibility of computer models with key stakeholders including owner operators and nuclear regulators.

Background

This call is part of a short pilot of the Advanced Nuclear Skills and Innovation Campus (ANSIC), delivered by NNL on behalf of BEIS, as part of the UK Government's commitment to the continued development of ANTs to help the UK reach net zero emissions by 2050.

The pilot campus programme, with a physical base near Preston on the Springfields nuclear licensed site, will serve as a research and innovation hub. ANSIC aims to support industry and academia to work on projects designed to help accelerate the deployment of ANTs.

The pilot programme will help to build an informed, reliable evidence base to:

- Establish future demand and scope for future initiatives
- Identify opportunities for industry collaboration and the practical challenges of delivering campus activities on a nuclear licensed site

The UK Government has committed to significant investment in the development of Small Modular Reactors (SMRs) and Advanced Modular Reactors (AMRs) as part of the transition to a low carbon economy. In July 2021, the Government also announced plans to explore the potential of High Temperature Gas Reactors (HTGRs) to enable an AMR demonstration by the early 2030s, to support net zero by 2050. As part of the delivery of the pilot phase of ANSIC, a series of challenge-led calls offers applicants the opportunity to receive a £25k feasibility funding grant to develop ideas or technologies applicable to any potential ANTs.

Feasibility funding is aimed at supporting the exploration and development of novel ideas and concepts. Typical activities within a feasibility project can include desk-based studies, development and production of small prototypes, and demonstrations.

Funded feasibility projects should be carried out at the applicant's own premises, and these calls do not include access to the ANSIC campus. **All agreed project tasks and final reports must be completed by 25th March 2022.**

Introduction

ANTs encompass a wide range of nuclear reactor technologies under development. Generally ANTs fall into one of two groups: Small Modular Reactors (SMRs) and Advanced Modular Reactors (AMRs). The technologies share common attributes including being smaller than conventional nuclear power station reactors and designed so that much of the plant can be fabricated in a factory environment and transported to site, reducing construction risk and making them less capital-intensive. SMRs are based on Generation III water-cooled reactors, similar to existing nuclear power station reactors. AMRs use Generation IV and beyond reactor technology, which use novel cooling systems or fuels to offer new functionality (such as industrial process heat).

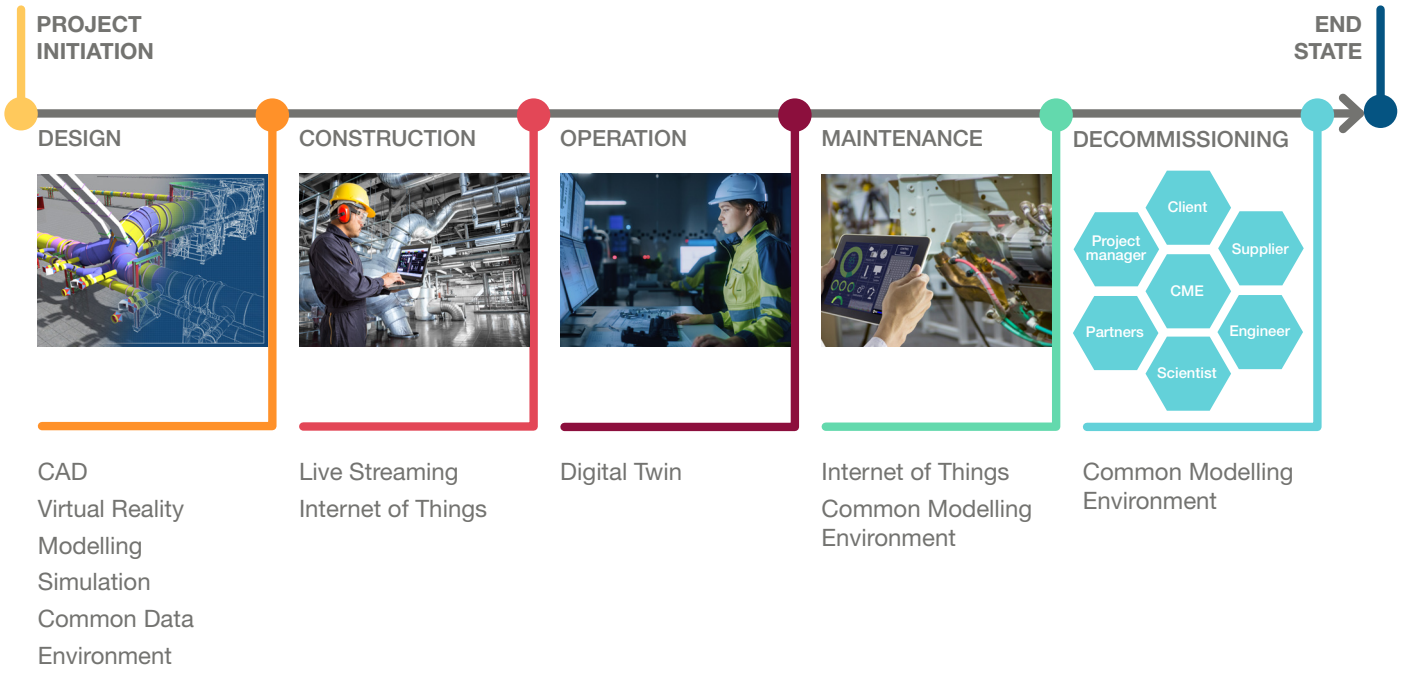
All reactor types, including SMRs and AMRs have an opportunity to embrace Industry 4.0 and incorporate substantially increased degrees of digitalisation. For example, reactors could be deployed on a fleet basis with some degree of remote operations from a command and control centre or be deployed as multi-module plants with the impact of shared resources and systems requiring the implementation of more sophisticated control systems. Design, build, operation and eventual decommissioning of these facilities is also expected to benefit from Industry 4.0, specifically around whole life-cycle asset management which is one of the cornerstones of digitalisation across the construction sector. Proposals are sought which may facilitate the uptake of disruptive digital technologies in nuclear to support the qualification and safe operation of ANTs.

Current practice

The nuclear industry has been slow to adopt widespread digitalisation across its existing work streams including reactor operations, post operational clean out and decommissioning. However, the UK nuclear sector has not been slow to recognise its potential and elements of digitalisation have been adopted as part of the on-going Hinkley Point C build. For example, initiatives led through the nuclear institute digital community of practice (Digital Special Interest Group) have brought together industry leaders to share and collaborate on ideas ranging from application of digital twin technology, virtual and augmented reality, remote sensors and condition monitoring and best practices in digital information sharing and standards.

Industry and government have collaborated on a number of Innovation Programmes in Nuclear Energy including a 4 year collaborative project involving industry leaders towards the establishment of a Nuclear Virtual Engineering Capability. A further example, in Project FAITH, which was funded under the BEIS Advanced Manufacturing and Materials programme, demonstrations have been developed across the life cycle of a representative nuclear asset. This collaborative project demonstrated the application of digital technology across a number of areas for the design and build of a fast reactor test rig including :

- Smart sensors to monitor the performance of the asset during modular design, build transportation and commissioning.
- Virtual reality and mixed reality during design, safety assessment and HAZOP management.
- High-fidelity digital twin technology demonstrating the coupling of system level simulators, sensor data and high fidelity computer models.
- The integration of digital twins within a common Modelling Environment to realise a whole cycle approach, as depicted below:



Challenge aims

Proposals which allow transfer of Industry 4.0 technologies (for example, those relating to integration of advanced digital, autonomous and smart technologies and advanced fabrication into complex systems) into the nuclear sector could unlock huge potential.

The challenge is to take technology proofs of concept, such as those highlighted above, and understand the barriers to applying these within the context of ANTs. These challenges are either perceived or real and must be overcome if we can move forward with the adoption of Industry 4.0 approaches. Specific challenges, which pertain to the overall challenge outlined in the introduction to this call include:

- Processing and managing of sensitive nuclear data on cloud infrastructure and provision of critical infrastructure to encourage and support cross industry collaboration.
- Stakeholder acceptance of the credibility of computer models and digital twins of nuclear infrastructure and their role in qualifying the integrity of nuclear infrastructure.
- The deployment of Internet of Things technology within high hazard environments.
- The establishment of cross industry standards to digitalisation to foster and maintain a collaborative approach to the delivery of ANTs.
- Digital twin concepts to enable continuous monitoring, early warning, diagnostics, and prognostics for the reactor systems.
- Advanced distributed sensing and data generation techniques to characterise critical components and systems.
- Automation, robotics, remote and centralized maintenance, and monitoring to ensure optimal plant operation.
- Predictive maintenance approaches to asset management, digital asset information management and compliance to nuclear regulation and model-based fault system detection techniques.

Benefits to focus area

- Entry of new products into nuclear markets, including domestic and international
- Acceleration of timescales for deployment of ANTs
- Reduction in costs to deployment
- Reduction in technical and programme uncertainties
- Enhancement in the ability to make safety claims and arguments, including reduction in uncertainty

If successful, projects delivered through the challenge will advance the understanding and technology readiness of components and systems that support the qualification and safe operation of ANTs for the production of various energy outputs and products.

The overall benefit of the project will be a clearer understanding and increased technology readiness level of systems that support the adoption of Industry 4.0 approaches to the operation of ANTs in a way that meets the requirements of the regulatory system and is cost effective. As a further benefit this will provide confidence (or otherwise) in the ability of ANTs to deliver heat and energy products as envisaged and identify the further steps that may be needed to realise that overall ambition. This would include demonstrating how the adoption of the digital technology meets the objectives set out within the Nuclear Sector Deal and Construction Sector Deal, synergy between which will support successful outcomes for the sector. Overall these outcomes will support delivery of the Government's 10-Point Plan[1] and Energy White Paper[2], which outline plans for decarbonising the energy system and indicate a more expansive role for nuclear energy in terms of the applications that the technology can support.

Constraints

The proposal should be clearly linked to one or more benefits or needs relating to ANTs, which may be a single technology or programme, or more than one. In the wider advanced nuclear reactor and technologies markets, there are numerous programmes which range greatly in timescale. Whilst there is no defined target programme or timescale for the proposal to achieve its aims, it should be clear which programmes it will affect, and at what stage in their lifecycle. Broadly, it is anticipated that proposals would have tangible impact within the next 5-10 years.

Functional Requirements

Solutions proposed should be cognisant of the regulatory and licensing requirements of the UK nuclear sector and the opportunity to bring technologies and approaches from other sectors.

It is anticipated that solutions could reduce overall costs, enhance the ability to make safety claims and environmental outcomes and/or improve efficiencies. The proposal should outline the magnitude of the potential benefit to realising the approach, in the context of ANTs.

Collaboration between nuclear and non-nuclear sector organisations is desirable but not mandated or required, however aligning a solution to ANTs and their development and deployment before 2050 is essential.

[1] The Ten-Point Plan for a Green Industrial Revolution. BEIS. 2020
[2] Energy white paper: Powering our net zero future. BEIS. 2020

What Next?

Game Changers are hosting an online briefing webinar for this challenge. Details of the webinar are available on the Game Changers website www.gamechangers.technology. If you have new ideas or innovations which can be applied to address this challenge we invite you to join us.

Please visit our FAQs for ANSIC on the website for answers to some commonly asked questions, or contact us on apply@gamechangers.technology if you have further queries about this call.

Applications must be submitted using the Game Changers online application portal. This includes a short application form and a requirement for a poster outlining the proposed solution.

The deadline for applications for this challenge is 12 noon on Friday 12th November 2021.

Assessment of applications

Submissions will be assessed by a panel and written feedback will be provided by Game Changers for all applications, whether or not successful. The panel will comprise members of the ANSIC Steering Group, which includes representatives from NNL, BEIS and the Nuclear Innovation and Research Office (NIRO).

Application forms and posters will be assessed consistently and transparently using the following criteria:

1. Clarity of project objectives and alignment to the challenge aims
2. The level of technical innovation involved in the proposed work
3. The skills, capability and capacity of the applicant team to deliver the proposed project
4. Value for money
5. Identification of risks and mitigating actions

Key dates

Date	Activity
8th October 2021	**Call Opens.**
21st October 2021	**Briefing Webinar. Registration via Eventbrite.**
12th November 2021	**Call Closes at 12 noon.**
W/C 22nd November 2021	**Panel Review of Proposals.**
W/C 29th November 2021	**Notification of Panel Decisions and Feedback.**
W/C 6th December 2021	**Project Kick-off Meetings.**
December 2021 – March 2022	**Project Work in Progress.**
25th March 2022	**All Project Work and Final Reporting Completed.**

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