FRAZER-NASH CONSULTANCY
A KBR COMPANY

Research and Innovation



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Foreword

Innovation plays such an important role in what we do and who we are at Frazer-Nash. Empowering our people to create extraordinary impact for our customers, our partners, and the communities in which we work requires us to continuously push the boundaries, always endeavouring to add new value.

This report captures a broad sample of some of the innovative work we have completed and continue to undertake across our team of teams. Everywhere I look within Frazer-Nash, I find brilliant people doing amazing things. The diversity of the work we undertake never fails to amaze and inspire me in equal measure, and I hope this report achieves similar results with you – the reader.

One common thread I have observed whilst working with innovators across Frazer-Nash is their humility and fine-tuned ability to achieve such spectacular results with minimal fanfare. It is somewhat against this tide that we have been able to showcase these examples of innovative excellence, and I thank all contributors for sharing their insights and successes, especially where this is counter to their natural instincts. We are pleased to have created this safe, inspiring space to recognise your achievements.

I'd also like to thank the leadership teams of Frazer-Nash and KBR for their belief and investment in the innovative ideas that we explore with our customers and stakeholders every day. It requires courage and confidence to take deliberate steps into the unknown, and success is not always guaranteed first time around. The following pages are testament to the fact that the confidence we have in our people and teams is well placed, as we innovate together for a better World.

Graham Joyce
Strategy & Innovation Director

Contents

Our people collaborate, challenge and innovate, applying human-centred thinking and technological expertise for a future of sustainable progress.

Our values

At Frazer-Nash we are guided by our values in everything we do, collaborating to support our customers in delivering some of the country's most important projects.

We value our people

We empower

We are people of integrity

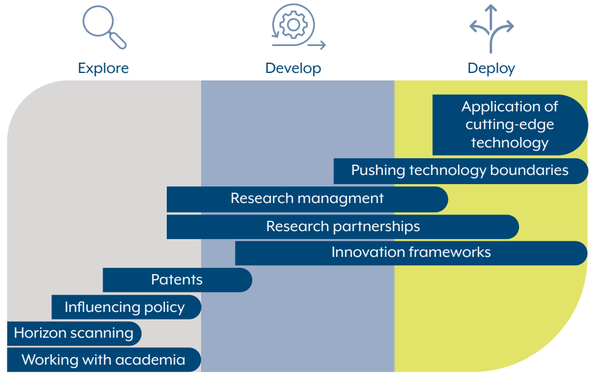
We deliver

We are a team of teams

Our Approach to Research and Innovation

Research and Innovation (R&I) has always been part of our DNA allowing us to make a positive difference to society and aligned closely to our values. Assisting our clients on their R&I journey, or developing our own concepts, are embraced with equal enthusiasm.

Across all of our sectors, the severity of the challenges faced, combined with the uncertainty and rapid rate of change, results in an unprecedented need for new solutions. Engineering has more tools than ever, but if engineering is to achieve its core purpose it must achieve more with less time, less money, less certainty and using fewer natural resources. So we need new solutions, and new solutions come from R&I – the R&I work that we (in the widest sense) do needs to make an impact. This is what provides our primary motivation.



Brian Gribben
Research and Innovation Manager

What is engineering for?

Engineering is the art and practice of changing and shaping the material world for the benefit of humankind - engineers turn ideas into reality. - **The Engineering Council, UK**

We can't make an impact on our own. Successful introduction of new technological solutions requires contribution from all stakeholders and 'systems thinking' considering all actors and users is essential to success. At Frazer-Nash, we have the capability and experience to work at any and all Technology Readiness Levels (TRL) levels from fundamental research to end-user and regulatory perspectives to explore, develop and deploy technology.

Working across stakeholders, we often bring them together to plan, deliver, assure and accept the new. This is a perspective and skill set that we bring to all of our research and innovation related work, from relatively small research tasks carried out by our own teams through to our largest research programme management roles.

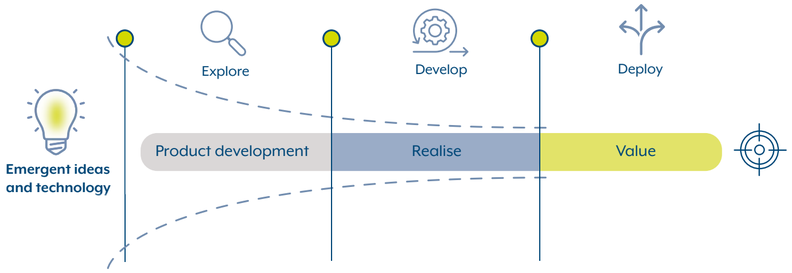
Our Innovation Process

Whether promising new concepts are our clients' or our own, and no matter if they arise from internal investment or from innovation programmes, we take a similar approach to their assessment and investment potential.

A key feature is the need for structured assessments or decision gates, which are represented by approval to "Explore", "Develop", and "Deploy". At each stage, a well-rounded view is needed on the factors that contribute to the success or otherwise of a new technology, which include the:

- The technical advantage and potential.
- Vision for an end-product.
- Existing and future markets and competition.
- Ability to protect intellectual property.
- Enterprise and societal strategic drivers.
- Alignment with enterprise goals and values.
- Investment required and revenue potential.
- Risk profile.

Innovation funnel



Only the first of these, the 'technical', comes naturally to engineering organisations. As maturity grows towards "Deploy", the emphasis becomes much more on the hard expectations of revenue and cost, but these considerations must also be present at earlier stages.

One of the key considerations is how to balance the requirements to fail fast, or to sideline concepts which will ultimately be unsuccessful before committing large costs, while still being open and flexible enough to allow 'winners' to progress and succeed, even though they may have some weak points initially. In other words, it is always easy to find a reason to say 'no' to investing in something new.

We believe that finding a good balance comes only through the experience of learning by doing and our commitment to benefitting from experience. At the end of 2023, Frazer-Nash has over a dozen potential products in the innovation funnel, traversing the full breadth of our technical capability and market reach.

Our Company

90+
Established technical groups

1500+
Staff

£168m
Turnover in 2023

Delivering from
15
UK offices

10%
Overseas work in 2023

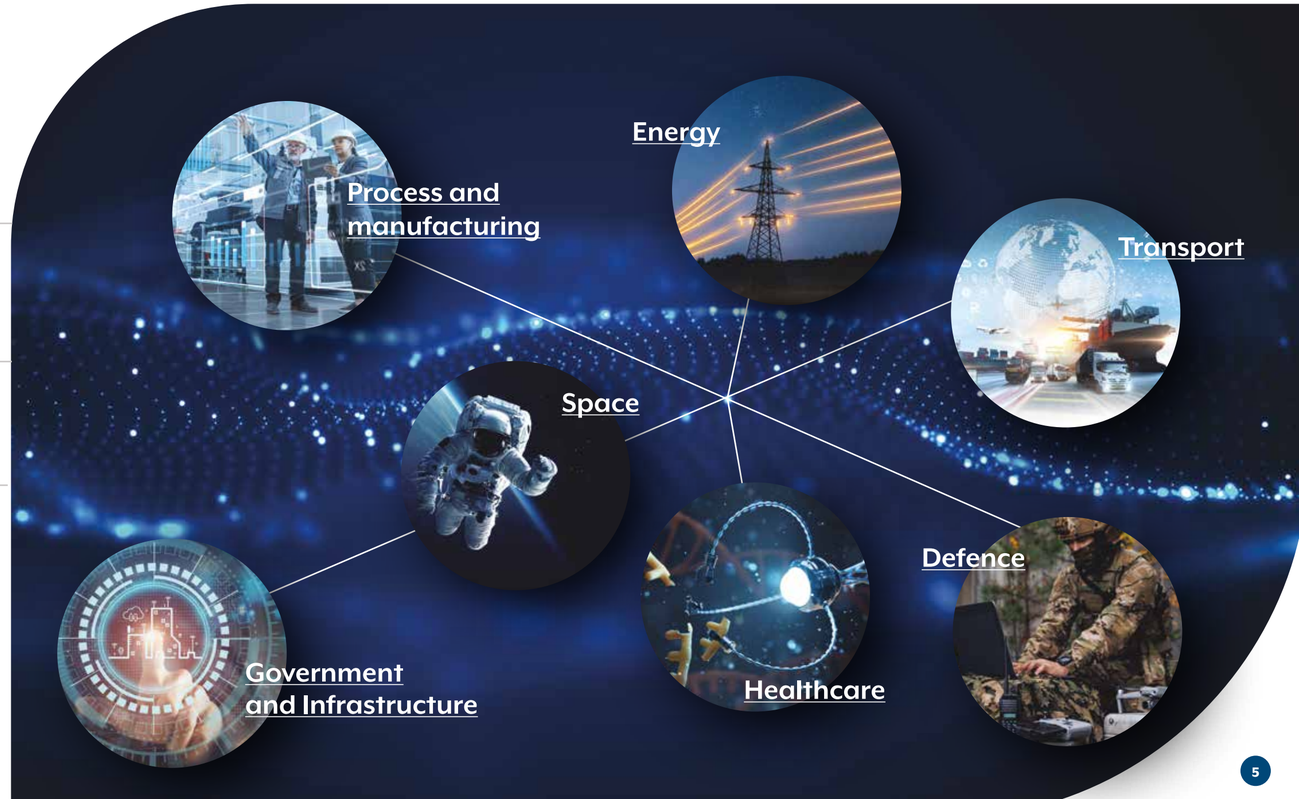
24
Publications in 2023

4
Patents filed in 2023

Accreditations

ISO 14001 CERTIFIED
ISO 13485 CERTIFIED
ISO 9001 CERTIFIED
ISO 45001 CERTIFIED
ISO 27001 CERTIFIED
CYBER ESSENTIALS PLUS
IT plus

Our Markets



Our Services

Manage/ Advise

- Strategic advisory
- Program management
- Sustainability and decarbonisation

Clarity and insight to transform your business.

Assess

- Asset integrity
- Fluids and thermal
- Software development

World-class capability to assess and improve performance.

Assure

- Assurance
- Asset management
- Security and resilience

Stature to support critical decisions on safety, security and business risk.

Design

- Design services
- Rotating machinery centre
- Electronic and electrical engineering

Systems design approach to develop effective solutions.

Integrate

- System engineering
- Digital transformation
- Robotics and autonomy

Expertise to deliver integrated solutions across whole project lifecycle.

FRAZER-NASH CONSULTANCY
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Working with academia

Working with academia

Working with universities and research institutions is an important element to our research and innovation activities. Harnessing the deep subject matter expertise that is offered by universities can be hugely beneficial in tackling specific research questions and in overall capability development.

We currently work with over 20 UK universities to deliver new research. Our ways of working are diverse, and tailored to specific requirements in each case, but often include:

- **Expert advice -**
  Frequently an innovation initiative benefits from academic experts contributing to planning the scope of activity and evaluating outcomes.
- **Collaborative research and development -**
  We partner with universities, especially where dedicated resources and facilities are required, to deliver longer packages of work which fit into the time scales of the academic world, such as aligning with PhD and Post Doctoral Research Assistant (PDRA) cycles.
- **Research student sponsorship -**
  Where capability development and research objectives align, we are keen to co-create research programmes and co-supervise students. The Engineering Doctorate (EngD) qualification is particularly well suited, as it allows the business to contribute fully to developing an individual's skills and experience, while directly injecting new ideas from universities into the business.

Working with academia on behalf of our clients can have organisational challenges related to requirements for project management, financial reporting, security and quality management. Often large institutional clients and universities talk different languages on these subjects – We effectively bridge this gap, offering research management as a service, and allowing all parties to focus on the important research outcomes.

Other long term and important benefits to our capability, and to that of our clients, come from rubbing shoulders with academia on research projects and programmes. Access to cutting-edge knowledge is enhanced, keeping our consultancy service at the forefront of technology developments. This includes helping us develop our own insights into longer term challenges and disruptive innovations, and continually testing and evaluating current practice in industry with emerging and novel ideas and approaches.

Exchange of talent is a great way to exchange knowledge and expertise. In the following sections, you will meet some of our staff who have part-time positions at universities, those who have been recruited directly from university research teams, as well as our sponsored graduate research students.

Visiting professors

In October 2020, David Richards, David McNaught and Graham Hawkes were awarded prestigious three-year Royal Academy of Engineering Visiting Professorships, enabling them to share their expertise with the next generation of engineers.

Dr Graham Hawkes

Engineering Manager and ONE KBR Technical Fellow

University of Surrey
Technical Advisory Skills,
Mechanical Engineering Sciences

Graham has delivered lectures on professional skills and industrially focused topics supporting core course content ranging from numerical methods to fluid mechanics. He also mentors and coaches 3rd year project teams, sits on the Department's Industrial Advisory Board and contributes to the new Industrial Aerodynamics and Wind Energy module.

As Engineering Manager for Energy Technology, Graham is responsible for the delivery of fluid dynamics, thermal and physics insight across the full extent of the energy sector, from nuclear to offshore wind. He also advises developers, operators and investors within the offshore and clean energy sector. He is currently working with a range of offshore wind farm developers to create and appraise tools to quantify blockage and farm-to-farm wake effects.

David Richards

Principal Consultant

Glasgow School of Art
Product Design Engineering

David shared his experience from a design engineer perspective in a consulting business context to help prepare the students for entering the workplace. His inaugural lecture "Swings, Lifeboats and Olympic Medals" set the tone and inspired several students to join Frazer-Nash.

With 30 years' experience of delivering mechanical and product design projects, David has worked across a variety of clients and industries with responsibility for resource management and technical delivery. He gets involved in all mechanical and manufacturing engineering aspects from the earliest research and concept stages through to the delivery of prototypes or one-off hardware, developing novel yet simple solutions to design problems.

David McNaught

Capability Manager, Ventures and Innovation

University of Strathclyde
Applied Systems Engineering

David has 15 years' experience of applying systems engineering to frame and solve unconventional engineering problems. As a Visiting Professor, he has used this expertise to develop two system engineering modules, teaching students overlapping approaches to problem structuring, systems methods, societal engagement, and professional skills.

David is part of the leadership of our Strategy and Innovation business unit, managing an innovation portfolio at the intersection of technology, policy, and market factors. As a consultant, he has developed clean technology innovation strategies in diverse industry contexts, including hydrogen production for oil and gas majors, nuclear fusion fuel cycles, and green steel making.

Academic research

Scientific methods and data analysis techniques are rapidly evolving, and Frazer-Nash needs to continuously improve and develop to remain at the cutting-edge of technology. One of the ways that we achieve this is by recruiting experienced academic researchers and giving them the opportunity to apply their research to deliver solutions for our customers.

Dr David Jesson
Senior Consultant
Materials Performance

A materials scientist and engineer by profession, training, and inclination, David joined Frazer-Nash following 15 years of academic research and laboratory management as a Research Fellow at the University of Surrey. Providing leadership for the Mechanical Testing Facility, it was almost inevitable his Twitter handle would be @breakerofthings.

Whilst David's PhD was in nanomaterials, he has studied the large as well as the small, conducting research on materials ranging from advanced composites to Victorian cast iron, with asset integrity and sustainability being connecting themes. David supervised PhD and EngD students during his academic tenure, bringing his experience of EngD programmes and academic connections to Frazer-Nash.

Dr Greg Chance
Consultant
Digital Systems Assurance

As a Research Fellow at the University of Bristol's Trustworthy Systems Laboratory, Greg assessed verification and validation tools and techniques for autonomous and AI-based systems. His publications include the verification of autonomous vehicles and drones, the specifications required for trustworthy assessment of systems and novel verification techniques, such as agent-based approaches for verification and using serious games for test case generation.

Previously, Greg was a Senior Research Associate at the Bristol Robotics Lab researching safety and robotics, undertaking human robot interaction studies to understand the hazards associated with domestic robots that can help people with mobility constraints with the activities of daily living. Greg joined Frazer-Nash in October 2022 and is applying his research in AI assurance more broadly to give clients confidence in their AI systems across the healthcare, automotive, energy and defence sectors.

Dr Sophia Coban
Consultant
Strategic Modelling

Sophia's expertise is in the field of computational imaging, with a focus on X-rays and gamma-rays as well as synthetic-aperture-radar, CCTV image streams and various forms of signal processing. Her PhD in 3D and dynamic 3D reconstruction in computational imaging was followed by three Post Doctoral Research Associate (PDRA) positions at the University of Manchester and Centrum Wiskunde & Informatica (CWI), during which she established the FleX-ray Laboratory at CWI in Amsterdam.

Since joining Frazer-Nash, she has applied her imaging knowledge and research to detect thermal anomalies in assets of interest, infer weight loss in post-irradiated graphite samples from X-ray CT reconstructions, and used image processing to improve product quality monitoring. In addition, she has applied statistical inference and information theory to cyber defence by combining Bayesian networks and knowledge graphs to predict user behaviour and the level of malicious intent.

Academic research

Dr David Landsberg
Senior Engineer
Serapis Group

David is an AI research engineer with two doctorates. He completed his first PhD in philosophy at St. Andrews University on causal inference before investigating statistical fault localisation as part of a DPhil in computer science at the University of Oxford. After undertaking two PDRA positions, David developed statistics and optimisation methods to solve large scale systems engineering problems.

David's knowledge of philosophy and AI methods gives him a unique perspective and understanding of the risks and application of AI techniques and machine learning. He currently oversees the technical work being delivered under the Serapis Lot 6 framework (page 39) and is using his AI expertise to identify social manipulation through causal inference.

Dr Clive Emary
Consultant
Advanced Modelling

Clive's interest in quantum technology began over 20 years ago when he completed his PhD at the University of Manchester (UMIST) in Theoretical Physics. Since 2006, he has researched and lectured in this exciting field at the Technische Universität Berlin, University of Hull and Newcastle University and published over 100 papers. His research background covers a wide range of topics from quantum technology and solid-state physics, through to mathematical biology and complex networks.

At Frazer-Nash, his focus is on the application of novel computing technologies to solve complex business problems. A key member of our quantum team, Clive is an experienced quantum developer with particular interest in optimisation, benchmarking and graph-theory applications.

Sponsored engineering doctorates

We currently sponsor two four-year Engineering Doctorates (EngDs), which deliver industrially focused, relevant research for Frazer-Nash that enhances our services, while the individual develops industrial experience alongside their doctorate research.

Hannah Mitchell
EngD Student
Structural Technology

Hannah already had an established career in the renewables sector having spent more than two and a half years working for a wind turbine certification company in Germany before she started to look for the next step in her career. She wanted to take the lead on a research project and develop a broader understanding of the offshore renewables sector.

The EPSRC and NERC Centre for Doctoral Training in Offshore Renewable Energy (IDCORE) provided the perfect opportunity to balance Hannah's industrial experience and a more purely academic PhD. Like many of the students who go through the course, a real highlight from the first year of training was the Marine Energy and Environment Course with the Scottish Association for Marine Science (SAMS) in Oban.

Hannah, now in her second year, is exploring the potential for applying a probabilistic approach to structural integrity and component life assessment to the offshore wind sector, with a particular focus on lifetime extension of turbine blades. Hannah is extending an existing Frazer-Nash 'Bayesian Network' methodology to analyse the structural integrity of offshore wind turbines by extracting data from operational turbine blades and inferring the remaining life of these components by analysis. This approach takes uncertainties into account and provides a continually updated model.

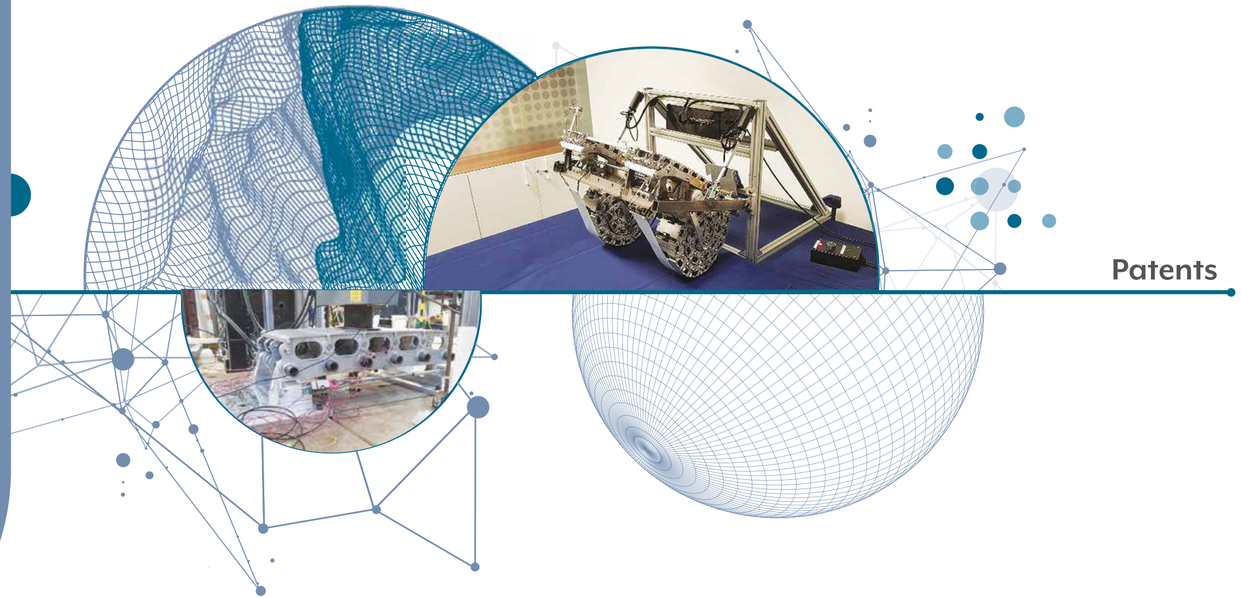
Charlie Hutchings
Engineer
Materials Performance

Frazer-Nash wanted to fund an EngD that meets industry demand to understand the pervasive impact that hydrogen can have on material properties, which complements our ambition to support clients with the generation and utilisation of low-carbon power.

Charlie stepped forward as an internal candidate after joining Frazer-Nash in September 2022 with a first-class degree in Materials Science and Engineering from Imperial College London. Research began in July 2023 through a Practitioner Doctorate in Sustainability from the Centre for Environment and Sustainability (CES) at the University of Surrey.

Charlie's research focuses on developing an insight into the hydrogen assisted degradation of materials and structures to better understand material compatibility of existing infrastructure, particularly where non-critical degradation is present. This will be investigated through modelling anticipated scenarios on a laboratory scale and assessing the impact of hydrogen on material properties through mechanical testing, microscopy, and surface analysis.

Alongside the University of Surrey, Charlie is working with Imperial College London and Cranfield University. The experimental data will be developed into models designed to predict if, and for how long, the existing infrastructure could be used and inform the operating conditions required to maintain operational safety and productivity.



Patents

Patents

Patents not only protect intellectual property, but also contribute to competitiveness, business growth and long-term success.

Understanding intellectual property and its protection, including patents, is important to our activities in technology innovation. We often work closely with technology businesses who are keen to identify and implement patent protection, and we play a full and committed part in that process.

As managers of research projects and portfolios, we design and implement collaboration agreements where partners all benefit from the mutual exchange of, or access to, intellectual property.

As participants in innovation programmes and investors in our own ideas, we develop roadmaps for the commercial implementation of our own innovations which can involve patent protection.

Three examples of our patent filings from 2023 are outlined from different technology areas and market sectors, reflecting the diversity of expertise within Frazer-Nash.

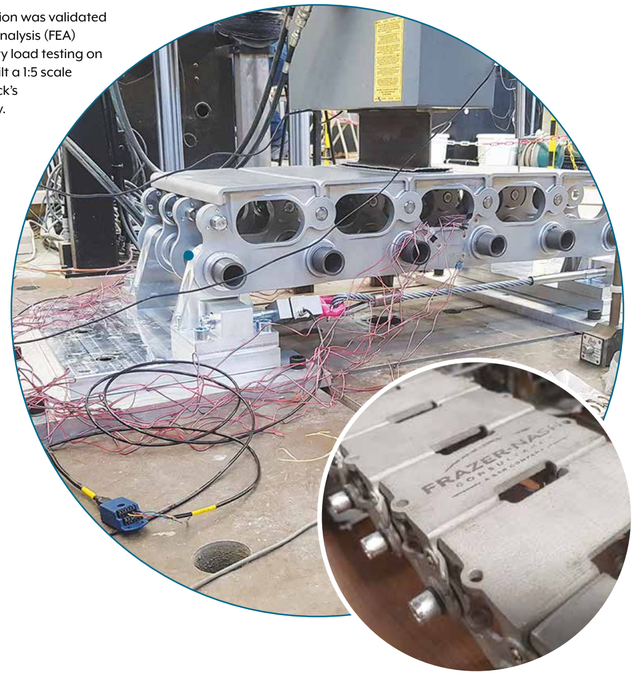
Short gap crossing

The British Army need to quickly and easily cross small gaps, such as a ditch or river, to allow vehicles to overcome obstacles and reduce their vulnerability. We have developed an innovative solution to enable armoured vehicles to cross these short gaps - reducing potential ambush exposure.

Our solution consists of a rollable track that is inspired by equipment used in the mechanical handling industry to support heavy loads. The track offers excellent strength and stiffness in its extended state and can be compactly coiled up for storage in a drum. It also uses its own independent energy source for deployment, which makes it a self-sufficient device that can be installed on a vehicle with minimal set up.

The rollable track performance is achieved using the patent-pending linkage mechanism that connects the track segments. The mechanism uses sprung pins that allows the tracks links to be coiled for storage whilst locking the segments in place during bridge deployment. This enables the bridge to form a natural arch that maximises strength to weight performance.

The strength of the solution was validated through Finite Element Analysis (FEA) modelling and laboratory load testing on full-size links. We also built a 1:5 scale prototype to test the track's deployment functionality.



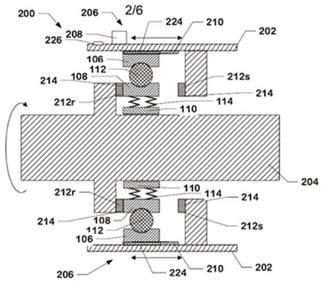
Oil-free hybrid bearing

Rotating machinery plays a vital role in modern life, in everything from power generation to transport and industry. However, most high-performance rotating machines run on oil lubricated bearings, which add significant cost and complexity, and impact performance, efficiency, and safety of rotating machines.

Foil-air bearings have been used to negate the need for oil systems on small, high-speed turbomachines, with a very thin film of air (or process gas) providing lubrication and clearance between the rotor and the stationary parts. However, their use is limited to small, lightweight, high-speed rotors.

We have developed a patent pending hybrid bearing, which maximises the benefits of foil-air bearings and extends them to the vast majority of rotating machines, including larger and slower rotors.

Our hybrid bearing design makes the most of foil-air and rolling element bearing technology in a novel way, providing a system that is greater than the sum of its parts and extending the benefits of oil-free rotating machinery to a far larger range of equipment.



Wind farm control

The growth of energy production from offshore wind farms is a major success story in the drive for reduced reliance on fossil fuels. Optimising the performance of existing offshore wind farms fulfils the need for more green energy at minimal cost.

Offshore wind farms are controlled on a 'greedy' basis - each wind turbine extracts as much energy as it can at a given moment. It has long been recognised that controlling the wind turbines collectively rather than individually may yield more energy from the wind farm overall – this is called wind farm control.

Control of offshore wind farms to generate more energy was the subject of our research project, funded by the SBRI Sustainable Innovation Fund. This project successfully demonstrated wind farm control using gravity wave response, and developed a more sophisticated induction control method that moderates the levels of 'greediness' through the wind farm. Less energy is extracted at the front of the wind farm to leave more energy in the wind for the remainder, thus achieving an overall net increase in energy extraction.

The realisation that the control mechanism is strongly influenced by the air and sea temperatures difference, or the surface layer stability, makes the potential for energy benefits much more significant and has led to a UK patent office filing.

Influencing policy

Image copyright
João M. Rosa/AmazonFACE

Influencing policy

As engineers and technologists, we are confident that we can invent and build engineering solutions to the major challenges of our time: that we can make a difference in climate and energy, transport and defence.

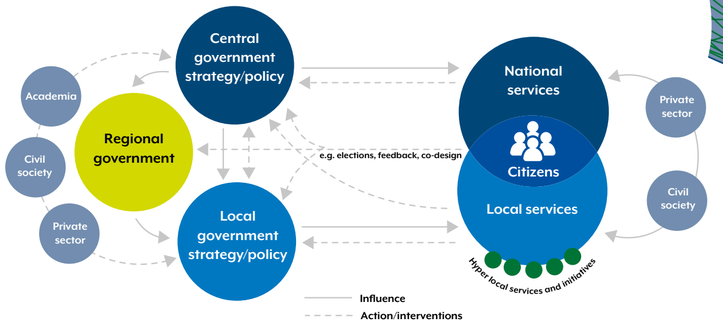
However, without funding to germinate them, a sympathetic legal framework to support them, and social support to implement them, our solutions will have no traction on the real problems that people face. Ensuring that the UK's national technology and industrial strategy fosters innovation is vital for achieving Net Zero, fit-for-purpose regulation of technology and our international competitiveness.

In his publication, 'Realising our ambition through Science', Sir Patrick Valance, (UK Government's Chief Scientific Adviser) recommends enhancing the use of science to promote government effectiveness and better policy-making. This is essential to provide the evidence and support needed to deal with the threats of climate change, an aging population, and tightening national security.

In this context, our policy support work is vital. The projects profiled here show our effectiveness in supporting legislators and civil servants to understand technology, working with them to set research and development priorities, and then examining proposals to ensure that taxpayer money is used effectively.

Whether delivered in service of clients in local and national government, public bodies and regulators, or academia and third-sector organisations, our policy advisory work will continue to be built on our deep technology expertise, trustworthy data analysis, and our understanding of complex projects.

Map of influence and actors involved in place-based policy



Visualising decarbonisation policy

The Energy Systems Catapult was set up to accelerate the transformation of the UK's energy system towards Net Zero by enabling innovation and making it easy and desirable to decarbonise homes and businesses. Together, with their customer DESNZ, they were interested in how digital twins could be used to understand the impacts of Net Zero carbon policy.

Domestic homes account for 16% of the UK's greenhouse gas emissions and decarbonising them is difficult due to the scale, complexity and cost of the challenge. This issue was used to demonstrate the value of digital twins by looking at how the best policy could be chosen under uncertain conditions.

A Graphical User Interface (GUI) was created to show the distributional effects of policy decisions changing over time in the UK. An innovative confidence filter allowed users to see which areas in the UK had particularly high or low confidence, alongside high or low impact on decarbonisation.

We built a bespoke Bayesian network visualisation tool to show users which parts of the calculation had the largest effect on the answers. Project partner, CityScape Digital, then developed a visual representation of the built environment to show the real world impact of decisions. This allows policy makers to clearly understand the outputs and results from the digital twin model.

This work has been shared at online events and conferences to showcase the ideas and disseminate them into the wider community.

Behavioural analytics and UK national security

Behavioural analytics is the application of data analytics to understanding human behaviour. Whilst both behavioural science and data science are now established capabilities within UK national security, they often operate in isolation, limiting their impact. Recent years have seen the emergence of increasingly sophisticated analytical techniques for deriving behavioural insights from data, but effectively deploying these techniques requires collaboration across multiple areas of expertise.

Our behavioural science expertise contributed to the development of evidence-based recommendations to help UK national security agencies prioritise the most promising areas of innovation, improve policymaking and encourage responsible deployment of behavioural analytics.

Behavioural analytics presents both opportunities and risks for UK national security. The Behavioural Analytics and UK National Security research report published by the Alan Turing Institute's Centre for Emerging Technology and Security (CETaS) in March 2023, that we co-authored, makes ten key recommendations. It highlights the need for a transparent approach, the importance of adequately trained analysts in human-machine teams and the concept of an efficiency vs insights spectrum.

We ensured that behavioural factors and ethical considerations were considered at every level, from research and development to deployment and evaluation of effect. The importance of people and process is being increasingly recognised in traditionally technology-focused arenas and we are now providing behavioural science advice to part of the UK government's AI strategy.

Climate research in the Amazon rainforest

Global carbon budgets rely upon assumptions about how much CO2 tropical forests will sequester. However, the response of these forests to rising CO2 concentrations in the atmosphere is uncertain. As the world's largest terrestrial carbon sink, the way the Amazon rainforest reacts to higher carbon emissions will therefore have major implications upon global carbon budgets.

AmazonFACE will be one of the largest open-air laboratories in the world and is needed to address a critical gap in international climate science research and understand how the Amazon rainforest will respond to climate changes. Funded by the UK government's Foreign, Commonwealth and Development Office (FCDO) and led by the Brazil National Institute for Amazon Research (INPA), the Met Office in the UK will work on the 10-year project in partnership with a range of organisations.

The project is located at a research station near Manaus, Brazil, and will use Free-Air Carbon dioxide Enrichment (FACE) technology to expose a large area of mature rainforest in the Amazon to a range of predicted future CO2 concentrations. It will develop greater knowledge about the functioning of the world's largest rainforest in a climate changed, higher CO2, future. This knowledge will guide regional, and global, policies on climate mitigation and adaptation.

Carbon specialists within our Sustainability, Environmental Assurance and Climate Advisory Group conducted a lifecycle carbon assessment for the Met Office aligned to the internationally recognised ISO 14040 standard. The assessment identified and accounted for emissions anticipated during construction, operation and decommissioning phases of the programme.

Image copyright João M. Rosa/ AmazonFACE

Carbon Benefits of the ISIS Neutron and Muon Source

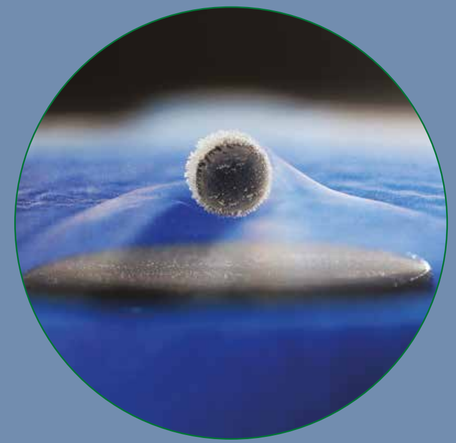
The ISIS Neutron and Muon Source is a world-leading research facility owned and operated by the Science and Technology Facilities Council (STFC) – part of United Kingdom Research and Innovation (UKRI). It sits on the Harwell Science and Innovation Campus in Oxfordshire and can study materials at the atomic level. Neutron scattering gives detailed information about the microscopic behaviour of condensed matter (solids and liquids), ranging from magnetism and superconductivity to chemical surfaces and interfaces.

The research undertaken at ISIS has a range of social, economic, and environmental impacts, such as enabling the understanding of technologies that support nationwide, and sometimes global, decarbonisation. STFC wanted to understand the environmental benefits of ISIS, and specifically, the way that ISIS's research has an impact on carbon emissions.

Our joint project team used a Theory of Change logic model to develop a unique approach to quantify the carbon benefits of some of the UK's most high-tech research by bringing together our expertise in:

- Sustainability to identify, predict and evaluate the environmental benefits of ISIS.
- Techno economic analysis to evaluate the economic benefit of the research.

STFC was so impressed with our approach that they wanted to quantify the benefit of more projects carried out at the ISIS facility. The intention is to develop this approach further to support the evaluation of research funding applications and monitor the contribution that wider UKRI-funded research makes towards national and global decarbonisation.



Consider a range of approaches

HM Magenta book methods, relevant carbon approaches (PAS 2080 and GHG protocol), academic literature, and a previouse evaluation of ISIS

Understand carbon impact pathways

Novel Theory of Change logic model

Product options

Demonstrated five high-level approaches to STFC staeholders

Select the best approach

Reccommended preferred way forward

Sustainable asset management

Over the past 40 years our economies have focused on short-termism and profits based upon the increasing demand for consumption. Organisations face huge challenges to reposition themselves to move away from these 'take-make-waste' operating models. They will have to redefine their purpose and value.

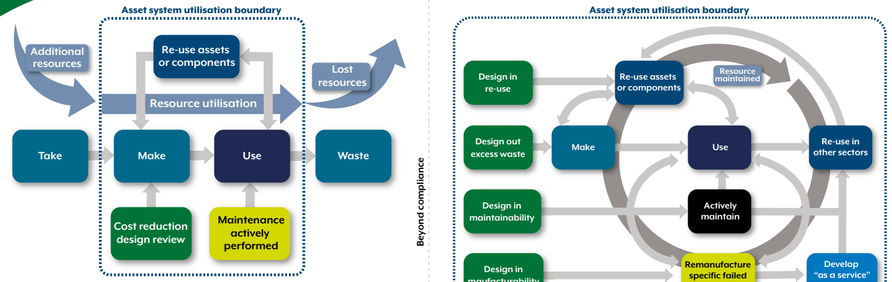
In addition, organisations are under increasing pressure to demonstrate their response to climate change and achieve Net Zero. For asset management, this represents an economic and societal shift towards sustainability and regeneration and the need to recognise sustainability goals, such as cutting the use of natural resources, minimising carbon, and reducing waste.

Organisations that care more about the long-term value they create and the lifecycle of their products and services, should do the exact opposite of 'take-make-waste' and move towards a circular economy that focuses on sustainability and regeneration.

Our approach applies 'systems thinking' to help organisations transition towards a circular economy. This has a significant impact on their policy, governance, values and engineering lifecycles (asset management) e.g. whole life value as opposed to whole life cost and business operating models.

As a result, we have created a framework that organisations can use to rank the effectiveness of different circular economy value propositions for investment and procurement purposes.

As Principal Consultant, Carl Waring provides strategic consulting for business, asset management, and the circular economy. He is a leading expert on circular economy transition as chair of The Institute of Asset Management (IAM) circular economy knowledge group and co-author of the IAM white paper 'How Asset Management Can Enable the Circular Economy'.



Electric vehicle charging infrastructure

The UK electric vehicle infrastructure strategy highlights the need to support local authorities to develop charge point strategies and scale up the roll-out of publicly accessible charge points. However, the location of these charge points will require sophisticated geospatial analysis to support decision making by local authorities.

Collaborating with the Geospatial Commission, we investigated the geospatial factors that influence Electric Vehicle Charging Infrastructure (EVCI) roll-out within local authorities to understand geospatial data needs, uncover barriers, and identify intervention opportunities.

Over eight weeks, engaging with nine diverse local authorities, we focused on EVCI planning policy. Workshops and discussions allowed us to understand geospatial factors, and their relevance to EVCI roll-out. Our review demonstrated that timely and accurate data can drive optimal location selection and therefore best serve the local community.

Our work emphasized the critical importance of geospatial data-driven decision-making in effectively guiding the installation of new Electric Vehicle Charging Infrastructure. The insights provided the Geospatial Commission with a valuable understanding of how geospatial data is currently used and developed best practice recommendations for future use.

Decarbonising general aviation

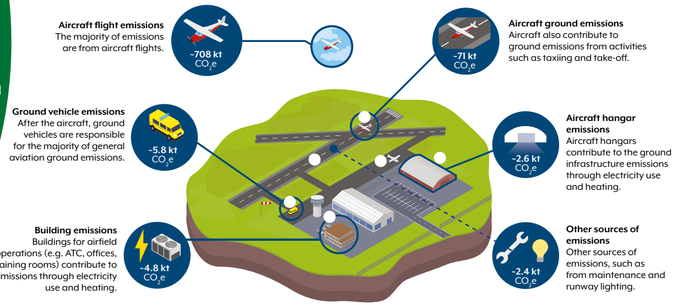
The UK Government has committed to achieving Net Zero emissions by 2050. This requires a transformation in every sector of the economy, including hard-to-decarbonise sectors like aviation.

Whilst General Aviation (GA) has a smaller carbon footprint than scheduled commercial aviation, its aircraft types and ground infrastructure are more diverse. GA includes all non-scheduled commercial civil aviation in the UK, such as essential public services like search and rescue and emergency services, as well as pilot training, private and official flights and hobby flying.

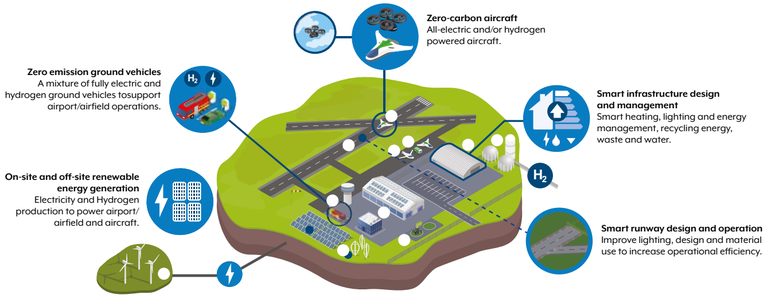
The UK Government Department for Transport (DfT) commissioned Frazer-Nash to investigate the greenhouse gas emissions from GA (aircraft and ground infrastructure) and establish a carbon baseline, as well as identify the challenges facing GA, decarbonisation technologies available and routes to Net Zero for the sector.

If the sector fails to keep up with the pace of decarbonisation delivered across the wider economy, it could be disproportionally impacted by future Net Zero policy such as carbon taxation. The resulting costs to the sector could far outweigh the costs of implementing the solutions.

This research fed into the UK Jet Zero Strategy, which recognises a requirement for continued research and a commitment to monitoring progress against emissions reduction trajectory on an annual basis from 2025, with a review of the strategy and delivery plan every 5 years.



A view of the carbon emissions associated with general aviation in 2019



A view of decarbonising general aviation in the future (2050)

Horizon scanning

Horizon scanning

Horizon scanning is a systematic process to detect the early signs of any potentially important developments with the emphasis on new or disruptive technology. It is used to support policymakers and other decision-makers in anticipating future developments, managing risks and pursuing opportunities to help build resilience to future shocks and reduce uncertainty. The general process used in horizon scanning is summarised in the Institute of Risk Management (IRM) guide.

It is not about predicting the future but provides a structured method to understand and prepare for future risks, which includes: Data collection, analysis, scenario development, risk assessment, decision-making and planning.

Continuously scanning the horizon is essential in the rapidly changing science and technology landscape and offers several benefits.

- Early detection of emerging trends and new opportunities.
- Identify credible technologies for research and development.
- Challenge current process and look across sectors.
- Long-term strategic planning and risk mitigation.
- Monitor future trends and prepare accordingly.

Horizon scanning is predominantly designed to take a long-term view to make better-informed decisions and stay ahead of the competition. However, these processes can also be used to support short-term decision-making, such as selecting the Best Available Technology (BAT) from across different sectors for an existing application through a state-of-the-art review.

We are experienced at undertaking all aspects of the horizon scanning process and have even looked at automating the data collection process through AI.

Technology intelligence

The Nuclear Decommissioning Authority (NDA) is responsible for safely, securely and cost effectively cleaning-up the UK's earliest nuclear sites. They regularly research and implement new and emerging technologies, but these are often close to deployment and involve near-term horizon scanning.

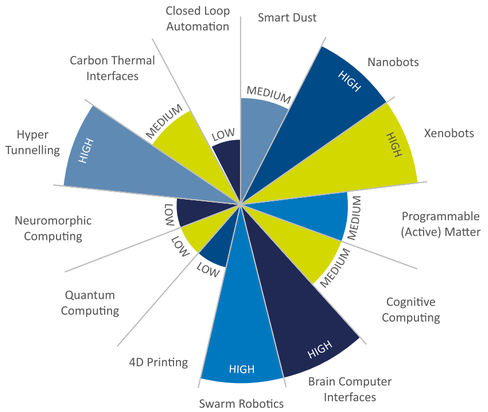
An opportunity was identified to move horizon scanning into the far term (10+ years from commercial availability) to enable the NDA to identify and respond to future trends and potentially help mould their future development. Our innovative approach involved several horizon scans over a two-year period including:

- Open Scans - wide ranging light touch scans identifying a diverse set of technologies.
- Targeted Scans - More focused deep dives into a particular down-selected technology.

We assessed the key characteristics of a diverse range of technologies, explored their potential applications and existing research programmes and reviewed their applicability and relevance to the NDA mission and Grand Challenges. This covered a broad range of topics from nanobots and closed loop automation to quantum computing and advanced sensing technologies, such as smart dust.

Our horizon scanning approach has seen interest in future technologies grow and fostered positive conversations around how the NDA could leverage ongoing research from other bodies, institutions and organisations to help solve the NDA challenges.

Moving humans away from harm



Automated horizon scanning

Over 5 million academic papers are published each year, which makes horizon scanning and keeping up with scientific advances increasingly difficult. Therefore, our client wanted a digital platform to enable them to automatically conduct horizon scanning of scientific papers and other publications.

The overarching goal was to develop and deploy tools and techniques to facilitate the identification of new and novel signals of interest for different focus areas, such as emerging fields, or other groupings of research that warrant further investigation and monitoring.

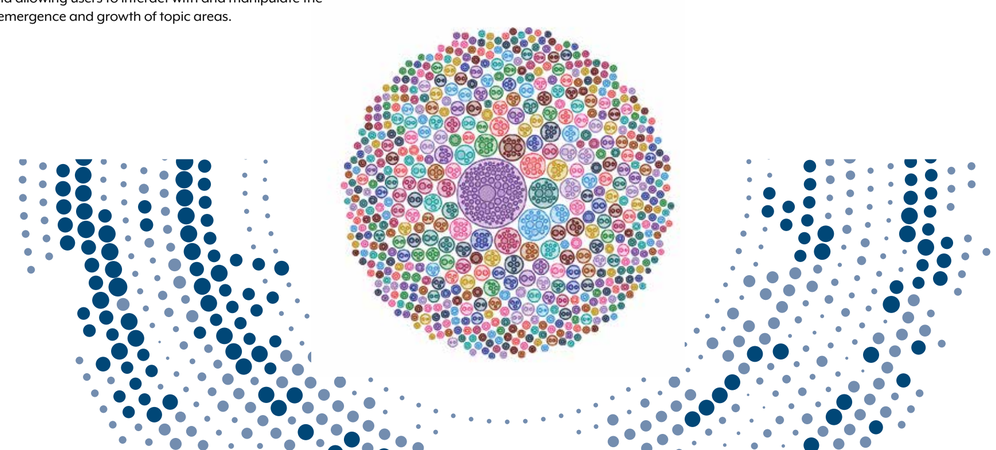
Our solution was to develop a scalable cloud hosted digital platform, with the following key features:

- A repository of scientific paper metadata, kept up to date by a fully automated ingestion pipeline.
- An asynchronous, automated analysis pipeline to group, characterise and enrich the ingested data using Natural Language Processing (NLP) techniques, interpretation into a human readable format using Large Language Models (LLM) tools and sentiment analysis of the language used in publications to gauge the level of "excitement" portrayed by the authors.
- An intuitive, web-based front-end allowing users to interact with and manipulate the data to identify trends and the emergence and growth of topic areas.

The platform has already demonstrated promising results in identifying signals that were not previously known, and in increasing the efficiency by which users can analyse large amounts of information. A key factor in the project's success has been the close working relationship with our client and our use of Agile software development principles; allowing us to iterate and adapt the platform functionality regularly and rapidly trial new and novel analysis techniques.

This digital platform continues to grow and evolve as a key contributor to our client's ongoing digital transformation program.

Output for 'Quantum' topic search



Hydrogen conversion feasibility study (HyVoltage)

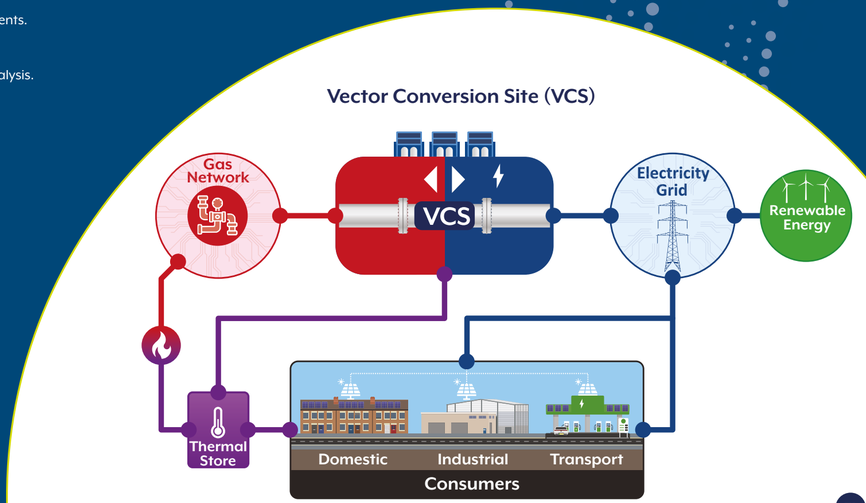
The UK gas network infrastructure could be used for blended or dedicated hydrogen, but policy, business models, and production and demand profiles for hydrogen remain uncertain. In parallel, the strain on electricity networks is forecast to increase and load profiles to become more complex during the transition to Net Zero.

HyVoltage aims to understand whether it is technically and commercially viable to interface the future electricity and gas distribution networks using collocated, bi-directional, and flexible Vector Conversion Sites (coupled power-to-gas with gas-to-power technologies), and if so, establish the most appropriate technology configurations, scale of use and benefits.

This one-year project, which began in October 2023, is a Network Innovation Allowance funded project for Wales and West Utilities, in collaboration with National Grid Electricity Distribution, Imperial College London, Cornwall Insight and the University of Bristol. Our teams are responsible for delivering:

- Assessments of candidate technologies.
- Technology and system-level scalability assessments.
- Multicriteria siting analysis.
- Agent-based modelling for consumer impact analysis.
- Cost Benefit Analysis.
- Outline design.
- Use case development.
- Commercialisation roadmap.

The projected commercialisation roadmap, delivered through this project, will outline the route to widespread adoption of the technology. If successful, the ambition is to build and test a prototype Vector Conversion Site to demonstrate the benefits of the system at an appropriate location on Wales and West Utilities network.



Thermal treatment of radioactive waste

Sellafield is the UKs most complex nuclear site, with hundreds of facilities which must be decommissioned safely and securely. This will generate a lot of nuclear waste; materials contaminated with radioactive substances, which needs to be packaged, treated, stored and ultimately disposed of. The larger the volume of waste generated, the more packages will need to be stored and disposed of, the larger the cost associated with safely decommissioning the site.

Thermal treatment is intended to raise the temperature of the waste to achieve some beneficial outcome, i.e. volume reduction or immobilisation. Our technology review followed a structured process to gather information from wide ranging sources of information to identify and understand the thermal treatment methods that could be used to decommission high activity radioactive waste. Some of the technologies evaluated include:

- Incineration
- Plasma furnace
- Pyrolysis
- Molten salt
- Hot isostatic pressing

Thermal treatment technology represents a huge opportunity to reduce the cost of nuclear waste disposal at Sellafield and other nuclear sites around the world. Our technology review provided up to date, accurate information on the technologies available, which is crucial to determine the most appropriate technology that could be applied to the UK's nuclear waste.

Research management

Research management

Technology Readiness Levels (TRLs) measure the maturity level of a technology throughout its research, development and deployment phases and are generally based on a scale of 1 to 9. Historically, universities have focused on basic research (TRLs 1 to 3), while private companies primarily invest in technology deployment (TRLs 7 to 9).

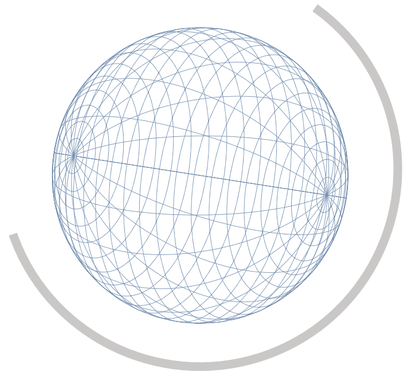
This gives rise to the central region where there is often a lack of investment and promising innovations can stall - sometimes called the 'Valley of Death'. We use our technical and project management expertise to manage large government-funded research programmes that bridge the gap between cutting edge research and technology deployment. This is achieved through our proactive and engaging research management approach, combined with strong collaboration between developers and users.

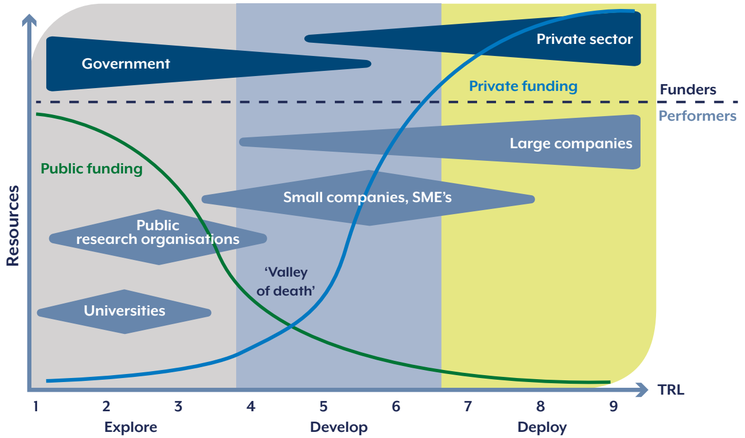
Through forming lasting partnerships with universities, research institutions and SMEs, we deliver maximum benefit to our clients. Our excellent reputation for managing research is built upon an appreciation of university requirements around intellectual property and publication.

Effective research management requires fully informed technical, programme and commercial management across all aspects of the project lifecycle. Our programme and project managers:

- Identify research needs and develop user requirements.
- Clearly define task specifications.
- Develop efficient supplier management processes.
- Provide expert technical oversight to assure task delivery.
- Focus on industrial application of research.

We successfully deliver research and research management at all TRLs across a diverse range of sectors and technical capabilities and exploit emerging engineering science and technology research to solve current and future challenges.





AI, Autonomy, Intelligence, Surveillance and Reconnaissance (A²ISR)

Sitting within the DstI AI Programme, the A²ISR project is a dynamic initiative designed to explore, demonstrate and harness battle-winning AI and Autonomy capabilities within the ISR enterprise, focused on:

- Automating the ISR enterprise, which dynamically and opportunistically creates and prioritises 'collect' tasking to optimally answer a spectrum of intelligence requirements.
- Demonstrating an AI-enabled approach to multi-domain intelligence analysis through collaborative human-machine teams.
- Empowering the best use of available data, transitioning the constraining factor from human capacity to computational power.

The last two years have seen Frazer-Nash and the A²ISR project create an entirely new approach to working with industry for DstI, fostering a collaborative one-team 'Project Office' environment to achieve success at pace.

We have brought together our deep technical knowledge in the A²ISR research space and Project, Programme and Portfolio Management (P3M) best-practice expertise, becoming a trusted delivery partner for DstI. This has enabled us to:

- Engage a supply chain of over 20 organisations.
- Scope supported competitions and partner research tasks totalling ~£11M across all A²ISR concepts.
- Develop a robust Test & Simulation Environment to test, integrate and analyse A²ISR concepts and technologies within a virtual operational environment.
- Orchestrate the A²ISR showcase that reached over 170 stakeholders from Defence and Industry, which enhanced comprehension and support for these concepts.
- Develop the exploitation campaign approach to understand and propose how A²ISR concepts, science and technology enable future ISR capabilities.

The final phase of the project focuses on working with Front Line Commands (FLCs) and other research programmes to drive forward the exploitation of the research concepts into future operational systems and capabilities.

Autonomous Resilient Cyber Defence (ARCD)

Frazer-Nash is leading the UK MODs research into the development of cyber defence agents for their future operational capability.

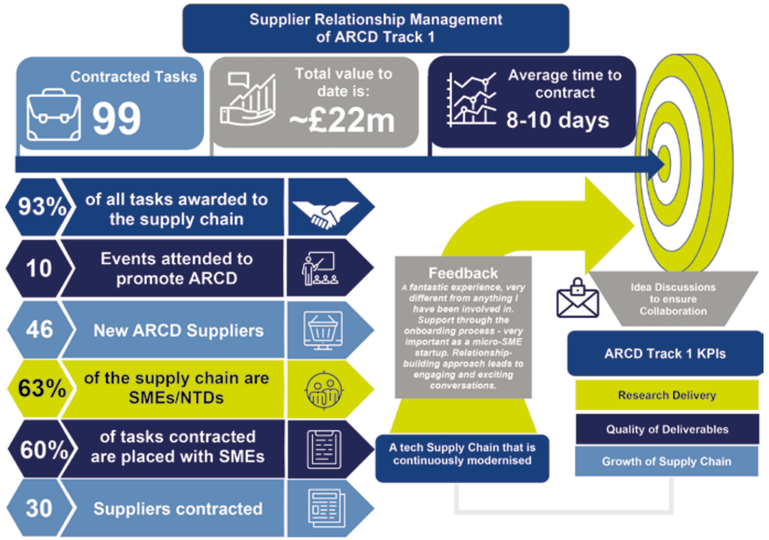
Due to both the increasing complexity of military networks and systems, and the sophisticated approaches of aggressors, it is becoming increasingly difficult for cyber-defenders to respond quickly and effectively to incidents. Therefore, the UK MOD funded the ARCD programme to mitigate these threats by compiling advanced and novel research that can be matured to be applied into defence environments.

It is a four-year programme where we develop the requirements, contract the work, and act as Technical Partner and Task Project Managers for project delivery. Our success is due to our innovative delivery model and commitment to build strong, lasting relationships across the industry, particularly with Small and Medium-sized Enterprises (SMEs), Non-Traditional Defence Suppliers (NTDs) and academic institutes – We are continually looking to grow the ARCD supply chain.

Our ability to successfully manage large research frameworks is demonstrated by the fact that Dstl are considering using our ARCD delivery model for their future work. They also recently published a promotional video on the 'Power of Partnerships' that includes the ARCD programme as a shining example of collaboration and partnership at its best.

ARCD is a dual track project. Frazer-Nash is responsible for Track 1 and our partner, QinetiQ, is leading Track 2, responsible for performing the experimentation and evaluation of the concept demonstrator capabilities. We are responsible for:

- High Risk and Disruptive Options (HRDO).
- Informed Cyber Sensing (ICS).
- AI Decision Making (AIDM).



Net Zero Innovation Portfolio (NZIP)

By 2035, the UK aims to be powered entirely by clean electricity and by 2050 have Net Zero carbon emissions. The Department for Energy Security and Net Zero (DESNZ) is investing over £1 billion through its Net Zero Innovation Portfolio to achieve both these goals.

Frazer-Nash has led the delivery of the £5.3m Technical Third Party Support contract for Lot 5 – Energy Generation and Distribution since 2021, and our expertise covers the following technical areas:

- Hydrogen
- Nuclear
- Offshore and onshore wind
- Bioenergy
- Heat pumps and retrofit
- Heat distribution
- Biomass boilers
- Solar heating

In collaboration with the other Lot holders, we support DESNZ to develop its programmes, and to assess and monitor the projects being delivered within the NZIP. Our team provides technical support to critical NZIP projects, and includes Baringa, Cambridge Architectural Research, the Centre for Sustainable Energy, Cornwall Insight, Costain, NNFCC, Sirius, Tadek, TNEI and TUV Nord.

Our support draws on a broad range of technical expertise and project management skills across several technology areas. For example, we have monitored projects on behalf of DESNZ to:

- Develop innovative low-carbon hydrogen supply solutions.
- Develop and demonstrate heat pump technologies, tools, and solutions.
- Demonstrate advanced modular High-Temperature Gas Reactors (HTGRs).

Our support helps DESNZ ensure that the funding provided through NZIP meets its objectives.

Defence Materials Centre of Excellence (DMEx)

The Defence Science and Technology Laboratory (Dstl) has set up a five-year £42.5m research partnership to develop ground-breaking new materials. The Defence Materials Centre of Excellence (DMEx) will bring together world-leading UK experts in a national effort to accelerate advances in defence material technology for extreme physical environments.

Advanced materials are vital to keeping the UK safe and have uses ranging from body armour for our Armed Forces, to the protection of sensitive electronics in satellites from radiation damage and corrosion-resistant submarine components.

The Henry Royce Institute (Royce) for advanced materials, which operates its hub at the University of Manchester, will lead the DMEx with 23 other partners from academia, industry, and research organisations. This centre of excellence will research and create new materials that can survive conditions such as 1,000°C, tropical to polar weather, extreme water depths and the impact of blasts and shocks.

Frazer-Nash has partnered with Royce to deliver the programme management function, bringing our experience of managing Research and Development frameworks on behalf of Dstl, to ensure the 'best athlete' approach to Advanced Materials, and providing the UK with genuine world-leading capability.

Our project management organisation, embedded as a single team with Royce, will provide a robust and agile project management function to ensure efficient delivery of tasks that supports Dstl's ambitious timeframes.

We are proud to combine our deep, pan-domain defence expertise with our programme and project management skillsets, to help deliver the DMEx.

Images copyright Henry Royce Institute

Serapis Lot 6

Dstl has an ongoing need to deliver cutting edge research and develop new and battle winning defence and security capabilities. The Serapis framework enables Dstl, MOD and the frontline commands to quickly and efficiently place contracts for scientific and technical research and development.

We are the prime contractor for Lot 6, which delivers research on the theme of Understand. Understanding is achieved through:

- Situational Awareness + Analysis = Comprehension (Insight).
- Comprehension + Judgement = Understanding (Foresight).

The technical content of Lot 6 ranges from fundamental research in data science, to operational tools to assist intelligence analysts. Technical areas include:

- Artificial intelligence, machine learning, deep learning, natural language processing.
- Knowledge agents and conversational agents.
- Logic, hypotheses and argumentation.
- Semantics, knowledge graphs, ontologies, knowledge engineering.
- Human machine interfaces.
- Human and place geography.
- Social media analysis.
- Sentiment analysis.

As prime contractor, we identify, contract and assure the tasks delivered by our supply chain, which comprises over 140 companies and academic institutions, as well as delivery by our own technical teams.

The successful delivery of this framework and value that it gives Dstl is dependent on our effective programme and supplier management processes and technical oversight. This is only possible through our technical expertise and cutting-edge application of data analytics and information processing techniques.

Now in Year 5 of the contract, we have delivered over 120 tasks with another 40 tasks in ongoing projects with a value of over £50 million.

Innovation frameworks

Innovation frameworks

Professional services frameworks that fund innovation provide a fantastic mechanism for Frazer-Nash to deliver transformative technology and drive collaboration.

Our proactive approach to the innovative application of cutting-edge technology, combined with our openness to collaborate with SMEs and universities, enables us to demonstrate our ability to deliver real value to our customers.

Once a need has been identified, these frameworks provide organisations a cost-effective way to address their requirements, giving them a simple contracting mechanism to explore, develop and deploy novel or disruptive technology to solve real operational issues.

These innovation frameworks and funding mechanisms are used across all sectors from renewable energy to nuclear decommissioning, electricity transmission and security. Examples include:

- Defence and Security Accelerator (DASA)
- Ofgem Strategic Innovation Fund (SIF)
- Sellafield Engineering Innovation Framework (EIF)
- Carbon Trust Offshore Wind Accelerator (OWA)

Defence and Security Accelerator (DASA)

The UK Government's Defence and Security Accelerator (DASA) is a cross-Government organisation, hosted by the Defence Science and Technology Laboratory (Dstl).

DASA is tasked with finding and funding exploitable innovation to support UK defence and security quickly and effectively while supporting UK prosperity. Their vision is for the UK to have strategic advantage through the most innovative defence and security capabilities in the world.

Ideas are sought from innovators small and large, providing funding to those who have not previously worked with Government. Regionally based innovation partners support the application process, covering the length and breadth of the UK including England, Wales, Scotland and Northern Ireland.

DASA has a wide remit across all areas of defence and security. They are interested in all fields of science and technology, better ways of working, better services, or any innovation that will make defence and security more effective.

In 2022-2023, DASA funded 249 projects and awarded £49.1 million of competition funding through:

- Open calls for innovation, which offer suppliers the opportunity to put forward their own ideas to defence and security stakeholders.
- Themed competitions, where proposals are requested by a set date to address a specific area of interest.

Over the past 5 years, we have successfully delivered over 30 projects with DASA funding through both open calls and themed competitions. These projects have ranged from uncrewed vehicles, surface vessels, gap crossing, human factors assessments and multiple AI/ML projects.

Ofgem Strategic Innovation Fund (SIF)

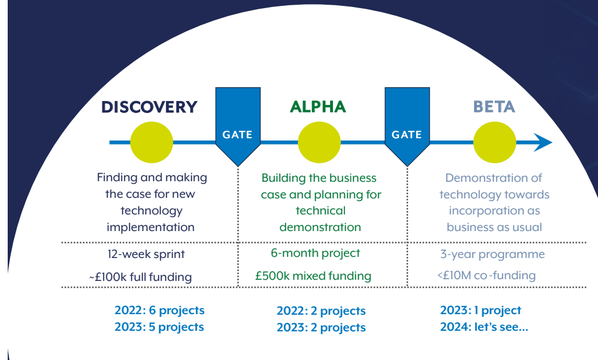
The Office of Gas and Electricity Markets (Ofgem) protects consumers by working to deliver a greener, fairer energy system. Their Strategic Innovation Fund (SIF) is designed to drive the innovation needed to transform the gas and electricity networks for our low-carbon future. These energy networks are the backbone of the Net Zero economy and transition to low-carbon energy.

SIF was launched in 2021 and is expected to invest £450 million by 2026. It requires the energy network owners and operators to identify, scope and deliver ambitious, innovative projects to enable energy security and accelerate the transition to low-carbon energy at the lowest cost to consumers.

SIF projects follow an annual funding cycle and progress according to a three-phase delivery model: Discovery, Alpha and Beta.

To date, Frazer-Nash has supported 9 different network operators, providing project development and management support, alongside specialised technical expertise across a range of energy transition disciplines.

Developing collaborative research and development partnerships are a vital aspect of delivery with funding only available to teams including a diverse range of organisations. We have been an integral part of building and managing these teams; having enjoyed collaborations with more than 25 different partners, including universities, charities, local councils, consultancies, technology developers, Original Equipment Manufacturers (OEMs), Research and Technology Organisations (RTOs) and other consultancies.



Our ongoing projects include:

- Advancing offshore wind's ability to support network stability thus allowing the grid to accommodate greater volumes of renewable technology and accelerating the decarbonisation of the UK electricity supply.
- Developing whole energy system impact assessment methodologies and scenario evaluation tools to enhance UK resilience.
- Progressing novel cable technologies to enable greater transmission capacities.

Sellafield Enabling Innovation Framework (EIF)

Sellafield is the UKs most complex nuclear site, with hundreds of facilities which must be decommissioned safely and securely. This will require new facilities, capabilities and systems to be designed, built and maintained. The lifetime programme to decommission the Sellafield site extends into the next century (2120).

The Sellafield EIF was set up to revolutionise the way that Sellafield works to deliver its mission safer, better and faster. Made up of 10 supply chain partners, the framework is designed to encourage collaboration bringing together the best athletes from the individual companies, and covers:

- Problem framing: Initial identification of needs and priorities.
- Problem definition: Define clear functional / technical / digital requirements.
- Solution delivery: Provide innovative, focused technical and digital solutions to support key decision making.

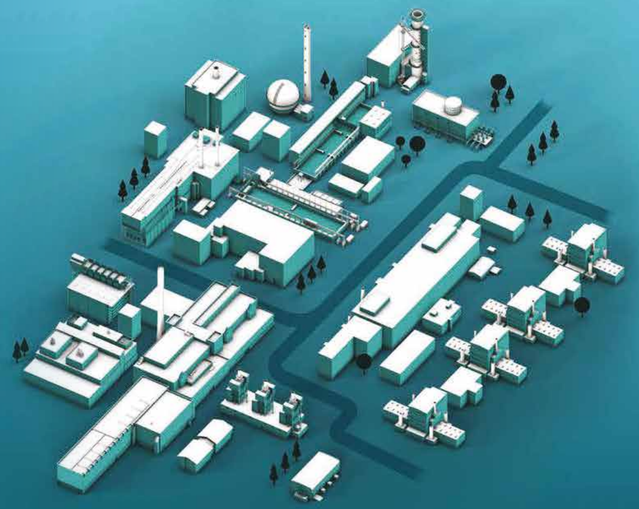
The EIF delivers value to Sellafield by offering new technologies or innovations that may bring significant return on investment with measures, metrics and targets for success. We have delivered a range of pioneering projects through the EIF:

- Additive manufacturing for nuclear decommissioning.
- State-of-the-art review for thermal treatment of radioactive waste (page 32).
- Concept design of a new waste container.
- Diagnostic CFD modelling of the Medium Active Solid Waste Encapsulation Plant (MASWEP).
- Technology review for CO2 emission reduction.

Frazer-Nash continues to deliver high value, innovative work through the EIF, collaborating with the other suppliers to deliver the best value for Sellafield.

"In the dynamic landscape of Nuclear Decommissioning, adopting a commercial framework that can foster innovation is key. This paradigm shift moves beyond traditional framework models, promoting a culture of creativity, agility, and collaboration between the supply chain. All 10 companies included in the framework have delivered for Sellafield, of which Frazer-Nash Consultancy has been a valued part".

Beatrice Fraser, Sellafield EIF Commercial Lead



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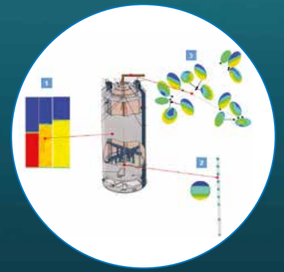


CFD model of the MASWEP tank and pipework to diagnose why the operational plant was struggling to fluidise the material in the vessel, which was verified against multiphase flow experiments.

Offshore wind energy research

We have been at the forefront of wind energy research for over 10 years, providing expert insight into collaborative industrial research programmes, including the Carbon Trust's Offshore Wind Accelerator (OWA) consortium of offshore wind developers, its derivative discretionary projects, and the Floating Wind Joint Industry Project (JIP).

During this time, the UK offshore wind capacity has increased ten-fold to 13.9 GW in 2022, but significant work is still required to achieve the UK's ambition to deliver up to 50 GW of offshore wind by 2030, including up to 5 GW of floating offshore wind. This will predominantly be achieved through new offshore developments, but maximising the efficiency of existing wind farms will increase capacity and reduce the cost of generation.

Our work with the OWA programme began in 2009 as technical lead for the OWA Wake Effects program overseeing the delivery of technical projects for the developers within the consortium. As a result, we have designed and managed research procurement programmes and demonstrated impact in pulling through low-Technology Readiness Level (TRL) concepts to full production. Our inclusive, requirements-led approach to delivery and stakeholder management has led to genuine successes in reducing the cost of energy.

We now have a team of over 30 offshore wind generation experts working with offshore wind developers and researchers around the world to reduce uncertainty in the offshore wind industry, understand new technology and optimise operations.

CFD simulation of wind farm wakes

Case Study: Global Blockage Effects in Offshore Wind

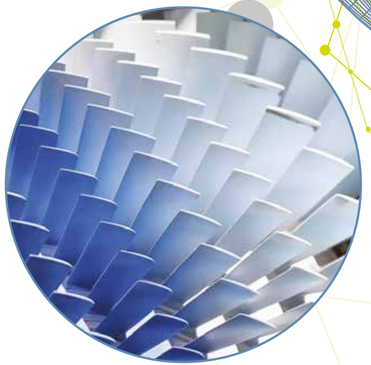
As wind turbines are brought together into a wind farm, they interact, through the formation of low speed wakes downstream. These wakes reduce the production of subsequent wind turbines that they encounter. Blockage can alter the pattern of wind farm production and also reduce total generation by a few percent. Since 2018, we have supported blockage research, jointly with DTU, focusing on model development, best practice for high fidelity simulation and analysis of legacy measured datasets.

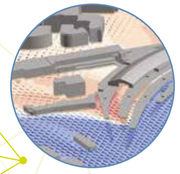
However, blockage is very difficult to measure and so the GloBE consortium (led by RWE) was established to tackle this problem. We are responsible for delivering our unique Rapid Model for Blockage Assessment and validating it against the measured data.

Case Study: Floating Wind Technology

Floating wind is an important enabler for wind energy expansion and provides the opportunity to access valuable wind resources in deeper waters.

- With the US National Renewable Engineering Laboratory, we identified and quantified the physical mechanisms that could cause differences between floating and fixed foundation wind farm yields. This has resulted in the development of new methods and tools for floating wind yield estimation.
- We work closely with our partners, both individually and within R&D consortia, to assess and quantify some of the key industry wide risks associated with floating offshore wind. This includes identifying which technology is most appropriate for a particular use case and how this is then traded off against wider project requirements (e.g. energy yield, cost, fabrication, installation and maintenance), and understanding how specific turbine and foundation configurations scale in performance, both to support today's optimisation activity and, to help developers plan for larger turbine ratings envisaged in future.





Research partnerships

Research partnerships

Research partnerships provide a mutually beneficial approach to explore, develop and deploy new ideas from concept through to industry demonstration.

We actively collaborate with Universities, SMEs and OEMs to win innovation funding that allows novel ideas to be developed, so that we can demonstrate the viability of the technology.

Our strong track record of winning innovation funding is due to our industry and research experience, combined with our innovative approach and ability to form lasting research partnerships with universities and other research institutions.

We develop research partnerships across all of our sectors. This has enabled us to collaborate and deliver demonstrators from green ammonia synthesis to predicting quiet landing periods at sea and extending gas turbine life.

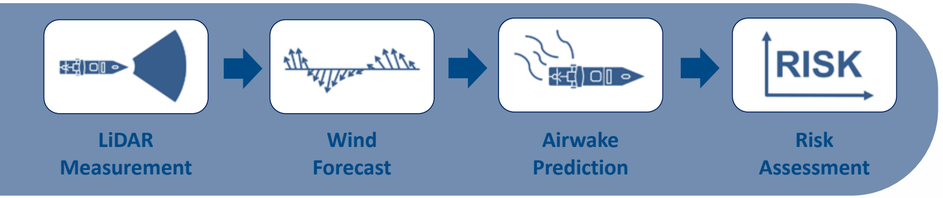
"It's great to be able to see our ideas turned into a working prototype and tested in the real world."

Safer UAS operation from ships

Operating an aircraft from a ship can be incredibly challenging, in part due to the highly turbulent wind conditions over the flight deck. Currently, navies around the world rely heavily on pilot experience and expertise to operate safely; however, this isn't an option for autonomous Uncrewed Air Systems (UAS).

Over the past 10 years, we have developed a world-leading expertise in Ship-Air Integration (SAI) services to navies, ship and platform designers, aircraft manufacturers, and offshore operators. This includes ship airwake modelling using advanced Large Eddy Simulation (LES) transient CFD modelling of the turbulence over the flight deck to generate operational Ship Helicopter Operating Limits (SHOLs).

We combine our airwake modelling expertise with the University of Exeter's research and knowledge of long-range Doppler scanning LiDAR to demonstrate a proof-of-concept Airwake Quiescence Prediction (AQP) system. This uses a scanning LiDAR on the ship to predict the wind conditions over the flight deck ahead of time to provide guidance to UAS on when it was or wasn't going to be safe to launch or recover.



Our research partnership with the University of Exeter began in 2020 after a successful application for DASA funding (page 42) Autonomy in Challenging Environment programme Phase 1. The work has resulted in a successful proof-of-concept AQP system that was validated against at-sea trials measurements.

Green ammonia plant demonstrator

Green ammonia is being increasingly recognised as a vector to enable green hydrogen, as a means of decarbonising fossil-fuel produced ammonia and as a carbon-free fuel in its own right.

The ASPIRE (Ammonia Synthesis Plant powered by Intermittent Renewable Energy) project has developed a novel flexible Haber-Bosch reactor that can technically and cost-effectively produce green ammonia using only water, air and an intermittent renewable energy source.

ASPIRE is a £4.3m Department for Energy Security and Net Zero (DESNZ) project funded through the Net Zero Innovation Portfolio (NZIP) Hy-Supply 2 competition, after a successful feasibility study. This will design and build a small-scale (137 kW or 300 kg/day) flexible green ammonia synthesis demonstrator plant at the Science and Technology Funding Council (STFC) Rutherford Appleton Laboratory in Oxfordshire.

This two-year project, that began in April 2023, is being led by STFC in close collaboration with the University of Bath, Johnson Matthey and Frazer-Nash. We are responsible for delivering four key workstreams using a multi-disciplinary approach:

- Independent design review and process governance.
- HAZOP and DSEAR safety assessments.
- Control system development and design.
- Business case and routes to market.

If successful, this proof-of-concept demonstrator plant could form the basis for large-scale off-grid green ammonia supply, as well as a low carbon, economically viable hydrogen supply solution.

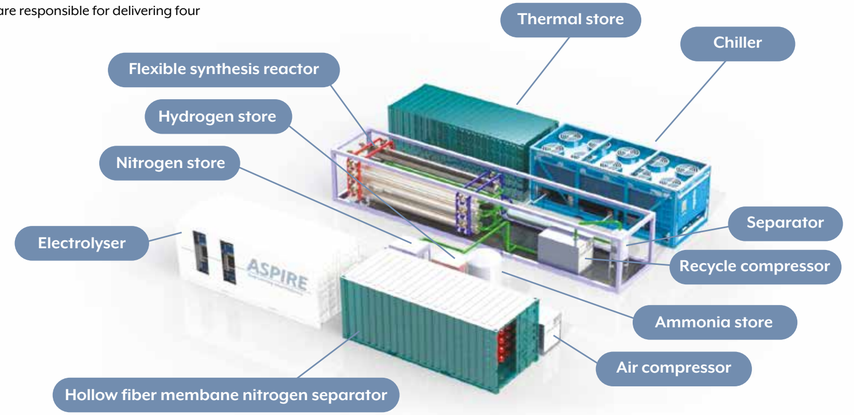


Image copyright STFC

Space Solar – A deep partnership

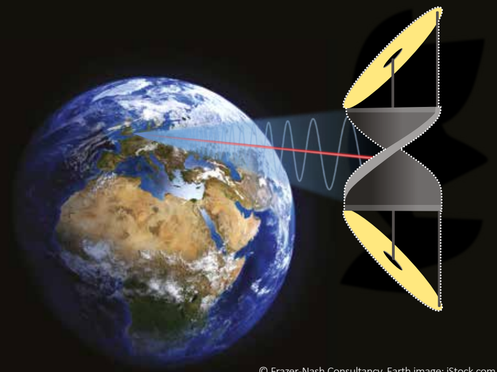
Frazer-Nash and Space Solar have evolved a deep partnership. Space Solar, a spin out from the Satellite Applications Catapult, is building on the outcome of the techno-economic study that Frazer-Nash carried out for the UK Government by embarking on the commercial development of Space Based Solar Power (SBSP). Space Solar has a revolutionary vision to deliver energy security and enable Net Zero with SBSP.

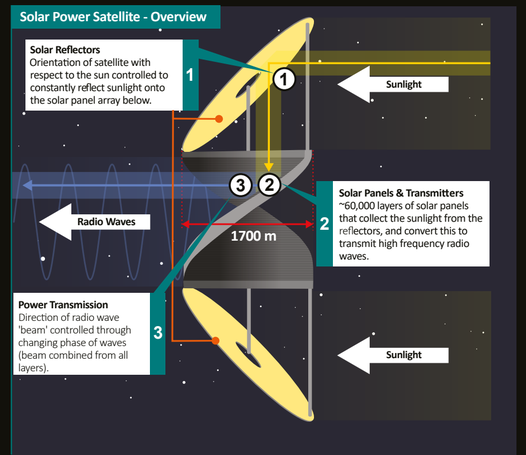
SBSP utilises satellites in orbit collecting solar power and beaming it down to earth as a focused high frequency electromagnetic energy beam. The energy transmitted from the Satellite is collected by a Ground Station, where the dispatchable firm power is distributed to the grid as a clean, secure, and affordable baseload. To provide a safe, secure, and economic system both the Satellite and Ground Station are extremely large and present several interesting engineering challenges. Space Solar is developing CASSIOPeiA, the leading SBSP concept with the potential to deliver market leading performance economics, which can deliver GW scale continuous, dispatchable low-carbon power.

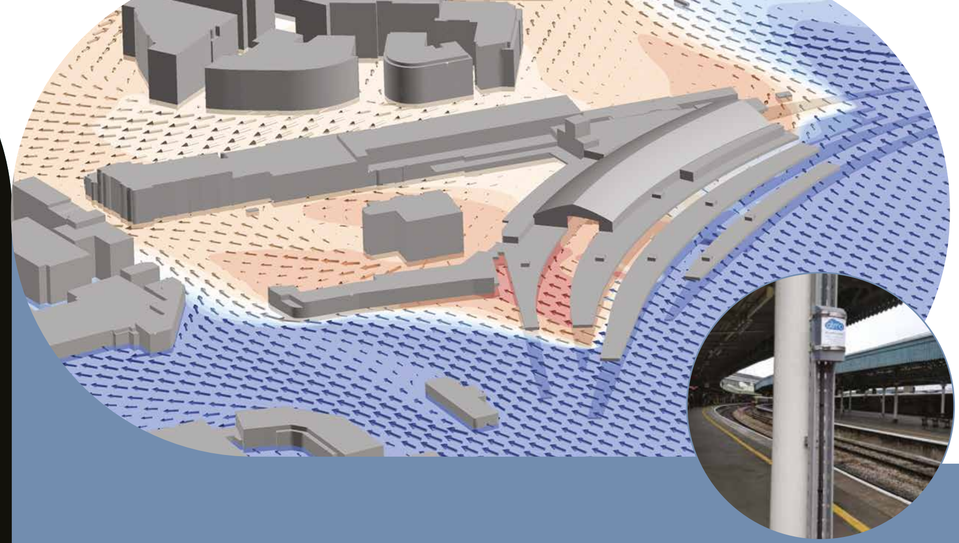
Frazer-Nash provides Space Solar with both technical and business expertise to develop an attractive and credible case for investment. We have embedded advisory and business consultancy experts to build a business that can scale to deliver commercial SBSP systems, and provided technical experts to lead the development of the evolving designs.

Our engineers have progressed the initial ideas into a well-defined concept design whose performance and remaining uncertainties are understood. We adopted a risk-based approach, focusing on the key technical challenges that drive the overall business case, such as the thermal and structural performance, developing innovative solutions to address the challenges and designing a full-scale concept.

Space Solar now have a robust concept design, an integrated plan for technology development and a business that is ready to scale. This programme is an exciting combination of New Space and Energy with the potential to make a significant contribution to the availability of clean affordable energy. Working in partnership we have helped Space Solar deliver its programmes and position for future success.







Air quality at railway stations

Although the rail industry has a relatively low contribution to the UK overall emissions it recognises that there is significant room for improvement in the air quality. Enclosed stations combined with high numbers of diesel trains can generate unacceptable air quality and smell for passengers.

As part of a 'First of a Kind' demonstrator initiative, organised by the SBRI and funded by the Department for Transport (DfT), we supported Atmo Technology Limited to demonstrate how its novel monitoring technology could help the rail industry to improve air quality at stations and depots.

The project combined Atmo Technology's real-time air quality measurement technology with our Computational Fluid Dynamics (CFD) modelling expertise to produce an air quality digital twin of Bristol Temple Meads station. This provides the rail industry with a step change in the level of detail, and value obtained from air quality assessments.

The digital twin of the station was validated against 6 months of sensor readings to identify where and when poor air quality occurred within the station. The impact of different mitigation measures on the station air quality could then be assessed prior to any CAPEX investment, something that wasn't feasible with existing monitoring and modelling approaches.

Extending turbine life

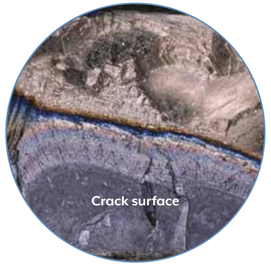
Across the aerospace industry, hot corrosion cracking has become more prevalent in gas turbine blades due to changes in turbine operation and materials. This mechanism is influenced by several factors, including stress, temperature, blade design, and environmental conditions. The ability to predict crack initiation and propagation is essential to manage the life of turbine blade components and optimise maintenance scheduling, whilst ensuring safe operation.

Frazer-Nash has supported the £4.9m five-year UKRI funded Materials and Lifing Improvements in Turbines (MALIT) research programme led by Rolls-Royce in partnership with Cranfield University and Imperial College London. This research builds on Laurie Brooking's PhD at Cranfield University, which investigated a new failure mechanism that had been observed in gas turbines that was poorly understood and difficult to predict.

Building on Laurie's expertise, we have developed a world-leading capability in this area and played a significant role in the successful delivery of MALIT, including:

- Developing innovative experimental techniques and novel material ageing models.
- Crafting and implementing advanced lifing methods and integrating them into digital twins.
- Designing and delivering software tools that allow Rolls-Royce to gain deeper insight from the interpretation of experimental tests, exploitation of extensive data to fit new material failure models and more clearly visualising the outcomes.

Our novel lifing models are currently undergoing trials across Rolls-Royce's gas turbine fleet. Early results are promising with significant savings expected by reducing maintenance requirements, minimising engine downtime, and extending the overall lifespan of critical components.



Optimised corrosion protection

Corrosion protection on naval vessels is often provided through a combination of coatings and sacrificial anodes, which corrode instead of the hull, protecting it from corrosion. However, the location and size of these anodes can impact the weight, and hence performance, of the vessel.

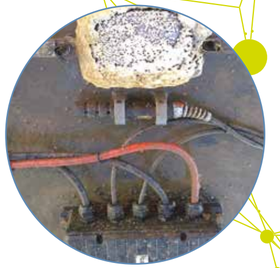
Over the past 5 years we have been working with Babcock and the Ministry of Defence (MoD) on the corrosion protection of tanks and free-flood spaces to develop and tune the performance of a new sacrificial anode alloy to both save weight and meet performance requirements.

This research has confirmed that significant weight savings are possible and provided sufficient confidence to allow a sea-trial to go ahead, prior to in-service implementation.

Explore	Develop	Deploy
• Modelling to understand the sensitivity of the electric field within enclosed or free-flood spaces. • Laboratory-based experimentation to understand how changes in composition affected anode performance and potential weight savings through life.	• Conducting three 6-month trials in conjunction with Babcock to determine the performance of the most promising alloys in real-world conditions. • Post-processing the trial results, which confirmed that the results were valid, consistent with expectations and between test samples. • Validation of the modelling predictions against the trial results and investigation into the impact of coating thickness.	• Working with the anode foundry to investigate the impact of manufacturing consistency, and so provide confidence in the robustness of the recommended solution.

Before trial with fresh anode

Test piece being lowered into position



Post trial with corroded anode

Scaling advanced air mobility in the UK

Advanced Air Mobility (AAM) presents an opportunity to revolutionise public transportation, offering significant travel-time savings with improved connectivity, resulting in potential socioeconomic benefits valued at £2.1 billion annually for the UK.

The building blocks for this future aviation revolution will be centred around automation, autonomy, and electrification, with benefits including reduced road congestion, load alleviation on existing surface transport modes, and new multi-modal trip options - all while maintaining the course for Net Zero emissions.

Frazer-Nash, in collaboration with GKN Aerospace and other industry stakeholders, including Urban-Air Port Ltd, the Department for Transport, Connected Places Catapult, Pascall+Watson Architects, and input from a major UK airport, explored how urban mass transit could be revolutionised by the advent of AAM.

Using GKN's Skybus concept - a 30-seat electric Vertical Take-Off and Landing (eVTOL) aircraft – a future "Park-and-Fly" service to Manchester Airport was investigated, offering significant travel-time savings in an environmentally sustainable fashion as well as reducing congestion on the road network.

We investigated the considerations around Vertiport (hubs for eVTOLs) locations, including the challenges associated with integrating these into a major airport, to understand how Skybus could unlock a range of benefits for both passengers and the wider community.

Our research recommended ways forward to address these challenges and accelerate the path towards a future in which mass transit is augmented by AAM in the world's major cities and beyond.

Funded by the Department for Transport as part of the 2022 Transport Research and Innovation Grants (TRIG) programme, delivered by the Connected Places Catapult.

Building a star on earth – fusion energy

Fusion is the process that takes place in the heart of stars, where a combination of hydrogen isotopes (deuterium and tritium) are heated to over 100 million degrees Celsius. No longer a gas but a plasma, the nuclei combine and in doing so generate a huge amount of energy from a small amount of mass.

It is an exciting time to be involved in the fusion energy sector with the UK's national fusion programme leading the way with the Spherical Tokamak for Energy Production (STEP) programme and the emergence of the delivery arm, UK Industrial Fusion Solutions Limited (UKIFS). STEP was spawned by the UK Atomic Energy Authority (UKAEA): The UK's national fusion centre of excellence that has been a major international fusion research centre since the 1960s, but there's also significant private investment with organisations, such as Tokamak Energy and First Light Fusion, developing innovative solutions here in the UK.

Globally, there has been over $6.4bn of funding invested across over 40 fusion developers, with most of the funds and organisations based in the U.S.

In March 2022, the US Department of Energy (US DoE) and the White House announced a, 'bold, decadal vision' for fusion energy. Following this, the Electric Power Research Institute (EPRI) and US DoE held a workshop to understand and develop a technology maturity plan to support this endeavour. Frazer-Nash was awarded the task of designing and facilitating this workshop, which involved fusion developers and national laboratories, focused on identifying viable technologies to support key aspects of fusion plant within the next decade.

In the UK, DESNZ recently updated its Fusion Energy Strategy and more recently announced a further £650m (taking UK investment in fusion energy to over £1.2bn) assigned to the Fusion Futures Programme (FFP) which will provide funding to develop technologies, facilities, capabilities and the capacity needed to support the realisation of viable fusion energy.

For STEP, the UK supply chain is embarked upon the early stages of a procurement process to develop the engineering and construction programmes. This £20bn endeavour will see STEP built at the EDF West Burton site in Nottinghamshire in the 2040's and will provide the catalyst for a Fusion Industry Supply Chain to develop and support a commercial fusion programme thereafter.

At Frazer-Nash, we are actively supporting fusion energy development in UK and the US. We are a Tier 1 supplier to UKAEA for engineering design, tritium engineering and manufacturing support frameworks. We have a diverse supply chain supporting us that includes domestic and international organisations to ensure technical delivery to schedule, cost and quality for UKAEA.

Commissioned by UKAEA, we convened the UK Fusion Skills Council using our fusion expertise, wide fusion network, expertise in facilitation, and relationship with DESNZ. This cross-sector group will generate an initial skills plan to inform future policy decisions.

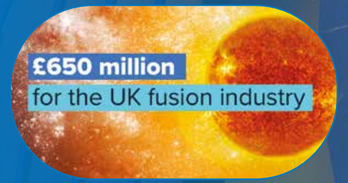
This is an exciting time for fusion energy, with significant funding and an emerging supply chain. With many hurdles still to overcome, fusion is truly in the engineering delivery phase.

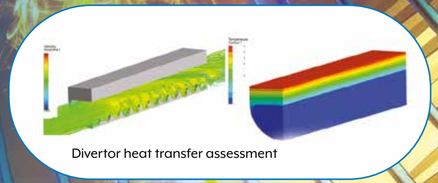
Case study: divertor design

The divertor extracts heat and ash produced by the fusion reaction, minimizes plasma contamination, and protects the surrounding walls from thermal and neutronic loads. We used the freedom of advanced manufacturing to improve heat transfer in divertor targets using coupled CFD-thermal and structural analysis with liquid lithium, water and helium as coolant options. Our analysis included Magneto-Hydro-Dynamics (MHD) effects and demonstrated that significant heat transfer improvements were possible.

Case Study: Liquid metal flow loops

Building on our AMR liquid metal thermal hydraulics expertise (page 59), we have developed a unique capability in the design of liquid metal flow loops, as lithium is required for breeding tritium. Our expertise has been applied to the concept and detailed design of three flow loops to support fuel cycle, MHD, corrosion and high heat flux testing.





Divertor heat transfer assessment

New nuclear technologies – Pathway to Net Zero

Nuclear power is recognised as playing an increasingly vital role in the global journey towards Net Zero and energy security, with increasing demand for clean, baseload power - A doubling of global nuclear generating capacity is needed between now and 2050.

This presents tremendous opportunities and large-scale engineering projects, such as the ongoing works at Hinkley Point C, represent a major contribution to increasing the UK's energy capacity. However, the UK's aspirations to deploy up to 24 GW of new nuclear cannot be achieved by large GW-scale plants alone, with a clear need for major contributions from scalable, readily deployable reactor technologies, in the form of Small and Advanced Modular Reactors (SMRs and AMRs).

SMRs and AMRs are attractive as they can be largely fabricated off-site, significantly reducing costs and lead times for installation, as well as minimising overall project risk when compared to 'traditional' nuclear new build projects. Their scalable nature also means that, for the first time, nuclear technologies can deliver broader industrial decarbonisation – for instance in the generation of clean hydrogen and ammonia.

The SMR and AMR landscape encompasses a phenomenal array of technologies, with over 80 unique reactor concepts currently under development globally. Some of these are based upon proven technology, such as the Pressurised Water Reactor (PWR) system adopted by Rolls-Royce SMR and many other Generation III+ SMR developers.

Moving forward to Generation IV AMRs, a diverse range of international developers are progressing designs aimed at the commercialisation of Molten Salt Reactors (MSRs), Lead-Cooled Fast Reactors (LFRs) and High-Temperature Gas Reactors (HTGRs). Each reactor type poses vastly different technological challenges, meaning the demand for innovation and 'fresh thinking' within the nuclear sector is at a level not seen for decades.

Within the UK, momentum has been building with the growing realisation that nuclear must be part of the energy mix to achieve Net Zero. In 2023, the formation of Great British Nuclear (GBN) has offered a much-needed alignment of strategy across the nuclear sector driving forward the UK's ambitious plans for SMR and AMR. The first step on this journey is an SMR technology selection competition, aimed at supporting a small number of exciting technologies through to a Final Investment Decision (FID) this decade.

Frazer-Nash is excited to be at the heart of the UK and international SMR and AMR landscape and have been actively supporting Rolls-Royce SMR as a trusted Tier 1 supplier, helping to drive the progression of their transformational programme. Our specialist, transferrable skills, fostered through our 30+ years of nuclear sector heritage, are in high demand from Generation III+ and Generation IV developers, where we employ value-adding skills to help vendors navigate design and regulatory challenges.

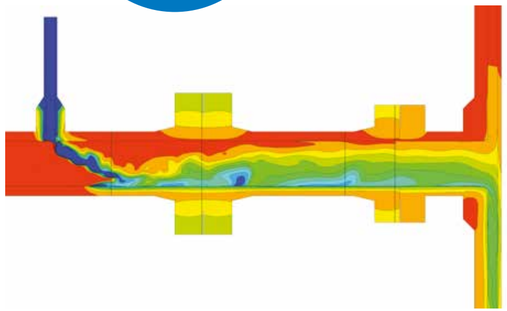
With the variety of opportunities available and sheer diversity of activity taking place, there has truly never been a more exciting time to be part of the nuclear sector. SMR and AMR developments will have a lasting legacy as nuclear takes its rightful place at the forefront of the global clean energy mix.

Case study: Nuclear Innovation Programme

We led several BEIS Nuclear Innovation Programme (NIP) R&D programmes, covering Advanced Materials, Safety and Security and Thermal Hydraulics delivered over four years with a combined value of £10 million.

A key objective of the NIP was to increase the uptake of modern digital engineering practices, improve understanding of passive safety arguments and upskill the UK nuclear industry for next generation reactor design. Some of the outputs from this programme included a Safety Case Toolkit and Nuclear Heat Transfer and Passive Cooling guidelines for advanced reactor design.

This body of work has become a go-to reference for new nuclear developers across the world.



Quantum computing

Quantum computation is a novel computational paradigm that harnesses the non-intuitive behaviour of the subatomic world to process information in a fundamentally different way.

Since the 1980s, it has been thought that quantum computers could unlock tremendous computational speed ups, bringing certain tasks that are too difficult for normal computers into the realm of the possible.

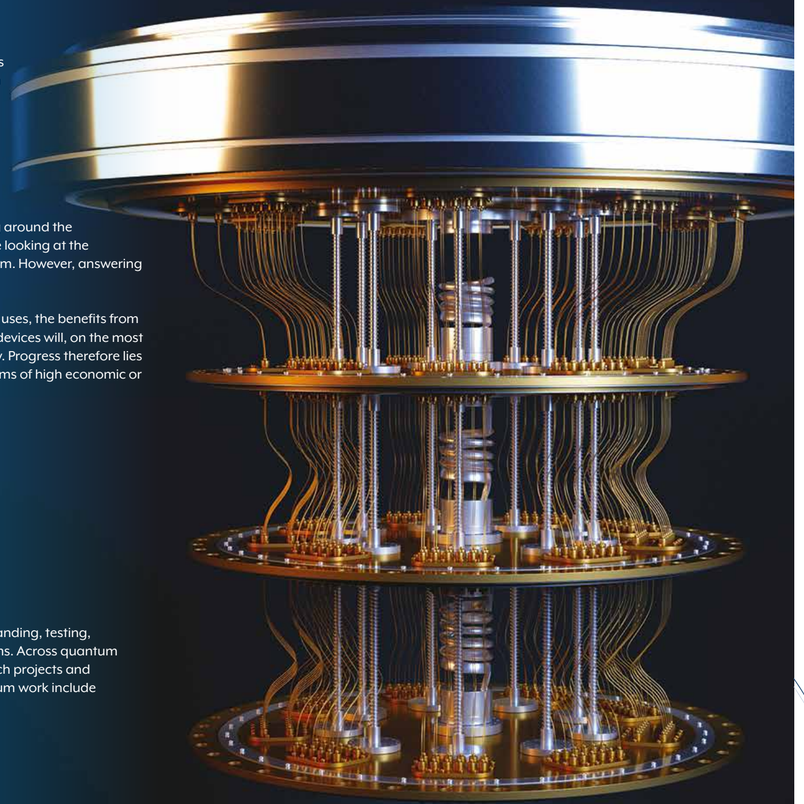
Quantum computation is now moving out of the laboratory and into the commercial domain. With significant ongoing investment, hype is peaking around the changes that quantum computing may bring. Increasingly, businesses are looking at the possibilities of this new technology, and asking what it might mean for them. However, answering this question is not easy.

Quantum computers are not simply better computers – for the majority of uses, the benefits from quantum computers will be limited. Even when fully developed, quantum devices will, on the most part, be costly to run and operate, and will work in an unconventional way. Progress therefore lies in finding the fit between the strengths of quantum computers and problems of high economic or societal value for which current approaches are lacking.

Potential application areas include:

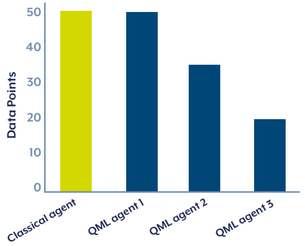
- Chemical research and drug discovery
- Material science, such as batteries and solar technology
- AI and machine learning
- Cybersecurity
- Manufacturing and supply chain
- Finance

Our quantum computing team have long-standing experience in understanding, testing, developing and integrating novel technologies to solve our clients problems. Across quantum computing, we provide horizon scanning, road mapping, targeted research projects and sustained research management. Some recent highlights from our quantum work include the case studies on the next page.



Case study: Machine learning data efficiency in cyber defence

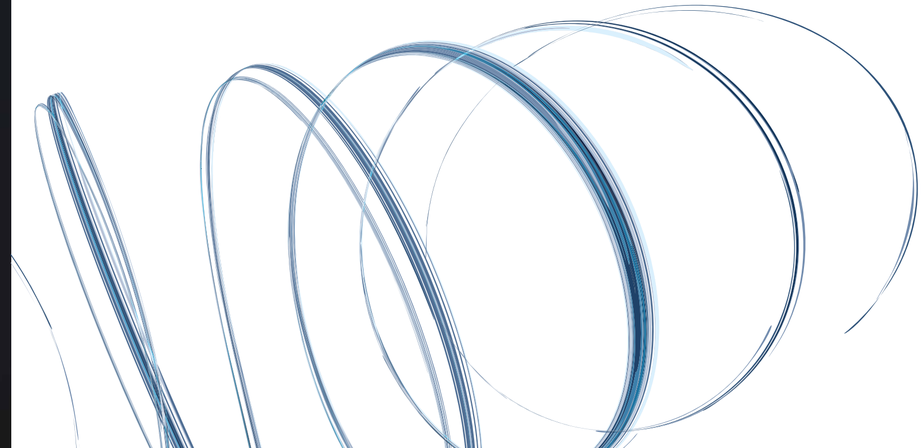
With rapidly developing malicious tools used by cyber criminals, it is widely believed that autonomous agents will play a key part in our defence against cyber-attacks. Working alongside OxBrdgRbtx, we have successfully embedded quantum machine learning in autonomous agents. When compared with conventional machine-learning agents, the quantum agents are more data efficient, learning faster per data point in simulated cyber-attacks.

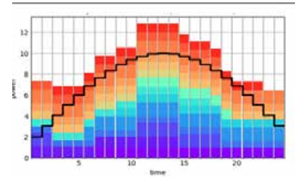


Data points needed by classical and Quantum Machine Learning (QML) agents to learn to defend against a simulated cyber attack. QML agent 3 learns much faster than the classical agent.

Case study: Network balancing using quantum optimisation

The increasing roll out of renewable energy sources brings many computational challenges in delivering a secure electricity supply. We have been working with National Grid ESO to explore the use of quantum computers to meet these challenges. Our recent work has demonstrated the capability of photonic quantum computers to solve supply-optimisation problems for network balancing.





Simulation results showing the capability of ORCA PT-series quantum computers to solve supply optimisation problems in electricity grid management.

Uncrewed air systems

Uncrewed Air Vehicles (UAVs) or drones can be controlled remotely and/or fly autonomously, while Uncrewed Air Systems (UASs) cover not only the UAV but also all of the systems required to operate the vehicle, including ground control stations and data links.

As technologies have improved and costs fallen, UAS use has expanded to include aerial photography, forest fire and environmental monitoring, policing and surveillance, infrastructure inspections, product delivery, entertainment, and even racing. There are also illicit use cases, such as smuggling, which present new challenges to law enforcement that we are helping to address.

With the increasing ability of UAS to operate autonomously and Beyond the Visual Line of Sight (BVLOS) of the pilots, the sky's the limit for the applications and benefits of UAS.

UAS expertise

Our dedicated UAS team, led by Stuart Keenan, actively supports and promotes UAS best practice through the Association of Remotely Piloted Aircraft Systems (ARPAS-UK). We offer a range of services, from UAS consultancy (including navigation of the regulatory landscape for BVLOS approvals, systems integration, etc.), to bespoke UAS design, development, and testing for specialist applications. In addition, as a CAA approved flying organisation, we have experience in running a range of UAS flight trials and operations.

We conduct data collection flights utilising COTS UAS for purposes such as video data collection, as well as test flying bespoke/in-house developed UAS.

DJI Matrice 30T

Looking ahead

Throughout recent years, development of UAS has been spurned by advances in the fields of autonomy and AI, which is still rapidly developing. Many industries have started to look to autonomous UAS operations as a solution to greatly reduce costs and timescales for a range of operations (such as inspection, payload delivery, and humanitarian/emergency response) in an environmentally sustainable way.

Of course, adopting autonomous and BVLOS UAS operations will not be without challenges, with significant airspace and regulatory changes being required. Our team of experts in fields ranging from regulation, infrastructure, digital systems and assurance is leading the way to facilitate the adoption of these novel technologies in industry.

Case study: Police close support nano UAS

We developed an innovative UAS solution that tracks objects of interest and informs the drone's flight controller by integrating a bespoke AI model into a modified COTS UAS. For the development of such AI models, data capture operations are conducted by our UAS pilots.

As an example of data capture activities for other projects, our pilots used our DJI Matrice M30T UAS equipped with a comprehensive suite of sensors, tracked and followed a representative target at night in different environments using multiple representative target vehicles. The data generated from these night flights has provided those developing the next generation of AI models with as wide-ranging and representative a dataset as possible.

Case study: National Grid Autonomous Aerial, Thermal Inspection of Substations (AATIS)

We supported the National Grid to develop and trial a revolutionary method of inspecting electrical substations. This relies on the use of UAS and AI to vastly accelerate a process that typically requires a number of staff to manually take a series of thermal images and then analyse them.

Using a COTS drone-in-a-box solution and a UAS equipped with a thermal camera, the image capture can be largely automated and accelerated. By then uploading the images to a database, they can be analysed by a specially developed AI model greatly reducing the cost and duration of the inspection.

Bespoke prototype UAS with integrated COTS LED dazzler to distract and disorientate a subject at range

Advanced manufacturing

Advanced manufacturing is the use of innovative technology to improve products or processes with the relevant technology being described as advanced, innovative or cutting edge. Therefore, this not only covers advanced manufacturing techniques, such as forming, forging, and additive manufacturing, but also factory/tool design, equipment installation and digitalisation.

The use of advanced manufacturing techniques is essential for the UK to remain competitive in high-value manufacturing industries. The application of automation, computation and AI can be used to develop new capability, increase quality and productivity performance and reduce costs.

Our Advanced Manufacturing Technology Hub (AMTecH) is the gateway to expertise for all your advanced manufacturing technology requirements. AMTecH was conceived to address the increasing need to tackle real-world engineering challenges across all sectors, by bringing together a broad spectrum of organisations in a supportive and collaborative environment, through which effective solutions can be better and more quickly realised.

We support manufacturing technology research, capability maturity activities, and new build projects across all manufacturing readiness levels. Our goal is to minimise quality and cost risks in production, ensuring a secure supply chain.

Our team has extensive experience with diverse products, sectors, technologies, and functions. We strive to deliver value and solutions for our customers, focusing on reducing manufacturing and quality risks to achieve a 'right first time' approach. Our capabilities cover:

- Additive manufacturing and near-net shape forming.
- Material, chemistry, and surface engineering.
- Controls and instrumentation.
- Automation and digitalisation.
- Analysis and simulation.
- Codes and standards.
- Machining and joining technologies.
- Product and process verification.

Our website (www.fnc.co.uk/amtech) is constantly being updated and provides further case studies and information about our collaborating organisations.

Case study: Residual weld stress

Welding processes apply complex thermal loading, which can result in residual stresses in the weld that can affect its performance and integrity. As part of a government funded program to develop the capabilities needed for future generations of nuclear power plant, we developed a method for modelling power-beam welding processes, which was validated against residual stress measurements. Through this and previous projects we have developed extensive knowledge in weld modelling that can be used to minimise post-weld distortion and demonstrate through life structural integrity.

Case study: Optimised manufacturing design

There's a pressing need to manufacture a substantial quantity of large stainless steel storage boxes to safely store radioactive waste for a minimum of 500 years. We were tasked with optimising the current waste box design for manufacturability and affordability, utilising advanced technologies and identifying opportunities for cost savings. Our approach involved breaking down the manufacturing process, challenging the design intent and undertaking structural calculations on design options. This resulted in a potential saving of 20% per box through lower material costs and reduced machining and welding.

Focus on decision modelling

Focus on decision modelling

We live in challenging times for businesses and governments. The combination of ageing infrastructure, climate change, rapid technology development and cost pressures mean that decisions are more complex and difficult than before. In the face of this complexity, it can be tempting to rely on intuition and gut feel in the place of more complex analysis.

However, this temptation should be resisted; through a combination of powerful modelling approaches, expert elicitation and interactive visualisation, decision modelling can be used to understand, justify, and explain the impact of choices, enabling better decisions to be made.

There is no one size fits all approach to decision modelling. Instead, analysts need to have a range of different techniques and methods in their toolbox, ready to use the most appropriate to solve their particular challenge. The selection of the right approach is vital in the success of decision modelling, as such it is crucial that analysts understand the problem they are facing and the information that can aid and clarify the decision-making process.

Applying decision modelling allows you to:

- Forecast the performance of your asset, system, or organisation under different future scenarios.
- Identify the best interventions and changes to apply to minimise risk and mitigate impacts.
- Quantify confidence in your ability to meet the required performance.
- Generate quantitative evidence to support operational change and investment decisions.
- Provide senior stakeholders with the confidence to make the changes required.

Clement O'Rourke
Group Leader
Advanced Modelling

As a strong believer in pragmatic modelling, Clem and his team use novel methods to combine expert knowledge and limited data to deliver powerful insights for our clients. Through the leverage of probablistic models, Clem strongly believes that the relative importance of underlying assumptions can be quickly easily tested, helping to build confidence in model outcomes in complex and high uncertain situations.

Jonathan Farman
Group Leader
Operational Modelling

Jon is an experienced leader in systems modelling, software development and data visualisation. His aim is to help his clients to make the best-informed decisions possible, helping them to realise their high-level strategic goals.

Using modelling and simulation to forecast how a system will perform in a future uncertain and changing environment, Jon and his team develop tools and models to quantify and compare the benefits of different choices. This includes investment and operational decision-making, business case support, software proofs of concept, process improvement and automation.

Optimise rail engineering works

Essential track maintenance works need to be completed as quickly as possible so that the track can become operational again. These rail possessions are meticulously planned in advance, but often still encounter delays and challenges due to the complex nature of the works that involve many components, teams, equipment and risks. The financial penalties for overruns are significant, running into the hundreds of millions per year.

Through analysis of historical rail possession task data and the integration of live, ongoing possession plans (from Primavera P6 and MS Project), we developed a capability for Network Rail to optimise live possession management works. Centred around a probabilistic risk modelling digital twin, our approach linked live project data with 'activity fingerprints' distilled from historic data, to predict when current possession will finish, what tasks are at most risk of overrunning, and the benefit of descoping activities.

Our tool (Pos-itrack) was integrated into a custom Power BI dashboard, hosted in the cloud, to enable decision makers to easily interrogate the possession plan, understand why delays are likely to occur and adapt plans accordingly.

The tool has now been tested and validated on five live possessions and shortlisted for a 2023 rail industry innovation award.

Maximise rail vehicle availability

Rolling stock need to be regularly examined, serviced and overhauled to ensure that they operate safely and reliably. Rail vehicle maintenance, and rolling stock storage, takes place at depot facilities around the country, but storage and maintenance capacity can impact their availability for mainline service.

Historically, depot design has been based on experience and functional requirements. Systems thinking and simulation-based modelling can be used to look beyond depots as a static facility to store and maintain trains and consider them as a dynamic environment where maintenance takes place within a set of wider constraints, such as track layout and operating requirements.

Our bespoke Depot Modelling software tool considers the depot as a whole – the system boundary is the depot boundary. It analyses thousands of permutations of depot activities through a user-friendly interface and fast running simulation, enabling:

- Cost effective planning, evaluation and understanding of depot performance.
- Identification of improved operational strategies by applying performance metrics.
- Exploration of the impact of changes without capital expenditure.

An effective depot is one that can fulfil the maintenance, servicing and storage requirements of a fleet safely and efficiently, optimising all facilities systematically ensuring on time availability of the fleet for mainline service.

Using systems thinking, modelling the dynamic capacity of a depot provides you with a practical and achievable method of optimising your depot decision making.

Automatic environmental risk assessment

National Grid Electricity Transmission (NGET) is responsible for keeping the UK's high-voltage electricity transmission network maintained and resilient, and their control room continually monitors weather events so that environmental risks can be efficiently managed and addressed.

While National Grid's infrastructure is engineered to be resilient, the increasing frequency of extreme weather events requires additional measures to assure the future robustness of its network and processes.

Automation of these processes will enable more effective monitoring and minimise possible impacts on asset operability, thereby reducing response times in emergency situations. We are leading a collaboration with Previsico and Liverpool University to replace NGET's current manual approach with an automatic risk assessment process.

- Frazer-Nash are developing a platform to automatically monitor and predict risks.
- Previsico are providing expertise and sensor technology for flood nowcasting and forecasting.
- The University of Liverpool are providing expertise and simulation of long-term hazards posed by river and slope erosion.

Our interactive visualisation of NGET's assets harnesses a combination of pre-existing data, monitored sensor data and simulated data to generate quantitative multi-hazard risk ratings for upcoming forecasted weather events. This provides automated alerts for real-time and long-term risks, allowing NGET to prepare and respond in a coordinated way.

Reducing NHS backlog

The National Health Service (NHS) is experiencing severe funding, staff and hospital bed shortages. Therefore, optimising efficiency and improving patient throughput is essential to reduce the record number of people waiting for treatment.

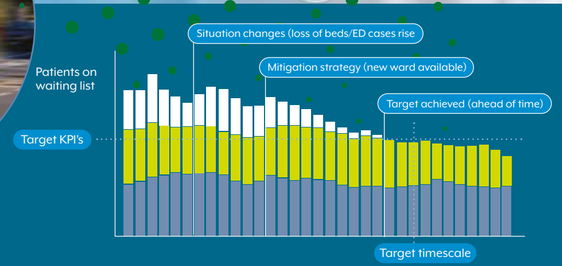
An NHS Trust was concerned about the elective surgery backlog post-COVID and wished to reduce ambulance waiting times due to Emergency Department crowding. Our scenario planning tool (EMPATH™) allowed the Trust to better understand their system and make strategic decisions, with confidence, that would improve their hospital's performance and thus patient experience.

The EMPATH model is a highly configurable patient-level simulation for forecasting the performance of current and future patient care pathways. This tool can quickly investigate changing patient demand, staff availability, streaming services, location capacities, and many other factors.

These forecasts highlight system weakness, resilience and efficacy, and allow exploration of optimisation strategies to strengthen business cases, shape new facility builds, and create effective staff rotas.

The underlying engine has been successfully applied in aviation and defence and is developed to international engineering quality standards. The bespoke web app provides out-the-box visuals for summary/scenario comparison, as well as drilling down into the detail.

Our quantitative, independent and assured analysis of current and potential configurations greatly enhanced the Trust's business case for new build surgical facilities, and the Emergency Department model is now being applied within the Trust's operational research team.



Reducing delays on the UK rail network

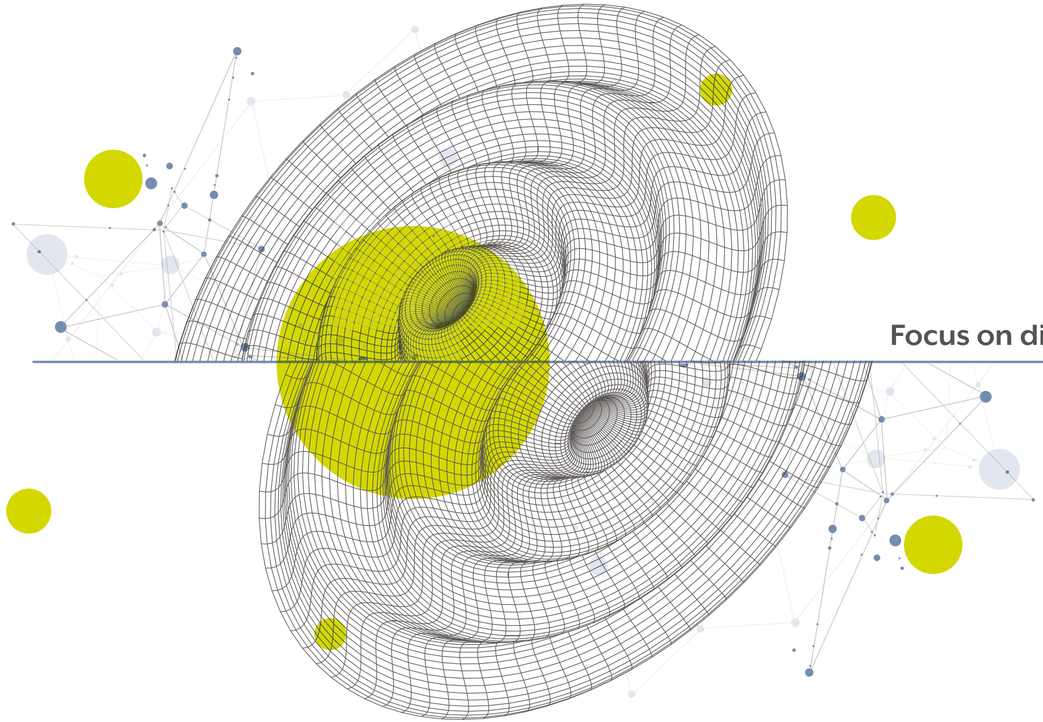
The UK rail network has a complicated infrastructure that is used heavily by both passengers and freight. Understanding how delays will propagate and the rail system will recover is a complex challenge.

With information recorded by every train as it passes through the thousands of timing points on the network, there is an abundance of data that is too detailed to give operators the holistic view required to make informed decisions but, if aggregated and presented suitably, has the potential to provide valuable insight.

Funded through the Network Rail and RSSB's Data Sandbox+ competition, we combined our advanced Machine Learning experience with Lampada Digital Solution's detailed rail network database to develop a model, trained on five years of historical data, that can predict how live delays propagate through the system. The delays were then displayed in a visualisation tool to allow users to quickly identify locations which may impact their operations.

Our Rapid Evaluation and Planning Analysis Infrastructure for Railways (REPAIR) predictive tool was extended to offer alternative routing solutions using Network Rail's route-finding methodology. This allows the user to run 'what if' scenarios to test the impact of different incidents on the system. This will empower controllers to make better decisions, faster.

We have subsequently partnered to produce a robust product that will provide rail operators insights into the propagation of delays. A demonstrator of REPAIR was installed in the National Rail Communication Centre (NRCC) office in Doncaster for over six months.



Focus on digital twins

Focus on digital twins

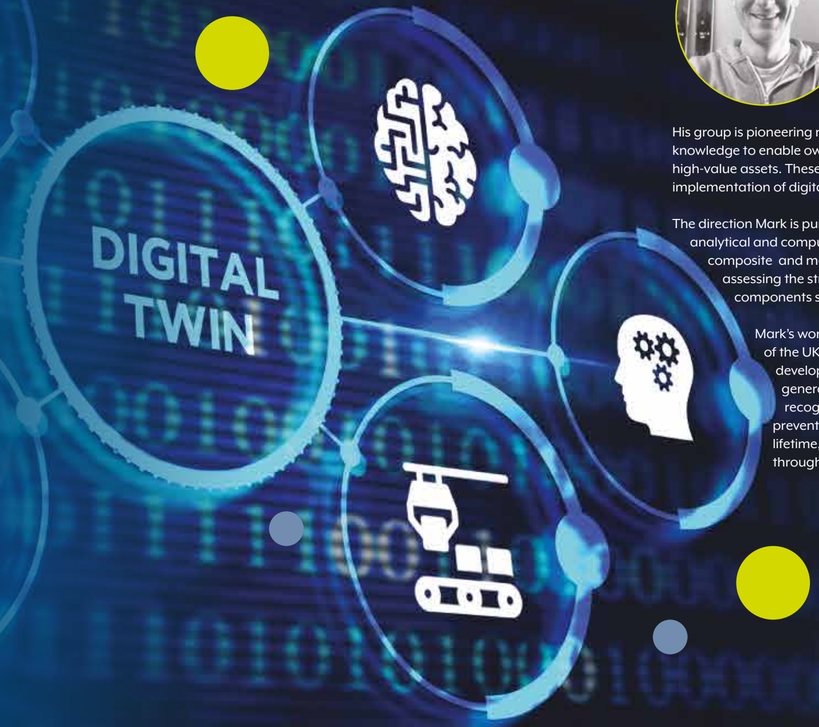
A digital twin is a digital representation of an asset, process or system that provides a better understanding of future behaviour in response to interventions and the environment. It uses a combination of data, predictive models and statistics to reliably describe the state of the asset in the right time (not necessarily real time). They enable intelligent decisions to be made for safely extracting maximum performance from assets and offer several benefits, such as:

- Reducing the cost of downtime through forewarning of asset failure, enabling preventative maintenance to be put in place.
- Maximising the revenue from assets through the ability to extract their full useful life based upon their actual operation.
- Mitigate the risks of future operation through the ability to reliably predict the impact of future scenarios.

A digital twin may not be the most effective or efficient approach to solve your problem: it is easy to be led by the data. We start by understanding the risks posed and what you're trying to achieve from your assets, which in turn informs the technology that needs to be put in place and finally, what data are required to underpin this. Our expertise enables us to:

- Understand the system and identify the scope of the digital twin.
- Select and apply the most appropriate simulation approach to understand how the asset behaves within its operating environment, and develop the model that will underpin the digital twin.
- Identify and extract the data necessary for model validation, exploit probabilistic techniques to quantify and optimise the reliability of the digital twin's output.
- Build a digital platform to manage interface of data, models and user interfaces.
- Develop GUIs so users can interpret the output and make informed decisions.

The advances in digital twin technology are being influenced by the growth in computational performance, which is enabling the use of more complex modelling approaches. AI potentially offers incremental improvements in the scope and speed of digital twins. Fast and effective physics-based simulations will provide provenance to the output of AI models, enabling them to be exploited more readily for digital twins of safety-critical assets.



Technical focus – digital twins

Mark Stevens
Group Leader
Data-Centric Asset Integrity

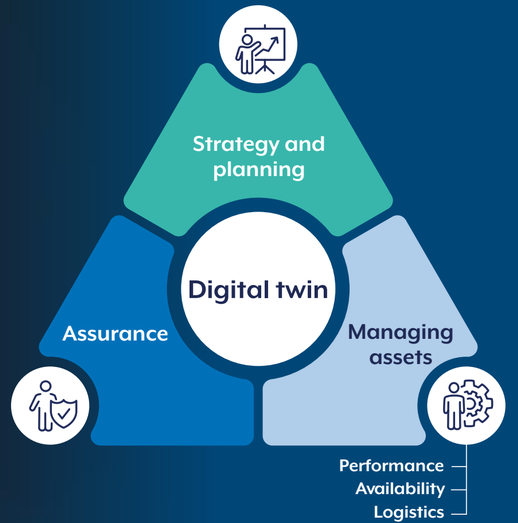
Mark Stevens leads our Data-Centric Asset Integrity Group, which employs a range of capabilities to simulate the behaviour of materials and components to understand how and why they fail. His group is pioneering new services that combine our structural integrity and data science knowledge to enable owners and operators to extract more performance and life from their high-value assets. These capabilities have underpinned our successful development and implementation of digital twins across industry.

The direction Mark is pursuing has been underpinned by over 20 years' experience applying analytical and computational methods to simulate the structural behaviour of composite and metallic components. His principal technical expertise lies in assessing the structural integrity of safety-critical nuclear power plant components subjected to high temperature operation.

Mark's work has justified the safe operation and life extension of the UK's existing nuclear fleet and contributed to the development of life assessment approaches for next generation nuclear power plant. In this time, he has recognised the role that uncertainty plays in preventing the safe maximisation of a component's lifetime, and the opportunity presented to address this through better exploitation of data.

Peter Van Manen
Principal Consultant
Materials Performance

Peter van Manen sits on the Strategic Board of the Digital Twin Hub, a Connected Places Catapult community with members in the UK and abroad that champions the development and use of connected digital twins. He is a member of the Governance and Trust working group that includes finance people, lawyers, business leaders, and engineers. This group has published papers concerned with the purpose, value, and outcomes of digital twins.



Condition-based maintenance of gas turbines

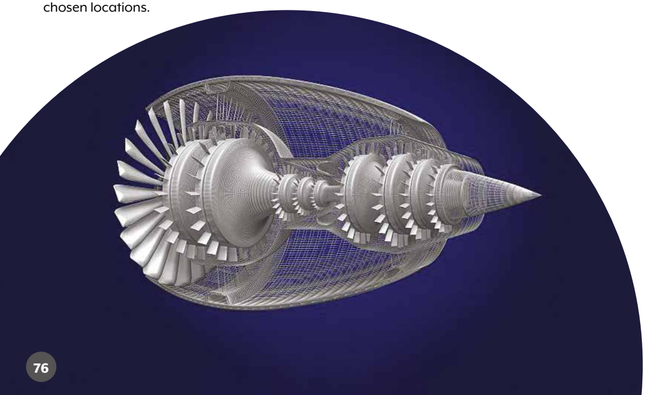
Our client has a fleet of approximately 15,000 industrial gas turbines. Maintenance schedules of this fleet is traditionally based around safe operating hours i.e. time-based maintenance and overhaul assuming a typical design cycle. This makes repair and overhaul of a fleet expensive due to:

- Operational costs due to downtime.
- Manufacturer costs for replacing high-value parts and inventory upkeep.

However, all systems operate differently, and maintenance procedures often replace parts that show no signs of damage. Changing to a condition-based maintenance schedule allows operators greater flexibility on the use of their asset. However, the difficulty is in finding a balance between waste versus sudden failure.

To do this a digital twin of the gas turbine must be created that uses real engine history to calculate accumulated damage and remaining useful life, allowing greater choice and flexibility for owners and operators. The complexity of this problem is the lack of data points around a blade's local environment to reliably predict the blade's condition from the known engine parameters.

At first glance, this seems a daunting prospect: a gas turbine is complex, and the failure mechanisms are non-linear. However, the problem can be simplified by only considering the parts that are likely to fail first. We exploit the accuracy of complex multi-physics models, validated by tests, to understand how measured data relates to the condition at the chosen locations.



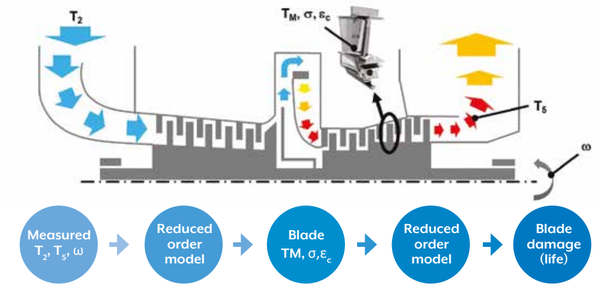
These complex models are simplified and represented using Reduced Order Models (ROMs) in our digital twin, as they are easy to implement and quick to run. The physics is underpinned by probabilistic techniques, allowing us to quantify the uncertainty in the output.

This validated digital twin has achieved a reliable, tailored unit-specific maintenance schedule that uses live data from turbine control systems to determine maintenance requirements from estimated residual component life across a whole fleet. The data is collected from each unit and the ROMs predict its condition in near real time, presenting it to the operator centrally. This enables our client to identify when each unit requires maintenance or replacement, allowing high value assets to be operated closer to their limits and reducing unnecessary interventions.

Our client now uses condition-based maintenance as a key selling point for their engines as it:

- Reduces the risk of failure and overhaul downtime across an engine fleet.
- Reduces their costs through less waste and leaner inventory management.
- Can be used to justify periods of overfire, providing flexibility to operators.

In the future, the digital twin could evaluate new maintenance and repair regimes using live fleet information and historical sensor data.



Reducing electrical cable failure

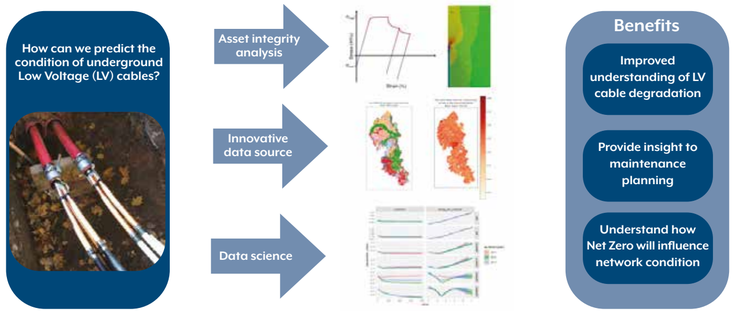
The low voltage (LV) domestic electrical network in the north-west of England consists largely of buried cables. Failures in the network cause significant disruption to consumers and cost to operators. Future network degradation will be accelerated through a combination of ageing, climate change effects and increased electrification, leading to more frequent failures.

Frazer-Nash are working alongside our partner, TNEI Services Ltd, to predict network failures so that interventions can be made to mitigate their impact. We have created a probabilistic framework to predict the likelihood of LV asset failure using our expertise in:

- Asset integrity analysis to understand the cases of cable failure and simulate how failure may be influenced by customer electricity usage, soil conditions and cable type.
- Innovative data sources (including Geographic Information System (GIS) data and smart meter data) to quantify location-specific cable operating conditions which may influence cable degradation.
- Data science to build a probabilistic model of the cable degradation, so that the likelihood of cable failure can be determined across the network.

Our tool (LV Predict) enables the operator to identify the appropriate interventions and investment needed to underpin reliable future network performance.

Electricity North West: predicting the future condition of an electrical network



https://lv-predict.fnc.digital/

How rail freight can help achieve net zero?

The transport sector emits more carbon than any other part of the UK economy, accounting for 26% of carbon emissions in 2021 (ONS report). Therefore, decarbonising freight transport is essential to achieving Net Zero by 2050.

Rail is considered a low-carbon mode of freight transport due to the energy efficiency of large freight trains compared to using multiple road freight vehicles. A modal shift from road to rail freight could therefore play a pivotal role in meeting the UK's statutory commitment.

The Rail Safety and Standard Board (RSSB) commissioned a task (T1229) to develop and validate an agent-based model which predicts the traction power demand, energy requirements and emissions along freight corridors for both current and future rail freight. This model could be used by the wider freight community to model scenarios which give insight into the impact of changes to operation on carbon emissions.

We demonstrated that there are significant benefits in both energy demand and carbon reduction by transitioning to longer trains with greater axle loads. This model also assessed the viability of novel technologies to power rail freight away from diesel locomotives and towards a Net Zero economy.

This confirmed that widespread electrification or the development of more efficient and economical battery, biofuel or hydrogen technologies is required for rail freight to transition to Net Zero.

*Rail Freight Strategy: Moving britain Ahead, Department for Transport, September 2016

**2021 UK Greenhouse Gas Emissions, Office for National Statistics, February 2023

Focus on machine learning and AI

Focus on machine learning and AI

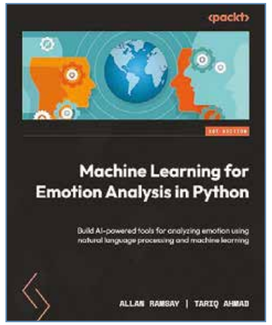
Machine Learning (ML) and Artificial Intelligence (AI) are at the forefront of the transformation taking place in modern technology.

ML is a subset of AI; it empowers computers to learn from patterns in data and make predictions or decisions without requiring explicit rule-based programming. AI, on the other hand, encompasses a broader spectrum of technologies that attempt to simulate human intelligence, enabling machines to perform tasks that traditionally required human cognition.

Natural Language Processing (NLP) is a crucial component within this space, focusing on the interaction between computers and human language, facilitating the understanding, interpretation, and generation of human-like text. In November 2022, the spotlight was firmly turned to NLP with the introduction of ChatGPT, an AI-powered tool enabling human-like conversations.

Together, these fields are revolutionising industries, from healthcare and finance to entertainment and beyond. The synergy between ML, AI, and NLP enhances efficiency and accuracy and opens doors to unprecedented advancements, pushing the boundaries of what technology can achieve in our rapidly evolving digital landscape.

ML and AI algorithms are constantly evolving and improving, but it is important to understand their limitations and how to apply them responsibly in order to harness their full potential effectively.



Dr Tariq Ahmad
Senior Consultant
Strategic Modelling

Tariq is one of our resident AI experts with a background in computer science and over three decades in software development, who specialises in NLP. Leveraging NLP to address diverse challenges, offering solutions for sentiment analysis, text summarisation, and language translation, Tariq's expertise extends across multiple sectors, aiding businesses in extracting valuable insights from unstructured data.

He is also an advocate for increased research and helping organisations enhance their strategic decision-making through NLP applications. Tariq is a published author having recently published his first NLP book "Machine Learning for Emotion Analysis in Python".

Identifying vulnerable households

The transition to Net Zero has seen the electrification of heat and transport, but these technologies remain expensive, and many people, particularly vulnerable households, may be left behind during this transition if they cannot afford them. We wanted to identify these vulnerable customers to ensure they receive the required assistance from their network providers.

We developed the Vulnerability and Energy Networks, Identification and Consumption Evaluation (VENICE) model to identify whether a household was vulnerable from the electricity usage by combining our behavioural science and data science expertise.

- Our behavioural psychologists undertook research into how a consumer may interact with their electricity differently depending on their vulnerability.
- Our data science team used machine learning, pattern recognition and probabilistic techniques, to identify these behaviours in smart meter data.

The model successfully identified some of the changes in a household's behaviour that indicate that the household may be vulnerable. This model could be used by the energy networks to identify households in need of additional support, enabling the networks to provide the, sometimes lifesaving, additional support during an outage.

This was a Network Innovation Allowance project funded by National Grid Electricity Distribution.

AI-powered asset management

Electricity networks cover the generation, transmission and distribution of power to millions of homes across large distances. Therefore, effective asset management is fundamental to the network's reliable and affordable operation. However, asset degradation is dependent on many factors including physical attributes, operational environment and history, which is a highly complex engineering problem.

Our Australia office created the AI-Powered Predictive Reliability for Asset Integrity and Safety of Electricity Distribution (APPRAISED) tool for SA Power Networks. This new tool reliably predicts when and how in-service distribution network assets will fail. Combining fundamental engineering, AI and data analytics, the highly adaptable condition-based algorithm reliably predicts asset life and identifies degradation drivers.

Developed over a year from concept to capability integration, the tool is currently applied in South Australia to monitor the health of 173,000 km of overhead conductors, 450 km of underground cables, 75,000 distribution transformers and 600,000 (Stobie) utility poles.

This innovative and cost-effective capability allows network operators to keep up with the rapidly changing electricity generation and distribution landscape and helps steer us towards Net Zero. The project was selected by Engineers Australia as a nominee for the Project of the Year for South Australia in 2023.

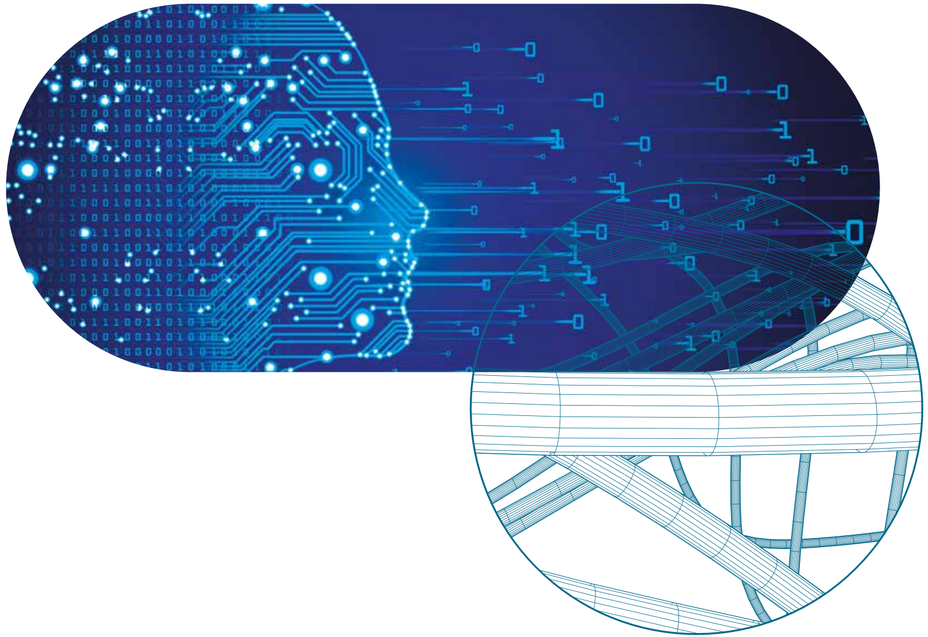
Advanced NLP Assistant (ANA)

Searching databases and systems for the one document that you are looking for is time consuming and tedious, having to open each one and use a traditional Ctrl + F search.

ANA is our Natural Language Processing (NLP) search tool, designed to revolutionise the way information is managed and accessed within Frazer-Nash. This innovative tool was developed internally as part of a collaborative, multi-disciplinary project between the Data Science and System Engineering groups.

The AGILE development methodology was used to quickly generate demonstratable outputs and fulfil the System Engineer's need to find relevant supporting evidence for verification and validation activities that can often require manually searching through hundreds of documents.

It is now a powerful, on-premise automated tool that uses NLP to go beyond traditional keyword searches, identifying semantically related content to deliver a more comprehensive understanding of your data.



- Automatically scans folders, extracting, processing and ingesting text data from Word and PDF documents to build a robust and intuitive database.
- Leveraging embeddings and a vector database, ANA assigns meaning and context to the data, allowing for smarter and more relevant search results.

ANA has been successfully used to search large, security sensitive, written data sets, as well as training and education courses, internal searches through CVs by HR, and finding case studies for bids/proposals.

Neural networks for video compression

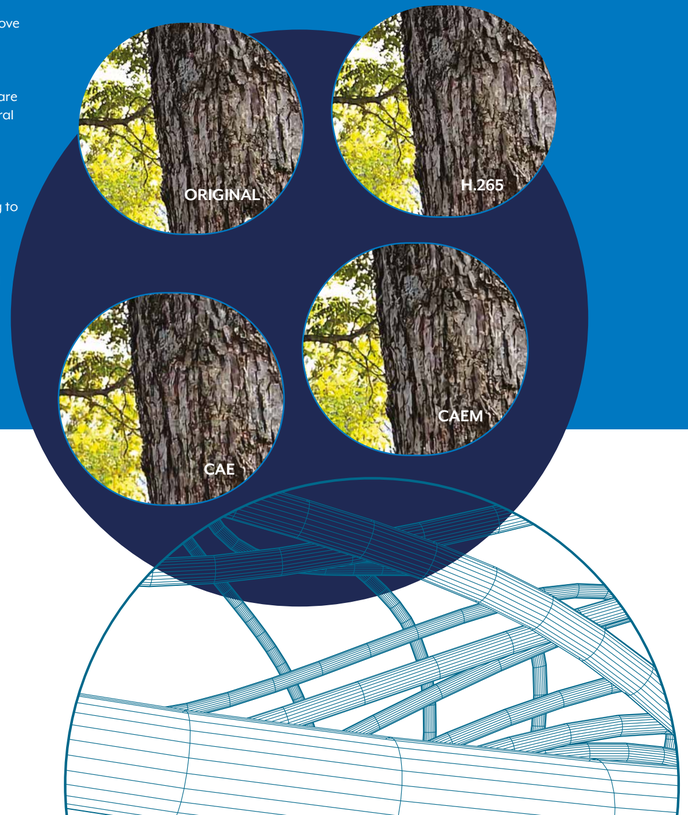
Video compression reduces the amount of bandwidth needed to transmit or live stream a video file. Traditional approaches look at differences between related video frames and remove redundant visual information, i.e. remove features from each frame that don't change, like the sky.

Our customer had a requirement for highly compressed video deployed on a custom hardware platform. They commissioned a research project to investigate the advantages of using neural networks compared to traditional video compression methods, such as H.265.

Neural network video compression is yet to overtake the popularity of traditional methods partly due to the need for specialised hardware. A state-of-the-art review of neural network video compression identified several approaches, which were then down-selected according to whether they could be realistically deployed in real-time on the proposed platform.

The results confirmed that one neural network approach (CAEM) provided a greater rate of compression than H.265 while maintaining comparable reconstruction quality but operated much slower. In contrast another neural network (CAE) was faster than H.265 but reduced reconstruction quality and compression rate.

The Deep Video Compression neural network approach that mimics traditional video compression struggled to outperform simpler neural networks, that only compressed single video frames, in compression rate, runtime, and ease of hardware deployment.



Verification, validation and vulnerability of AI

Machine learning (ML) models learn from existing data to identify trends and patterns and can be extremely accurate when operating on data similar to that which they were trained with. However, if, in operational use, the data differs from that seen in training, this can impact performance potentially causing the system to behave unpredictably and unsafely.

Dstl wanted to develop Uncertainty Quantification (UQ) methods to understand the level of trust that should be put on a ML model's outputs. This included the underlying metrics, as well as a general testing framework to apply, compute and interpret those metrics, and the tools and techniques that can be used to extract meaningful insights into the model's trustworthiness.

This work demonstrated that measures could be applied to multiple dataset types, at run time and at design time, to understand the level of trust in an ML model. We approached the task in three stages:

- A state-of-the-art review to gain a comprehensive understanding of the latest approaches to UQ, uncertainty visualisation and trust in reliable AI/ML outputs.
- Dstl's foreseeable use cases were analysed to ensure that effort was targeted on those trust metrics that would be most widely applicable to their end user requirements.
- Two measures to quantify trust in an ML model were selected, example data was sourced and synthesised, and the chosen measures were implemented and verified.

Autonomous Aerial, Thermal Inspections of Substations (AATIS)

Condition monitoring is essential for maintaining the health of assets in the electricity transmission system. An important indicator of asset health and life expectancy is the thermal condition of the assets, particularly assets within substations. The current practice to determine thermal condition involves manually taking thermal images according to defined schedules, which are then analysed by dedicated experts.

We identified an opportunity with HEROTECH8 to overcome these challenges by deploying an autonomous substation inspection system which will enable normalised data to be captured and analysed autonomously. Our solution uses:

- HEROTECH8'S world leading drone-in-a-box solution allowing an inspection drone to automatically capture normalised thermal images of assets.
- Machine learning to recognise defects in the assets to reduce the post-processing burden and provide engineers with useful insights.
- Beyond Visual Line of Sight (BVLOS) safety case justification to operate remotely and safely without human intervention.

This revolutionary method of inspecting electrical substations has been successfully developed and trialled for the National Grid, demonstrating our ability to integrate UAS and AI to vastly accelerate the current process of manual inspection and analysis of electrical substations.

Automatically identify scientific claims

Advances in data science, Machine Learning (ML) and Artificial Intelligence (AI) can be used to automate the ingestion, processing and collation of information feeds to better understand the shifting science and technology landscape.

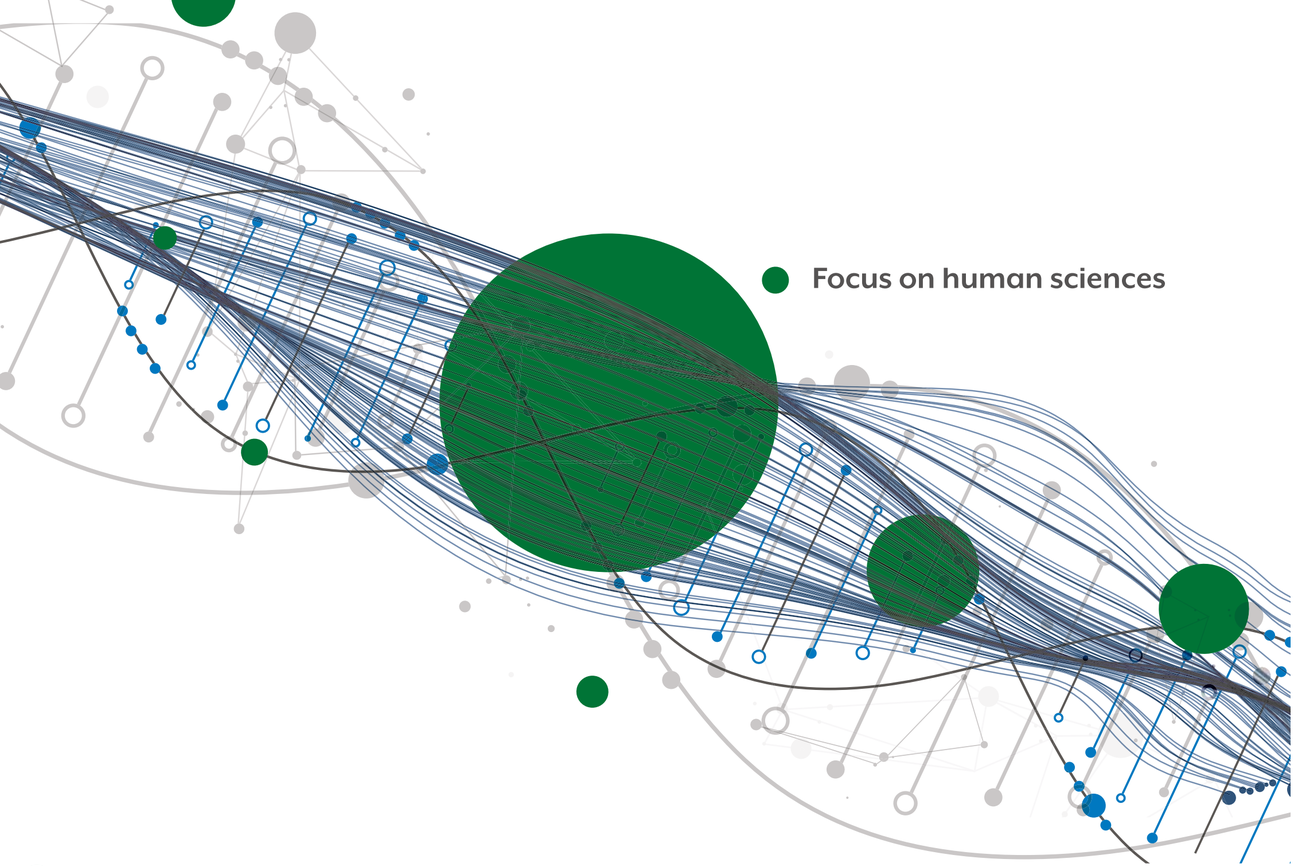
In collaboration with the University of Kent, we addressed our client's requirement to automatically identify and surface new trends or developments in three stages:

1. A transformer-based model was developed to robustly identify claim sentences within academic literature and identify the relevant scientific concepts.
2. These claims were broken down into their constituent parts (e.g., subject, object, verb) such that the relationship between them could be abstracted and understood.
3. The subject-object pairs, in conjunction with the relations between them, were then used to form the basis of an interrogable knowledge graph.

The knowledge graph, which describes science and technology concepts and their connections or relationships, was underpinned by a flexible, extensible, ontology. An upper ontology, comprising core (high-level) concepts and relationships, and a lower ontology comprising lower-level, domain-specific concepts. The complete solution was deployed via an existing tool developed by a third party.

The proof of principle demonstrator automatically identifies claim sentences in source articles, breaks them down, and stores them in a knowledge graph along with their associated concepts.

This tool allows users to easily search for and identify claims most relevant to their area of research, eliminating the need to manually search for academic papers.



Applied Human Sciences

What is human science

Applied human sciences focuses on understanding and improving human life through the practical application of research and theory. It brings together disciplines like psychology, sociology, anthropology, human factors engineering, biological and health sciences.

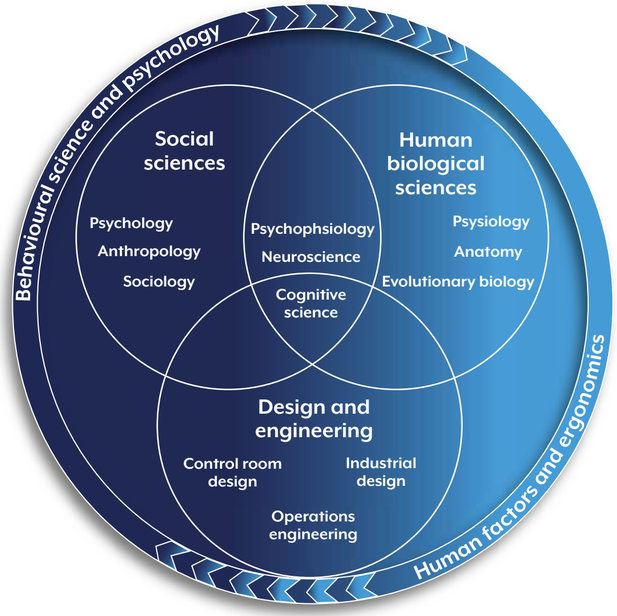
It addresses real-world issues by enhancing human well-being, fostering personal and community development, and improving quality of life. An important factor in human science is the exploration and consideration of ethics, for example, the use of artificial intelligence and its implications.

Within Frazer-Nash, our human science research is focused on the psychological, social, and physiological aspects of human science, such as human behaviours, culture, safety, and human interaction with technology. We use our human-focused capabilities to understand human behaviours and the interaction among humans and other elements of a system to:

- Increase effectiveness, efficiency and resilience.
- Identify and manage potential human error.
- Optimise well-being.
- Enhance decision-making processes.
- Improve overall system performance.
- Address societal challenges.

Social sciences:
Understand behaviours and interactions of individuals, communities and societies with each other and with their built, technological and natural environments.

Human biological sciences:
Provides insight into how the human body works, how it adapts to conditions, and is affected by environmental factors.



Behavioural Science and Psychology

Behavioural science considers the interactions between human beings, while psychology more specifically looks at the science behind human behaviour and mental processes. They are devoted to understanding, predicting, and influencing human behaviour across various contexts by applying theories and principles from psychology, sociology, anthropology, and other behavioural sciences.

We focus on the practical application of behavioural research to solve real-world problems, enhance individual and organisational performance, and improve overall well-being, using:

- **Observation and experimentation:** Systematically studying behaviour through observation and experimentation in both controlled and natural settings.
- **Understanding decision-making:** Investigating how individuals make choices and judgements, considering cognitive biases and environmental influences.
- **Analysing behavioural patterns:** Examining recurring behaviours to identify patterns that can predict or influence future actions creating behavioural insights.
- **Interdisciplinary approach:** Integrating insights from various fields to achieve a comprehensive understanding of human behaviour.

Using a wide array of tools and techniques, we provide sector-agnostic behavioural expertise, adopting a human-centric approach to address challenges across industries and market sectors, such as:

- Human resilience and insider threats by examining human vulnerability.
- Social dynamics incorporating elements of trust and culture.
- Human performance through assessment and enhancement, especially in relation to human interaction with technology and AI.
- User engagement and experience.

We ensure that the human element is always considered.

Meet some of our team...

Dr Heather Taylor
Group Leader

Heather is a highly experienced Chartered Psychologist who leads the innovative Applied Human Sciences group. She began her psychology career working in clinical trials, transitioned into academic research in mental health, and subsequently practiced as a clinical psychologist. With a PhD in Cognitive Neuropsychiatry, Heather leverages her deep understanding of the brain to comprehend human behaviour. She creates bespoke psychological models and adeptly translates theoretical concepts into real-world applications.

She brings a unique perspective to stakeholder requirements and ensures that cultural, societal, and individual values are considered to foster beneficial outcomes. Using her broad expertise in experimental research and ethical training, she advises on the ethical principles in human research and AI development.

By emphasising the importance of the human element in systems, Heather guarantees that user perspectives are integral to the development and deployment of new technologies and brings a unique and invaluable perspective to every project.

Dr Emma Bradford
Principal Consultant

As a forensic psychologist who specialises in socio-cybersecurity and the psychology of AI, Emma has acted as a subject matter expert on a wide range of projects exploring the utility, feasibility and desirability of behavioural analytic approaches and AI in different contexts. This includes looking at the use of behavioural analytics within UK National Security (page 21).

Emma's work promotes the importance of people and process factors in traditionally technology-focused arenas and ensures that the human in the system is considered at every level of tool development and deployment. She has a deep commitment to fostering ethical practices in AI development and deployment, and has created frameworks, advised policies and developed learning aids to ensure technological advancements are aligned with societal values and promote positive outcomes for stakeholders.

By working closely with stakeholders from across multiple different industry sectors, Emma has delivered bespoke products, recommendations, and strategic direction to private and public sector organisations, both nationally and internationally.

Human insider vulnerability

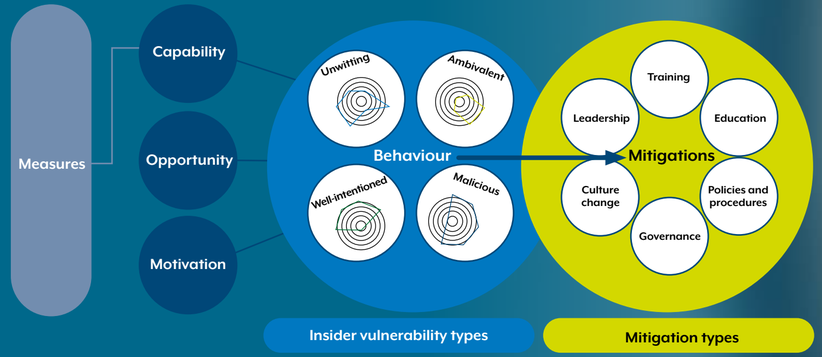
Most organisations routinely take steps to protect their assets from external threats – but a large proportion of attacks on technology, property or resources come from the inside, not the outside. Understanding why an attack might happen is just as important as understanding how it might happen.

Insider attacks can have devastating effects – In the financial services sector, the average loss in the US is reported to be $750,000 (£500,000) per insider attack, with the real cost often being much higher. In the security and defence arena, an insider attack can obtain restricted knowledge, inflict serious injury to personnel or even prove fatal.

Our Human Insider Vulnerability Evaluation (HIVE) model indicates a potential insider vulnerability and identifies the most suitable mitigation for an individual to reduce internal security vulnerabilities to organisations.

We differentiate between types of insider, moving beyond traditional assumptions that all insiders are either malicious or naïve. The types of insider vulnerability were identified using the capability, opportunity, and motivation behavioural model by looking at the drivers of human behaviour. In turn, this allows the most appropriate mitigations to be identified depending on the insider vulnerability type and the underlying risks associated with combinations of behavioural drivers.

The links between capability, opportunity and motivation are identified and how, when combined, they manifest behaviourally with relation to insider actions. A range of different measures were then developed to elicit information from an individual for each of the 3 underlying factors and determine the most appropriate assessments which would define the risk profile for each insider actor type and the identified tailored mitigations.



Our model allows organisations to identify and address human vulnerabilities before they are exploited.

Behavioural considerations of AI

AI technology is developing at high speed, transforming many aspects of modern life. It is embedded in applications that we take for granted, influencing our behaviour without realising it.

Our client is developing their AI strategy, and they are keen to understand the behavioural impact of AI use. This will ensure that their AI technology aligns with human values, respects ethical principles, and contributes positively to both the client and society as a whole.

Through an evidence-based consideration of the associated ethical and security implications, and factors related to AI usability and trust, we created a considerations framework to assess AI concepts. This framework ensures that behavioural factors are considered throughout the development, deployment, and evaluation stages, encouraging a holistic assessment of the risks and benefits of AI use.

We have also evaluated human interaction with AI from a user experience(UX) perspective with insights gathered from SMEs through workshops, interviews, and cognitive/heuristic walkthroughs. For instance, these techniques provided a deep understanding of the typical tasks undertaken during cyber-attack scenarios, revealing not only the actions taken but also the reasons behind them.

Our UX research results in user personas and journey maps that illustrate the needs and goals of users, highlighting opportunities to meet these needs or eliminate barriers. These insights are then used to develop prototype interface designs, which are tested with users to ensure they fulfil task requirements.

By incorporating user experience and insights into AI technology, we ensure that the systems are user-centric, fostering trust and effectiveness in real-world applications.

Human factors engineering

Human factors engineering is focused on how systems work in practice, with real, and fallible, human beings at the controls. It integrates principles from engineering, design, social sciences and physiology to understand how people interact with systems and their surroundings to design systems, products, and environments that optimise human well-being and overall system performance.

Our aim is to enhance safety, effectiveness and efficiency by integrating design elements to minimise human error, mitigate hazards and improve efficiency through:

- **Ergonomics:** Designing workspaces, tools, and equipment to fit the human body and its movements, reducing strain and injury while improving comfort and productivity.
- **Safety engineering:** Identifying and mitigating potential hazards in system design to prevent accidents and injuries, enhancing overall safety.
- **Human-system interaction:** Examining and optimising the ways in which humans interact with machines and technology, ensuring these interactions are efficient and error-free.
- **Environmental design:** Creating physical environments that support human performance, including factors such as lighting, noise, temperature, and workspace layout.
- **Human-centred design:** Focusing on creating systems and products that accommodate human abilities, limitations, and preferences, ensuring they are intuitive and effective for users.

Integrating human capabilities and limitations into the design of tools, processes, and environments, reduces the risk of accidents and errors, thereby enhancing workplace safety. This is especially vital in high-stakes industries such as aerospace, healthcare, nuclear and manufacturing, where mistakes can have severe consequences.

By ensuring that systems are designed with human factors in mind, industries can achieve higher reliability and resilience, ultimately leading to better performance and sustainability.

Gordon Bisset
Managing Consultant

Gordon is a Chartered Ergonomist and Human Factors Specialist with experience across many highly regulated industries, bringing nearly two decades of expertise to his field. He has worked extensively with clients, providing expert guidance on embedding user-centred design principles, and applying Human Factors Integration (HFI) methods within complex programmes to ensure that the needs of end users are satisfied.

Gordon possesses a deep understanding of the intricate relationship of the human role within complex systems and systematically considers and analyses the physical, psychological, behavioural and environmental needs of end users. This allows systems to be optimised to maximise human performance, thereby enhancing operational effectiveness and improving user and system safety.

Mavra Manaf
Senior Engineer

Mavra pursued a Bsc in Neuroscience at Cardiff University to explore her interest in understanding how the human brain functions and its impact on human behaviour. To further apply her knowledge, she then completed an MSc in Human Factors and Ergonomics at the University of Nottingham, which allowed her to understand the theories behind user-centric design within aspects of systems engineering, human-computer systems, and medical device design and regulation.

Within Frazer-Nash, Mavra brings her HF knowledge to bear in multi-disciplinary project teams primarily applying HFI methods across defence and nuclear sectors. Over the past two years, Mavra has supported Hinkley Point C (HPC) and is currently leading the definition of HFI activities for the commissioning of the Main Control Room (MCR). Such activities include workspace and layout assessment, environmental assessments and Human Machine Interface (HMI) and Human Computer Interface (HCI) assessments. Mavra has also completed HF reviews of commissioning procedures and applied HMI/HCI design principles to support design reviews, assist development teams and optimise overall user interaction.

Ensuring operator reliability and feasibility

Hinkley Point C (HPC) will be the first new nuclear power plant in the UK for over 30 years and consists of two nuclear reactors that will provide 3.2GWe of zero-carbon electricity for around six million homes.

Each reactor is controlled from a main control room that brings together the hundreds of different control systems, instrumentation and information necessary to safely manage the reactor operation.

Integrating Human Factors (HF) into all aspects of the design and development of HPC is essential as it ensures that all information is clearly and easily accessible to the operators, maximising the reliability and feasibility of operator actions during safety-critical events.

We have played an integral role in delivering the human factors integration requirements for HPC over the past four years. This includes:

- HF assessments to support the commissioning and pre-operations teams.
- Developing the HPC main control room HF commissioning strategy, which defines the HF assessments that need to be conducted as part of the as-built Verification and Validation (V&V) process.
- Environmental assessments, workspace and layout assessments, and V&V of the Human Machine Interfaces (HMIs) through observational studies.
- Human reliability assessments to substantiate the feasibility of operator actions during safety-critical events to ensure that operational safety measures are appropriately considered and implemented.
- Procedural documentation, staffing and training to align HF good practice to the commissioning and operations, and facilitate the identification of HF issues on the plant.

Image copyright EDF

An exact replica of the main control room is a core part of the HPC Simulator and Training Centre, which is being used to train operatives in how to control and maintain the reactors.

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Rail Operations Weather Service (ROWS)

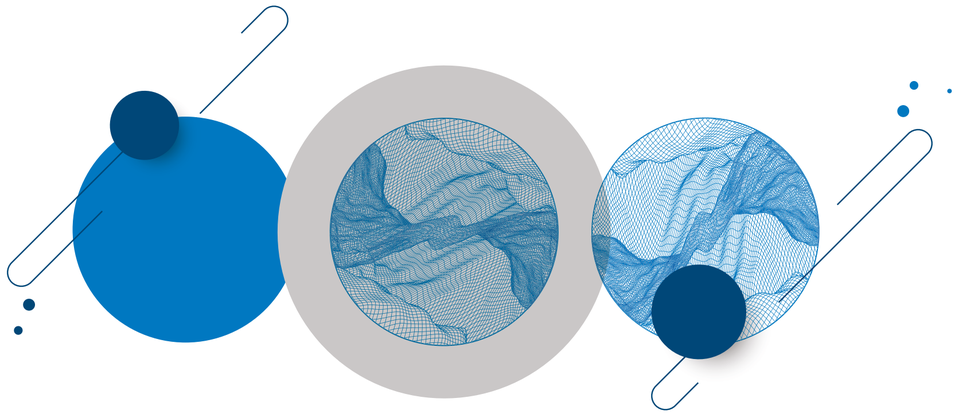
Weather is a constant source of challenge for the UK rail network from floods, snow and ice to extreme heat. As part of Network Rail's weather resilience and climate change adaptation strategy, they are developing tools, processes and support to help routes run a better service during adverse and extreme weather.

Before 03:00 every day, Network Rail receive detailed weather forecasts and alerts for routes and local areas. Their bespoke weather forecasting service allows the route operations teams to plan and respond to incidents that could affect rail travel.

A new Rail Operations Weather Service (ROWS) is being developed to improve the quality of weather information and support UK rail operations staff in managing weather related risk. The Human-Computer Interface (HCI) with the ROWS software is fundamental to ensuring that staff can access, visualise and make decisions reliably and quickly.

As part of the software development process, our human factors experts have worked with Network Rail to understand users' needs and capabilities using an evidence-based approach and provide a formal assessment of the user goals and decision-making. Rigorous task analysis methods, user engagement, and coordination with the development team ensure effective and efficient user performance.

Our ongoing support will focus on the emerging system design to identify possible sources, and consequences, of user error, with the aim to mitigate these within the design and so reduce in-service risk and disruption.



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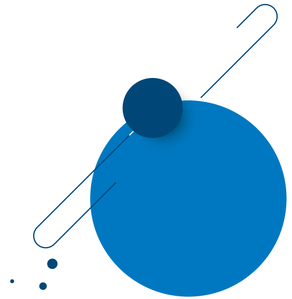

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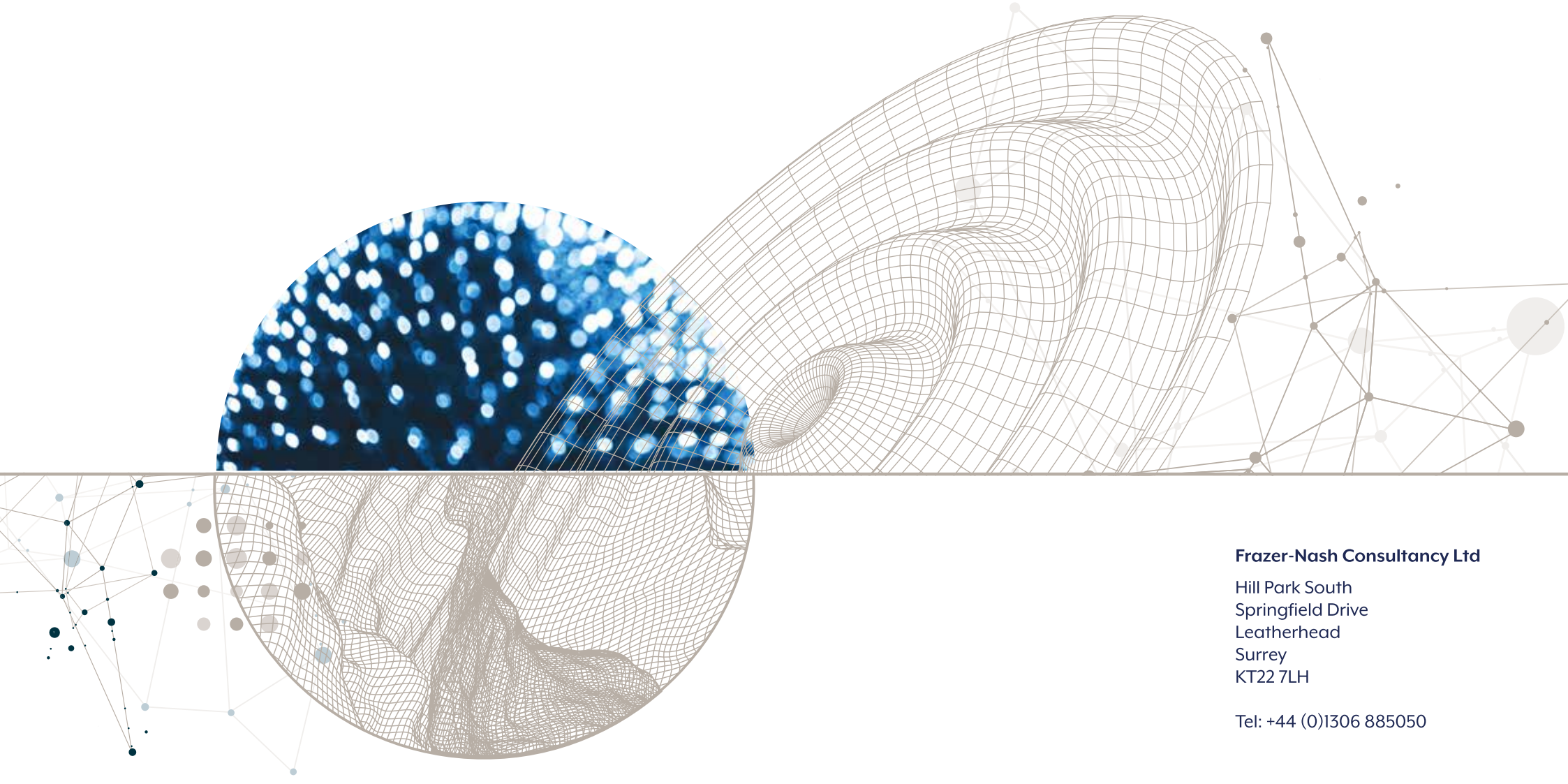

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