STRATEGIC CONTEXT
& FUTURE OPPORTUNITIES

Science & Technology Facilities Council

UK Research and Innovation

Our vision

Discovering the secrets of the Universe
Developing advanced technologies
Solving real-world challenges

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UK Research and Innovation brings together nine Councils including the Science and Technology Facilities Council into a single organisation that aims to ensure the UK maintains its world-leading position in research and innovation. For more information visit: www.ukri.org

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Introduction

Science, research and innovation lie at the heart of the UK's continuing prosperity. The ability to innovate – to develop new ideas and make them useful – is central to government's industrial strategy and is critical to the mission of our new organisation, UK Research and Innovation. Whilst the UK is a global leader in science and research, we know that we must do more to translate research into practical applications and exploitable outcomes, as a route to greater economic impact and social prosperity and this will be the focus of UK Research and Innovation's first strategy.

The world is experiencing exceptional change economically, politically, socially and in our natural environment. The worlds of science and business are changing too, with new tools and new approaches often requiring a fusion of physical, digital, chemical and biological technologies. Addressing global pressures such as population growth, climate breakdown and the rapid spread of infectious diseases increasingly demands inter- or multidisciplinary approaches, sometimes involving expertise from across the research and business communities. In creating UK Research and Innovation, the government has brought together the seven UK Research Councils, Innovate UK and Research England, to combine their great individual strengths, develop an improved system that will be greater than the sum of its parts and focus collective effort on these 21st century challenges.

However UK Research and Innovation can only contribute to economic growth and a more sustainable society if we actively push the frontiers of human understanding.

UK Research and Innovation

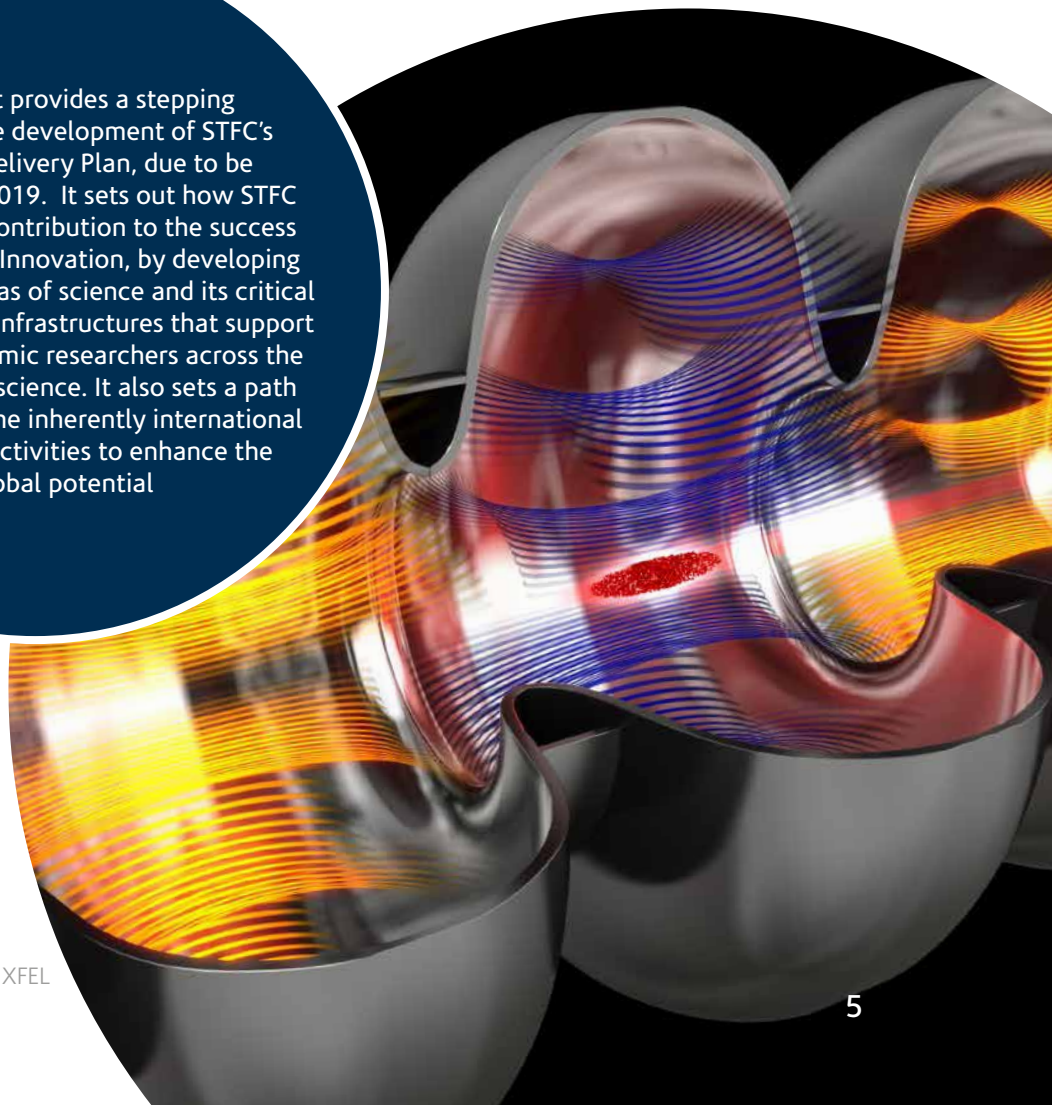
UK Research and Innovation brings together the seven UK Research Councils, Innovate UK and Research England with the mission to work with our partners to ensure that world leading research and innovation continues to flourish in the UK. We are proud to be a member of the family and will support and help to connect the best researchers and innovators. We will invest every pound of taxpayers' money wisely in a way that generates excellent scientific and societal outcomes and ultimately impact for citizens, in the UK and across the world.

Credit: Dreamstime.com

As one of the nine bodies of UK Research and Innovation, STFC must play an important role in this effort. Its research seeks to understand the Universe from the largest astronomical scales to the tiniest constituents of matter, yet creates impact on a very tangible, human scale. From cancer treatment to airport security, high-tech jobs to hydrogen-powered cars, energy generation to accident-scene emergency care, its impact is felt across and beyond the UK in many aspects of daily life.

The formation of UK Research and Innovation provides many opportunities for STFC to contribute more and these are developed in UK Research and Innovation's Strategic Prospectus. As a first step to making the most of these opportunities, STFC working with its community has reflected on its achievements since 2010 and explored how it might more fundamentally review its approach. Important themes that run through UK Research and Innovation include increasing the emphasis on multidisciplinarity and stronger collaboration with academic and industrial partners. The intention is to work with all parts of UK Research and Innovation and its community to develop an ambitious direction of travel for publication in STFC's Strategic Delivery Plan. This document provides some strategic context and ideas for how this might be achieved.

This document provides a stepping stone towards the development of STFC's first Strategic Delivery Plan, due to be published early in 2019. It sets out how STFC can make a major contribution to the success of UK Research and Innovation, by developing and exploiting its areas of science and its critical large-scale research infrastructures that support industrial and academic researchers across the whole spectrum of science. It also sets a path for capitalising on the inherently international nature of STFC's activities to enhance the UK's global potential



Credit: XFEL

Our approach

This document sets the context for the transition to UK Research and Innovation, outlining the individual and collective contribution STFC brings to make this new organisation greater than the sum of its parts. It builds upon STFC's Corporate Strategy, published in 2010, reflects STFC's progress as an organisation and responds to the rapidly changing external environment.

STFC's contribution begins with our science which sets out to resolve some of the most ambitious and challenging scientific questions facing the world today, such as 'How did the Universe begin and evolve?', 'How do stars and planetary systems develop?' and 'Is life unique to our planet?' To respond to these questions, STFC develops and exploits frontier research in particle physics, astronomy, nuclear physics and space science through activities at UK universities and in its national laboratories, and working internationally through a wide range of long-term collaborative research projects.

The UK enjoys excellent international standing in these disciplines through technological and scientific leadership built up over many years. Progress increasingly relies on sophisticated experiments at a range of large-scale bespoke facilities, often at the leading edge of what is technically possible. STFC uses those same skills to plan, design, construct and provide world-leading multidisciplinary facilities used by academic and industrial researchers across the whole spectrum of science and often funded by UK Research and Innovation Councils. This inventive technology and new instrumentation, opening up new ways to investigate matter, enables Nobel Prize winning discoveries and attracts world-leading researchers to the UK.

The government has set an ambition for the UK to become the world's most innovative economy. In support of this ambition, it has committed to raising total investment in R&D to 2.4% of GDP by 2027. Central to this commitment and ambition, is ensuring the UK remains a world leader in global science and innovation. The UK can only remain world class if we are international in outlook. We must also raise our game, capturing more value for the UK from its excellent science, ideas and innovations and ensuring that we derive maximum impact from the public funding that we invest.

In response, STFC has updated its vision, to better reflect the distinctive capabilities and the contribution it brings to UK science, research and innovation.

Discovering the secrets of the Universe
Developing advanced technologies
Solving real-world challenges

Credit: ESS/Team HLA

In order to expand the frontiers of human knowledge and pursue the fundamental scientific challenges of our time, STFC operates at the leading edge of technological and engineering possibilities, typically collaborating with partners across the globe. STFC is committed to operating and further developing its portfolio of world-class facilities, working with and supporting the other Councils of UK Research and Innovation, to create the best environment for research and innovation in the UK.

STFC develops UK-based skills and expertise and, working in collaboration with the other Councils of UKRI, translates research into practical applications and exploitable outcomes that address the most important industrial and societal challenges of our time. Through university partner institutions, national laboratories, and research and innovation campuses, STFC creates new jobs and innovative businesses, delivering economic impact and supporting balanced growth across the UK.

STFC's science also creates significant social and cultural impact. Exploring the first moments of the Universe, measuring collisions between black holes and providing the tools to delve into the deep structure of matter are exciting quests that engage the public and inspire the scientists, technologists and engineers of the future. The facilities and technology are used by academic and industrial researchers across the whole spectrum of science, enriching society, improving health outcomes, increasing resilience and sustainability.

STFC's Strategy, published in 2010, established the enduring long-term strategic goals – world-class research; world-class innovation; and world-class skills. It also set out six strategic themes, intended to influence the focus of delivery. It was recognised that these themes would need to change over time to reflect progress and shifts in the external environment.

To more accurately reflect STFC's distinctive contribution to UK Research and Innovation, three new strategic themes have been developed: data-intensive science; research and innovation campuses; and developing advanced technologies. Developed collaboratively with staff, advisory bodies and our community, these new themes complement the existing themes – building international influence; solutions for 21st century challenges; and inspiring and involving. The latter were already well aligned to the priorities of UK Research and Innovation.

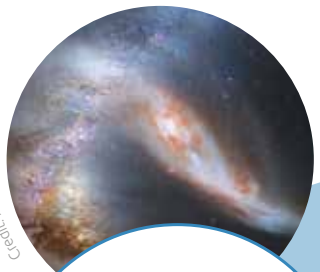
Underpinning STFC's ability to deliver and play a major role in making UK Research and Innovation greater than the sum of its parts are three strategic enablers, ensuring that we use the collective resources across the entire research an innovation community to generate maximum scientific, economic, social and cultural impact.

About STFC

What we do and where we operate

STFC was created in 2007 as an inherently multidisciplinary science organisation. We deliver our mission through three long-term strategic programmes, operate at six sites across the UK (see map on page 9) and are involved in international collaborations on a global scale (see map on pages 12-13).

Our three, interrelated, long-term strategic programmes are underpinned by five world-leading capabilities in technology and computing infrastructure:



Frontier research: Developing and exploiting a world-leading programme of particle physics, astronomy, nuclear physics and space science supports research, innovation and skills development at our partner universities and research institutes and through a range of international facilities.

Scientific facilities: Planning, designing, constructing and providing stewardship for world-leading, large-scale facilities used by academic and industrial researchers, enabling and driving research, innovation and skills training to deliver multidisciplinary research priorities and help address industrial and societal challenges such as those in energy, healthcare, security and climate science.

National research and innovation campuses: Built around our UK facilities and laboratories, these are hubs for academic and industrial collaboration on research, technology and skills, fostering innovation, growth and jobs.

Detectors and instrumentation

Accelerators

Specialist engineering

Optics

e-infrastructure

These five capabilities, which are essential to enabling and tying together all other aspects of our programme, cannot be cost-effectively and reliably procured on the open market. They give the UK a competitive edge in participating in the highest-priority international projects, with our laboratory staff and teams in universities playing a key role in building novel technology. They allow us to design and build facilities that play an essential role in the multidisciplinary work of the other UK Research and Innovation Councils and that others emulate around the globe. Our specialist expertise makes the UK a partner of choice for both international collaborative projects and commercial contracts.

STFC's UK sites

We work with around 1,800 researchers in the external community to deliver advances in frontier research that address fundamental questions about the Universe. This sector of our community – spanning the academic fields of particle physics, nuclear physics, astronomy and space science, which are the core areas of our science – work at more than 50 universities and research institutes across the UK. As well as designing and running experiments, making observations and analysing data ,they undertake R&D in our five underpinning capabilities that are fundamental to the development and exploitation of our frontier research programme. In addition, staff at our laboratories make major contributions to the development of these technologies and their broader exploitation in the design, construction and operation of our multidisciplinary facilities that play a crucial role in the multidisciplinary work of all UK Research and Innovation Councils.

Our community

Our thriving community, over 6,000 strong, includes the academic researchers that we fund, the academic, industrial and international users of our facilities who are often funded by UK Research and Innovation Councils, and STFC's own employees. Many people feature in more than one of these groups, for example we share joint appointments with universities and many of our staff hold visiting professorships. The synergies that result are vital to our success.

Progress in our core areas of science increasingly relies on sophisticated experiments at a range of large-scale custom-built mission-based facilities, such as the LHC at CERN, involving challenging technology and often at the leading edge of what is possible. We use the same skills and technology to plan, design, construct and provide stewardship for a range of world-leading, large-scale multidisciplinary facilities - such as Diamond, ISIS and CLF - used by academic and industrial researchers across the whole spectrum of research and innovation, from physics to chemistry, engineering to biology, the environment to archaeology. These multidisciplinary facilities are custom-built – using synchrotron X-rays, neutrons and lasers to solve industrial and academic multidisciplinary challenges across the remit of UK Research and Innovation.

The conception, development and operation of all these cutting-edge facilities are typically long-term, collaborative endeavours that demand creativity and inventiveness and in turn drive academic and industrial innovation. For example, in the next 10 years, the SKA will require us to handle data volumes, provide high-performance computing and design software that are thousands of times beyond the world's current capability. Such apparently incredible demands on technology – including novel requirements for detection systems, instrumentation and computational analysis – mean that research infrastructure projects take decades of meticulous planning, investment and execution.

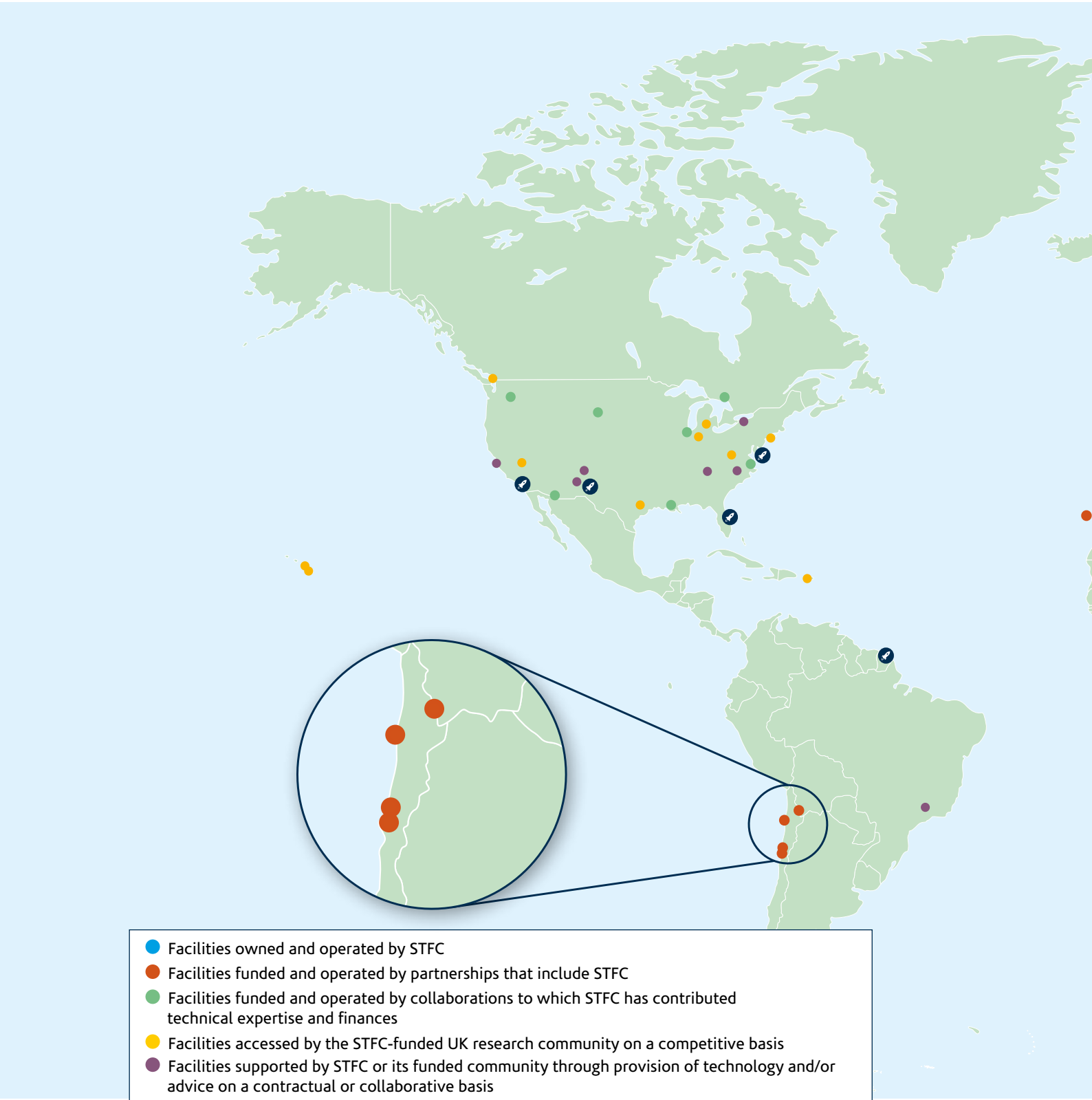
Although the SKA requirements seem unfeasible today – as did those of the LHC when the project was first approved – addressing challenges on this scale is why STFC exists and our experience and capabilities help to maintain the UK's scientific leadership.

Providing the necessary science and innovation infrastructure for the nation's researchers is critical to UK Research and Innovation's mission. As a first step, it is developing a research and innovation roadmap to understand the current and future potential capability. This is a challenging task and will offer enormous benefit in planning more strategically for the future. STFC's Executive Chair is leading this important project on behalf of the nine UK Research and Innovation Councils.

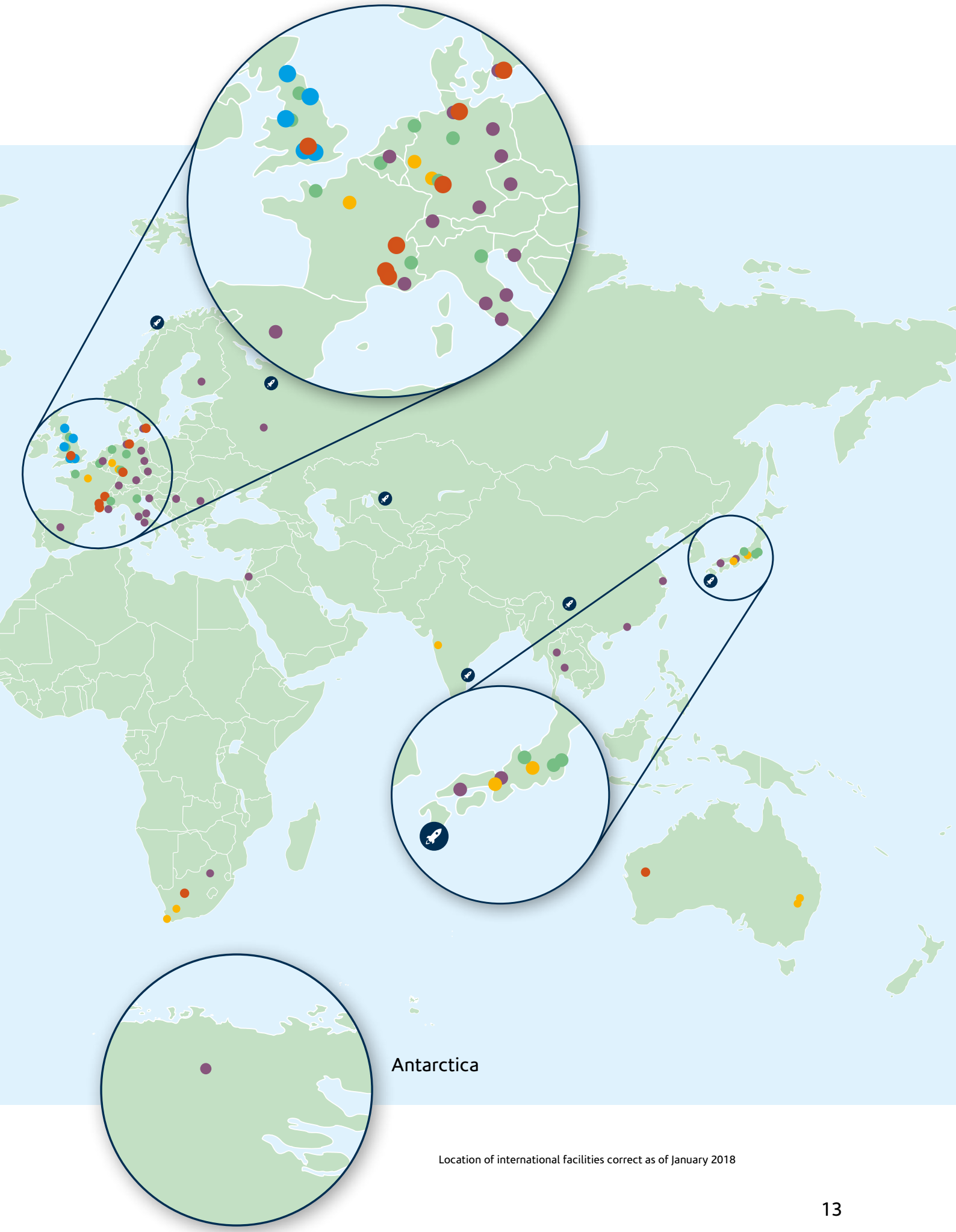
As a foundation for this work, STFC has mapped the range and global reach of the facilities it supports (see map on pages 12-13). The facilities, which are sited in over 60 locations spread across 17 individual countries, include those that we own and operate, those we develop in partnership and those where we contribute technical expertise to benefit the health of the global research community.

Credit: Credit: ESRF/D. MOREL

STFC's global reach



- Facilities owned and operated by STFC
- Facilities funded and operated by partnerships that include STFC
- Facilities funded and operated by collaborations to which STFC has contributed technical expertise and finances
- Facilities accessed by the STFC-funded UK research community on a competitive basis
- Facilities supported by STFC or its funded community through provision of technology and/or advice on a contractual or collaborative basis
- Launch facilities for space missions carrying scientific equipment developed by STFC or its funded community



Location of international facilities correct as of January 2018

STFC's achievements

2017 marked a decade since STFC's formation. We have been at the forefront of some of the most important discoveries of the 21st century. Here are just a few of our achievements...

2007

- STFC is formed through the merger of PPARC and CCLRC.

2008

- Diamond Light Source opens with its first 7 beamlines.
- Research and innovation campuses are launched by by government.

2012

- Discovery of the Higgs boson at CERN in experiments designed, run and supported by STFC staff and STFC-funded scientists from UK universities.
- The UK's DiRAC supercomputing facility is upgraded, improving the exploitation of observational and experimental facilities for physics and astronomy.
- STFC's OCTOPUS laser facility provides a breakthrough in understanding a biological process that causes common cancers.

2013

- An STFC-led international collaboration delivers the MIRI instrument to NASA to form part of the James Webb Space Telescope.
- The Hartree Centre is founded in collaboration with IBM to accelerate adoption of data-centric computing by industry.
- UK astronomers, supported by STFC, play a leading role in the discovery of 11 exoplanets.

2015

- The UK secures the global headquarters of the SKA project, to be located at Jodrell Bank.
- STFC spin-out Cobalt Light Systems develops an airport -security liquid scanner and wins the Queen's Award for Enterprise.
- Rosetta becomes the first spacecraft to successfully rendezvous with a comet – STFC funded UK participation and designed Ptolemy, one of the Philae lander's instruments.

2016

- STFC-funded researchers involved in the Nobel prize-winning experiment at SNO on neutrino science.
- STFC designs and builds the most powerful laser in the world for the HiLASE project.
- First detection of gravitational waves is announced, supported by STFC technology and STFC-funded scientists from UK universities.

THE FUTURE...

2019-2030

- First results from DUNE.
- The SKA begins delivering results.
- 2021: Launch of the James Webb Space Telescope.
- 2024: The ELT, begins operation.
- 2025: The High-Luminosity LHC at CERN begins operation.

2018

- Diamond Light Source Phase III is completed: 32 beamlines are now operational.

2009

- The LHC comes into operation at CERN – through STFC the UK was one of 11 countries involved in its design, development and construction.
- ISIS Target Station 2 is completed on time and to budget, providing 7 new neutron instruments

2010

- The Research Complex at Harwell officially opens, a multidisciplinary laboratory for cutting-edge research in physical and life sciences.

2011

- £500 million in economic benefit is realised through long-standing collaborations with Oxford Instruments and e2v.
- Research using ISIS's Engin-X instrument enables 5-year extension of the life of two nuclear power stations.
- ESA selects the Harwell Campus to host its first UK Business Incubation Centre.

- Discovery that atomic nuclei can be 'pear-shaped' in research at CERN, co-funded by STFC.
- Professor Peter Higgs shares the Nobel Prize for Physics for his part in the discovery of the Higgs boson.
- A new methodology is developed to produce a non-infectious vaccine for the foot-and-mouth virus, based on research at Diamond Light Source.

2014

- UK announces its intention to become a full member of the European XFEL project
- The ALMA Observatory, one of the world's largest ground-based astronomical projects, becomes fully operational.
- STFC spin-out KEIT Ltd improves manufacturing processes based on technology developed to measure water vapour on Mars.

2017

- STFC engineers deliver the first piece of prototype equipment to the ESS in Sweden, which will become the world's most powerful neutron source.
- Cryo-electron microscopy transforms structural biology, based on sensors developed by STFC.
- STFC spin-out The Electrospinning Company becomes a leading provider of clinical-grade electrospun biomaterials for the medical device industry.

- A Nobel Prize for Chemistry is awarded for work on cryo-electron microscopy, drawing on sensor development with STFC.
- A Nobel Prize for Physics is awarded for the detection of gravitational waves, drawing on technology and research developed and supported by STFC.
- ISIS instrument ChipIR comes online, offering new capabilities for the electronics industry to test vulnerability against cosmic rays.

Strategic goals

We will realise our vision through our three strategic goals of world-class research, world-class innovation and world-class skills; these enduring goals define our core business.

Credit: Diamond Light Source

Strategic goals

World-class research

With three Nobel Prizes recently resulting from our science and technology programmes, our frontier science disciplines regularly ranking highly in global citations and a strong tradition of developing ground-breaking research infrastructures that other nations strive to emulate, our research programmes are truly world class. We will continue to provide the foundation and enhance the UK's capability to achieve long-term impact – producing new understanding of the structure and origins of the world around us and the Universe beyond, and addressing the multidisciplinary challenges of the 21st century.

Ambition

Sustain the UK as a globally leading nation in research to understand the Universe, and provide the world-leading single-discipline and multidisciplinary facilities that support the UK's international research status across the whole spectrum of research.

Key objectives

- As part of UK Research and Innovation, STFC will ensure access to the large research infrastructure needed to support the country's leading international research status and programmes, including the rapidly advancing science of free-electron lasers.
- Continue to focus STFC's vibrant frontier research programme on the highest-priority projects in particle physics, astronomy and nuclear physics while positioning the UK to complement global science strategy and lead the next big inspirational initiatives.
- Continue to invest strategically in our world-leading programme in data-intensive science and skills, increasingly needed to support our scientific programme and facilities.
- Invest in the underpinning technologies required across our programme and facilities to maintain leading-edge capabilities for use by STFC and the wider UK Research and Innovation community.

Context

Research is at the heart of everything we do. We deliver a world-leading long-term programme of strategic frontier research that seeks to understand the Universe from the largest astronomical scale to the tiniest constituents of matter, addressing four key questions: how did the Universe begin and how is it evolving; how do stars and planetary systems develop and is life unique to our planet; what are the fundamental constituents and fabric of the Universe and how do they interact; and how can we explore and understand the extremes of the Universe? STFC's investment consistently delivers some of the most technically challenging instrumentation and missions ever undertaken to resolve these most ambitious and demanding science questions, from finding the Higgs boson, to landing a space probe on the surface of a comet, to the searches for the dark energy driving the acceleration of the Universe and the first detection of gravitational waves predicted by Einstein. STFC's strategic approach has helped to establish the UK's leading position in our areas of research.

STFC's mission to provide access to the world-leading infrastructure needed by UK researchers is a core contribution to this frontier science endeavour. Progress in these fields increasingly relies on sophisticated experiments at a wide range of large-scale bespoke facilities such as those at CERN, FAIR and ESO. We use those same skills to design, build and operate national multidisciplinary

facilities – the ISIS Neutron and Muon Source, the CLF and Diamond Light Source – that are proving vital for researchers across a wide range of research fields. We also fund UK access to complementary facilities worldwide, such as ESRF and ILL. These enable researchers to explore and understand the structure of the world around us – from the most advanced materials science for future development in the aerospace industry to the most fundamental processes governing life, health and wellbeing.

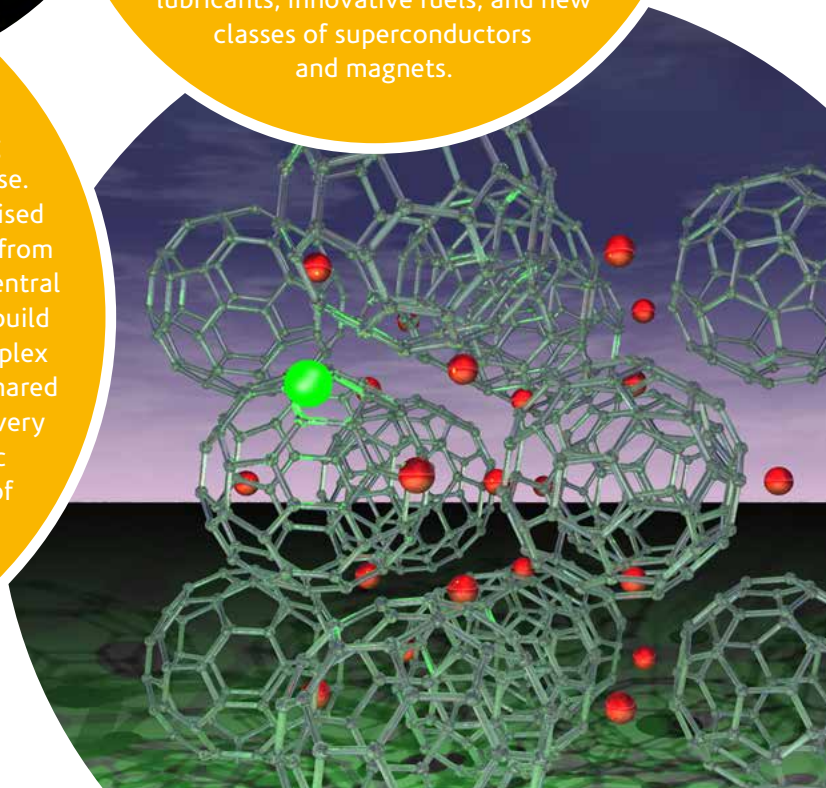
By working with our community to keep the UK at the cutting edge, during the next 10 years STFC will lead the UK's participation in an internationally leading, data-intensive, research programme of the highest quality. In particular, we will lead the UK's participation in five major new international facilities: the XFEL in Germany, the ESS in Sweden, the SKA in South Africa and Australia, the ELT in Chile and DUNE in the USA. We will also take the lead in planning future large-scale UK facilities designed to address the highest-priority research challenges, including the rapidly advancing science of free-electron lasers.

Collectively, these national and international capabilities help meet key priorities of the other Councils and partners in UK Research and Innovation, including universities, industry, charities and government departments, providing the UK with the world-class infrastructure and data capabilities needed to support productive, multidisciplinary and multinational collaborations.

Credit: CERN

In July 2012, British researchers at CERN confirmed they had found the Higgs boson, marking a significant breakthrough in our understanding of the fundamental laws that govern the Universe. The existence of the particle was originally theorised by Professor Peter Higgs. Scientists and engineers from – and funded by – STFC enabled the UK to play a central role in this discovery, contributing to the design, build and exploitation of the LHC, one of the most complex scientific instruments ever built. Professor Higgs shared the Nobel Prize for Physics in 2013 and the discovery was a global media event securing huge public interest. As well as advancing our knowledge of the Universe, UK industry wins an average of £25 million every year in contracts from CERN.

ISIS has delivered at least £1.4 billion in net economic impact, based on the research carried out up to 2014, and has already paid for itself twice over. This facility supports several thousand scientists for research in physics, chemistry, materials science, engineering and biology. The structure of buckyballs – carbon structures called fullerenes – was first determined at ISIS in the 1990s and these are now a significant component in high-performance lubricants, innovative fuels, and new classes of superconductors and magnets.



Strategic goals

World-class innovation

Novel products for industry, new ventures, clusters of high-growth businesses with huge potential benefits – these all come about from harnessing the innovative capacity of STFC's programmes. By delivering world-leading science facilities for extraordinary industrial and academic research, translating discoveries into practical applications and exploitable outcomes, and developing our research and innovation campuses, STFC plays a key role in mobilising the UK's inventive capacity, creating high-value jobs and high-technology businesses.

Ambition

Deliver a step change in our support for innovation, catalysing outcomes so that STFC's community is recognised as much for innovation as it already is for research.

Key objectives

- Forge collaborations with leading businesses, Innovate UK and other partners, to address scientific and industrial challenges to drive productivity and growth.
- Further increase our contribution to innovation in the UK by identifying, supporting and realising opportunities and exploitable outcomes across our programmes.
- Enhance the role of our research and innovation campuses, key UK Research and Innovation assets for delivering local and national growth, growing clusters of high-tech international businesses.

Context

Since our first Strategy was published in 2010, establishing World-Class Innovation as one of our three overarching goals, we have made great strides in ensuring that the innovative capacity of our science programmes, research facilities and campuses supports the growth of the UK economy. Our annual Impact Report demonstrates the progress we are making.

Through the multifaceted nature of our science and research programmes we have developed a range of approaches and support mechanisms to actively enhance and drive innovation, in all its forms. Companies are using ISIS to help determine whether their critical electronic components could be adversely affected by cosmic rays by accessing a new dedicated beamline. We develop advanced technology to tackle the challenges of frontier research, which can be applied to challenges in other sectors; for example, technology originally developed by the West of Scotland and Glasgow Universities for detecting gravitational waves has since been applied to grow new bone by vibrating stem cells, work that also received funding from EPSRC and BBSRC We also dedicate funding and translational activities to respond directly to the challenges of the 21st century: for example, by harnessing the power of IBM Watson cognitive computing technology we have developed a cognitive advisor for Alder Hey Children's Hospital which is currently available through the Alder Play app and hospital website to way-find and provide information to patients thorough a chat interface.

We support innovation from the very early stages, fostering novel ideas and spinning-out new ventures. Our business incubator programmes provide tailored support to meet the needs of start-up enterprises, with over 100 companies in sectors such as biomedicine, energy and security having benefitted in the last six years. In addition, we play an important role in promoting opportunities for UK companies to win commercial contracts from

international science facilities and organisations, such as ESO, CERN, ESRF and ILL, ensuring a return for UK businesses from government's global investments. Over the past 10 years, UK companies have won over £220 million in contracts from our international facilities and collaborations.

Our ambition is to deliver far more. We have created three new themes in this strategy to drive our focus on world-class innovation: the first to improve the application of our advanced technology to business challenges; the second to use the power of data-intensive science to enhance productivity; and the third to begin the next phase of growth of our successful research and innovation campuses. We will also strengthen our partnerships with established businesses and other partners to respond to specific industrial challenges, enabling them to exploit our facilities to enhance their international competitive advantage. Together these activities will create an innovation ecosystem where new and developing high-tech companies can grow and flourish, developing better products and services utilising our advanced technology and facilities.

STFC delivers considerable impact by commercialising intellectual property and, since 2002, has created 19 new companies. Cobalt Light Systems develops award-winning technologies for non-invasive analysis of materials – based on spatially offset Raman spectroscopy, a technique invented at the CLF. The resulting products can rapidly and accurately measure chemical composition without touching or changing the sample. Applications include the rapid detection of dangerous liquids and hazardous chemicals and quality control of pharmaceuticals in closed containers and packages. Cobalt's liquid scanners are already deployed in 75 major airports and, in time, may allow the relaxation of the liquid ban in air passengers' hand luggage. A new handheld device will allow further expansion into markets such as security, border protection and emergency services. Cobalt is growing rapidly, manufactures all products in the UK and is committed to remaining on the Harwell Campus.

Scientists designing new medicines can access the XChem facility at Diamond Light Source to accelerate the process of developing novel compounds for drug discovery. This increases testing capacity by allowing 1,000 compounds to be screened in less than a week, shrinking the experimental stage from months to days. Scientists are using the facility to design new medicines for viral and bacterial infections, cancer, heart disease, diabetes and neurodegenerative conditions.

Credit: Pixabay

Strategic goals

World-class skills

Cutting-edge research, innovative technologies and world-leading facilities – these are STFC's platform for developing the highly specialised expertise vital to our science and for harnessing the capability required by the UK in the 21st century. We need a broad and sustainable multidisciplinary skills base to deliver STFC's internationally leading science and technology programmes. Securing this scientific, technical and engineering expertise in the highly competitive international market will require a new and sustained approach.

Ambition

Secure the talent needed to advance STFC's world-class research and facilities programme, sustaining the UK's position as a globally leading research and innovation nation.

Key objectives

- Ensure we have the skills needed to deliver our frontier research programme and maintain the UK's position as a globally leading nation.
- Provide the skills base to design, build, operate and exploit UK and international facilities and to keep them at the leading edge of technology.
- Identify and develop the high-tech skills, developed through our science and technology, such as in artificial intelligence, needed to maintain the UK's position at the forefront of modern science and engineering, and support government's industrial strategy.

Context

World-class research and innovation depends on the outstanding performance and contribution of UK researchers, technologists and engineers. Our three long-term strategic programmes – frontier research, scientific facilities, and national research and innovation campuses – are all dependent on the highly skilled people that we employ, train and support. Without the skills base provided by apprentices, graduates, doctoral students, post-doctoral researchers, research fellows, technologists and engineers in universities, our laboratories and national and international facilities, we would not be able to deliver our vision.

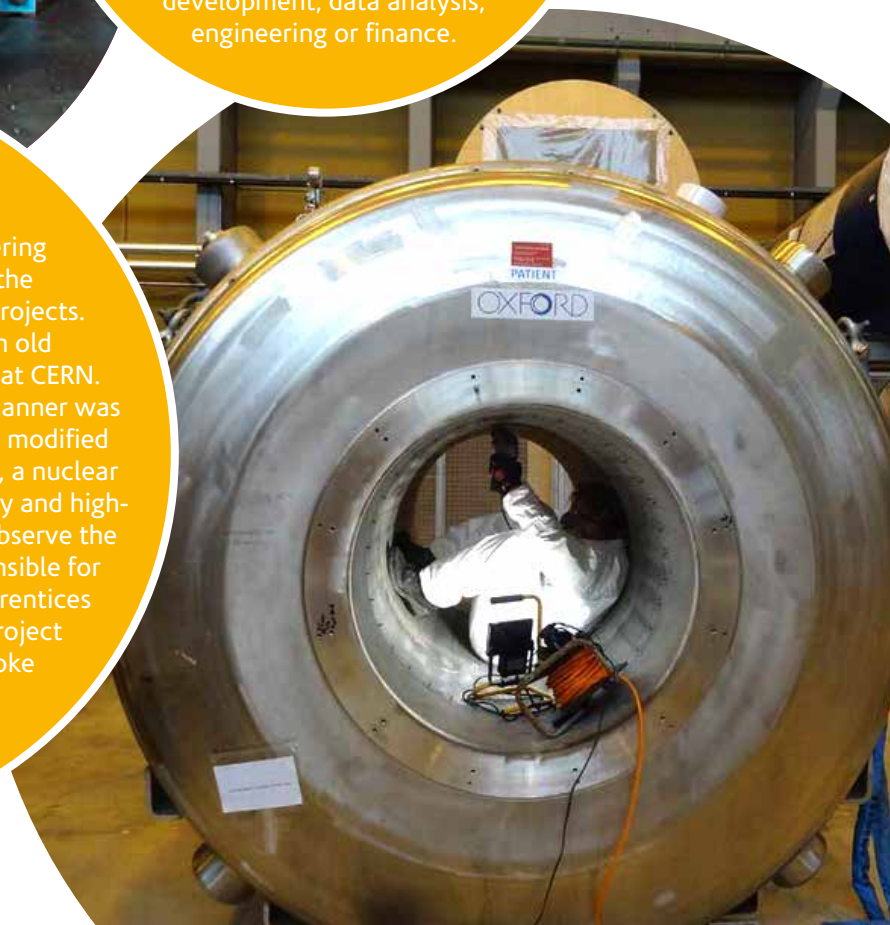
Nowhere is this more apparent than in the design, construction, operation and exploitation of large-scale world-leading facilities. Collaborations between the wider UK research community and our staff have, for example, designed and built scientific instrumentation at the heart of telescopes in the Atacama Desert, the CLF, and Advanced LIGO in the United States. Our contribution to world-leading research infrastructures does not stop there. Our teams ensure the smooth and continuous operation of the major experiments at CERN, the UK national facilities at Harwell and T2K in Japan. It requires a distinctive combination of technical, engineering, scientific and collaborative skills to deliver projects and technology on this scale.

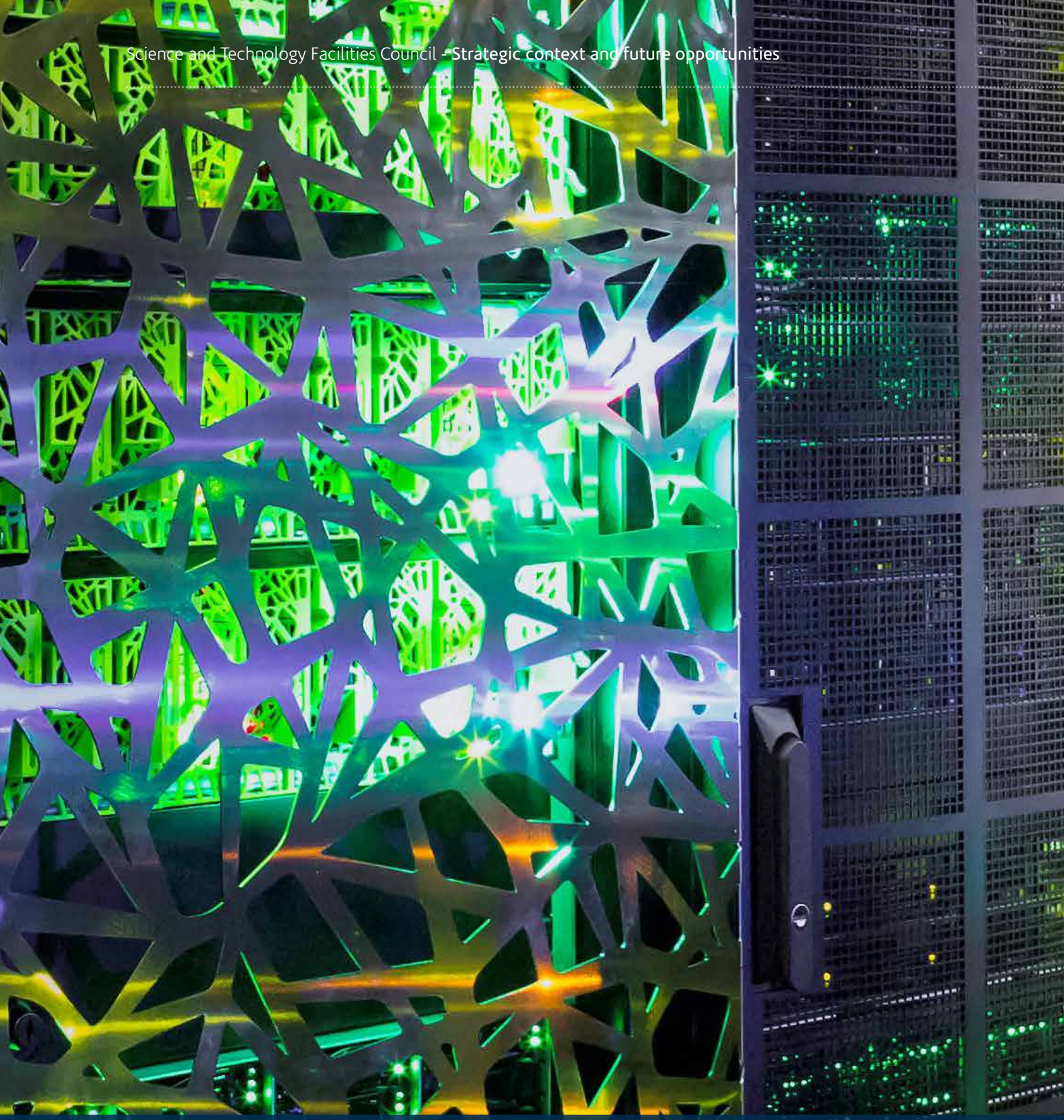
As part of UK Research and Innovation, STFC has an important role in training enough people in the UK to maintain the health of our world-leading science and technology and to support a modern industrial strategy. This is not going to be easy given the highly competitive international market for scientific, technical and engineering expertise. The growing international demand for such technical skills – particularly mechanical, electrical and software engineers plus data scientists and IT system and security specialists – is also key to the delivery of our long-term science and technology programmes. Our needs in these areas are not being met reliably through the open market and we need to develop new ways of attracting, developing and supporting people with the necessary skills to enable our programme to continue.

An increasingly important approach is to grow much of our own talent, strengthening our skills base from apprentices to researchers. By using our public engagement programme to inspire the next generation and through developing greater numbers of early-career scientists, engineers and technologists in our laboratories and university research programmes, we can support this and reinforce the multidisciplinary collaborative nature of modern international science and engineering.

STFC supports a rolling cohort of around 800 PhD studentships in particle physics, nuclear physics and astronomy. Our students are highly prized by industry and commerce for their first-hand experience of manipulating large, complex datasets – rarely provided by other disciplines. Around one third of our graduates enter the private sector with over 70% of these taking on a role in software development, data analysis, engineering or finance.

STFC's award-winning apprenticeship programme is recognised by the Institution of Engineering and Technology. An important part of the training is to work on our leading science projects. One such project was the recycling of an old hospital MRI scanner to study atomic nuclei at CERN. A superconducting magnet from an old MRI scanner was shipped from Australia to CERN where it was modified for use on the laboratory's ISOLDE instrument, a nuclear physics facility which provides both low-energy and high-energy re-accelerated radioactive beams to observe the properties of atomic nuclei. The team responsible for reconfiguring the magnet included two apprentices from STFC's Daresbury Laboratory. The project cost around £130,000 whereas a bespoke magnet would have cost more than £1 million.





Strategic themes

We will transform the way we achieve our strategic goals by focusing on six strategic themes.

Strategic themes

Building international influence

Whether it's the ESS in Europe, DUNE in the United States, or the Copernicus satellite programme in space, STFC plays a crucial role in the world's largest international science partnerships. Our experience in cultivating cross-border collaborations, coupled with our UK leadership in international policy forums, enables us to play an increasingly prominent international role in the development of collaborative research infrastructures – critical to the mission of UK Research and Innovation.

Ambition

Increase the UK's global influence by being at the forefront of international research collaborations, creating high returns in science leadership, excellence and impact.

Key objectives

- Bring together and facilitate global partnerships and collaborations to support the next big inspirational science projects.
- Attract more investment from international partners to work on shared global programmes, invest in UK-based facilities and support UK Research and Innovation collaborative projects.
- Continue to strengthen STFC's role as the UK's ambassador for global research infrastructure projects in all fields, supporting UK Research and Innovation international strategy.

Context

Increasing international influence is a key goal of UK Research and Innovation and STFC's significant experience ideally positions us to take a leading role.

Working with our community, we have built a reputation as a global leader in research, technology, engineering, facility operations and project management. Through strong engagement, we play a leading role in key international research collaborations and RI policy forums such as the G7 Group of Senior Officials on RIs and the OECD Global Science Forum. This has led to high visibility for the UK, as well as increased international investment and access at overseas facilities.

In recent years, we have joined new international facilities such as the ESS and XFEL to provide UK researchers across UK Research and Innovation Councils with access to leading multidisciplinary facilities. We have also joined large international projects such as the SKA and the ELT to strengthen and underpin STFC's world-class research programme in particle physics, nuclear physics and astronomy. We are reinforcing our role in promoting opportunities for UK business to win commercial contracts and maximise industrial returns from the facilities we are involved in. We also play an important leadership role in developing governance and financial agreements.

It is too early to quantify what the effects of the UK's decision to leave the EU will be. Future investment decisions regarding facilities and infrastructure will however need to take account of this new environment and ensure that UK researchers, from all disciplines, can continue to access leading research infrastructures across the world.

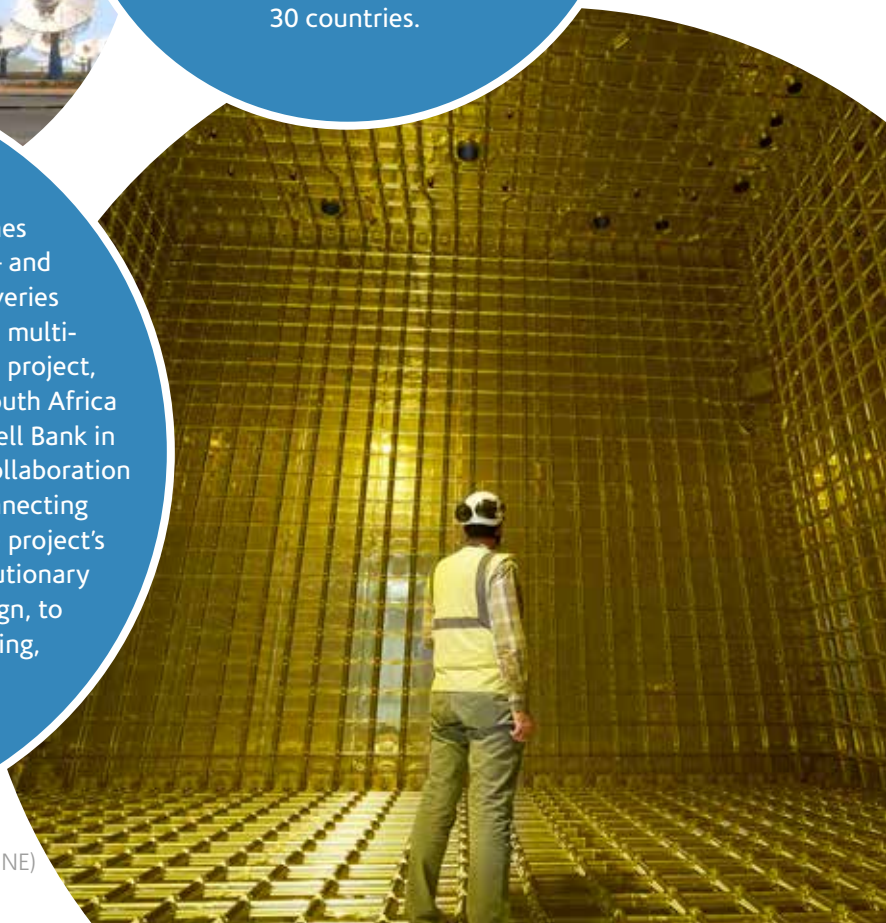
We will continue to work on behalf of UK Research and Innovation and other research infrastructures (RIs) in representing and best positioning the UK's interests. STFC has established a track record of being outward-looking and inclusive in developing RI policy, supporting all UK Research Councils and RIs in engaging with the European and global RI bodies. We have been appointed by the Department for Business, Energy and Industrial Strategy to provide the RI National Contact Point for the EU Horizon 2020 RI programme to ensure that all UK institutions can derive maximum benefit from this programme.

Through its management role and trusted relationship with government, STFC is able to view RIs from the perspectives of Science Ministry, funding agency and delivery partner. This gives us a unique position in European and global discussions where many delegates represent only one of these dimensions. It means we are able to promote an integrated approach to RI policy and, through our membership of bodies such as the Horizon 2020 RI Programme Committee and the G7 Group of Senior Officials on RIs which cover Science Ministry and agency-level issues, we can present a harmonised policy approach.

Credit: SKA Organisation

Under the new UK-US Science and Technology Agreement, STFC is investing £65 million in a $500 million global science project based in the USA. DUNE will study the properties of neutrinos, to understand more about how the Universe works and why matter exists at all. The DUNE collaboration currently involves over 1,000 scientists across 30 countries.

The SKA will be the world's most advanced radio telescope – 10,000 times more powerful than current telescopes – and designed to make ground-breaking discoveries about the Universe. The equipment for this multi-billion-pound global science and engineering project, involving 10 member counties, is located in South Africa and Australia. The headquarters, based at Jodrell Bank in the UK, co-ordinates construction and global collaboration of technical experts in radio astronomy, connecting institutions from more than 20 countries. The project's sheer scale and complexity requires a revolutionary change to traditional radio telescope design, to deliver radical developments in processing, computer speeds and supporting technological infrastructure.



Credit: CERN (protoDUNE)

Strategic themes

Data-intensive science

Whether it's hosting the SKA, the world's next 'big data' project, developing the first animation graphics to visualise mathematical data, or creating the UK's internet registry for companies to benefit from the World Wide Web, STFC has been at the forefront of data-intensive research for decades. As part of UK Research and Innovation we will remain a major transformative force, finding new ways to extract value and knowledge from data, critical to the UK's industrial strategy.

Ambition

Deliver cutting-edge solutions to support our own research programme, the productive exploitation of our facilities and the UK's position as a world leader in the analysis and application of data.

Key objectives

- Ensure the UK's e-infrastructure supports the country's leading international research status and delivers the data capabilities essential for academia, industry and STFC's science programme and facilities.
- Harness our strengths in high-throughput computing, high-performance computing, high-performance data analytics and their application to machine learning and artificial intelligence to train a new generation of data specialists for industry and commerce.
- Revolutionise the future delivery of research by accelerating the use of real-time data-processing and machine learning, computer simulation and data analytics for big science projects and facilities.
- Transform the competitiveness of UK industry by accelerating the development and adoption of artificial intelligence and machine learning technologies.

Context

This is a key area for UK Research and Innovation and expertise in data-intensive science and technologies, driven by the requirements of our outstanding science programmes and facilities, is one of STFC's key strengths. For example, we were the first to develop computer simulation tools, spawning the UK's computer animation sector. We also led the UK's work to deliver an internet infrastructure, hosting the first UK website and creating the .co.uk internet registry, a vital part of the UK's online economy which now manages 12 million UK business domain names.

This pioneering approach is driven by the needs of the world's 'big science' projects that consistently push the boundaries and demand innovation in computing capability, driven by the exponential growth in the volume, speed and variety of research data. CERN was one of the world's first 'big data' projects. Breakthroughs such as the discovery of the Higgs boson in 2013 would have been unimaginable without cutting-edge computation, storage, networks, software and skills operating together across national boundaries. Initiatives such as the SKA and the Copernicus Earth-observation programme are expected to produce 100-fold increases in data rates, massively stretching current capabilities and driving development to keep the UK at the forefront of computing technologies.

Increasing numbers of scientists in the UK, from both academia and industry, rely upon e-infrastructure to generate and analyse their research results. To address the challenge of extracting value and knowledge from research datasets that are now simply too big to be analysed in traditional ways – whether from large scientific facilities, model simulations, experiments, or large scale observation systems – we are developing and delivering innovative solutions. For example, the JASMIN superdata cluster for climate and Earth-system science, developed in partnership with NERC, co-locates a supercomputer and a datacentre to bring processing power close to the data. Similarly, we are developing proposals to co-locate and invest in technologies, resources and skills to understand, interpret and share data from STFC's facilities to best support researchers from across the science base.

However, it is not only science that stands to reap big benefits from this approach. Predictive analysis of large, complex datasets and the application of machine learning and artificial intelligence are transforming business and government decisions, finding new correlations, spotting trends and extracting value in ways unthinkable just a decade ago. By bridging academia and industry to tackle challenges facing businesses STFC, as part of UK Research and Innovation, is driving innovation, building skills and boosting productivity in spheres ranging from disease-mapping and catastrophe-modelling to fuel-cell design and product development working with companies including Rolls-Royce, GSK and Unilever.

We know that putting in place the e-infrastructure needed by UK researchers can only be achieved by UK Research and Innovation and partners working together. However, STFC's experience and track record of sharing expertise and resources across organisational and, in many cases, international boundaries puts us in a strong position to produce the technology and skills urgently needed for tomorrow's data challenges and to increase the UK's capability in emerging fields of data science.

Radiotherapy is a fundamental weapon in the battle against cancer. The PRaVDA Consortium is helping to design, build and commission a device to optimise tumour treatment, reducing risk for patients. Computer simulations of the experimental setup are replacing time-consuming laboratory experiments. This has only been possible through the assistance of the GridPP collaboration, originally set up to provide world-class computing to support experiments at the LHC.

Unilever is taking advantage of STFC's expertise in high-performance computing through its partnership with the Hartree Centre at the Daresbury Laboratory to accelerate its product discovery process. For example, Hartree worked with Unilever on the formulation of a fabric conditioner. Traditional laboratory stability tests typically take a time-consuming 8 to 12 weeks, but by harnessing the supercomputers at Hartree this can be reduced to 45 minutes. High-performance computing capabilities, together with a specialist 3D visualisation suite, allow product developers to explore data and see correlations that are otherwise elusive. For a fast-moving consumer goods company such as Unilever, speed is critical in bringing products to market and providing competitive advantage.

Strategic themes

Solutions for 21st century challenges

From developing the next generation of battery technologies to deliver cleaner energy systems, to new plasma devices that destroy microbes in packaged fresh foods – our programme provides a rich mix of capabilities that we are using to develop exciting new approaches to tackling the complex and dynamic challenges of the 21st century. UK Research and Innovation, driven by the desire to make a difference, is prioritising activities with the greatest potential to respond to the pressing issues of the day and STFC is strengthening its challenge-led approach to deliver tangible benefits and support UK growth and productivity.

Ambition

Work as part of UK Research and Innovation with industry, academia and government in the multidisciplinary effort to solve 21st century challenges.

Key objectives

- Build on our key strengths and collaborate with partners to develop challenge-led solutions that address both the UK's industrial strategy priorities and the United Nations' Sustainable Development Goals.
- Capitalise on the new streams of funding available from government to help UK industry gain competitive advantage in developing markets by accelerating innovative technological solutions.

Context

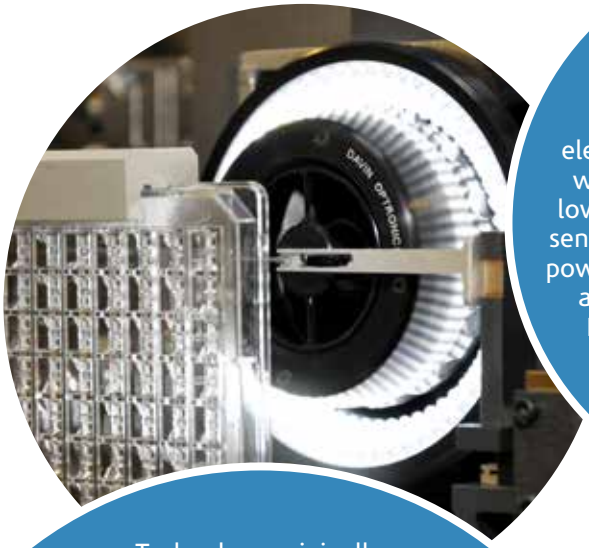
Solving many of this century's challenges requires multidisciplinary solutions delivered through the sustained application of the best scientific minds. We believe that harnessing the remarkable range, scale, sophistication and distinctiveness of STFC research, technologies and facilities will make a significant contribution to achieving successful outcomes in this sphere.

Since 2010, we have delivered a step change in our challenge-led approach, introducing dedicated funding and translational activities to develop solutions to the challenges of the 21st century and investing in new multidisciplinary networks that draw upon our capabilities to address priority areas. Our projects have brought together STFC-funded researchers with science, technology and industry groups, attracted new users to our facilities, and found new applications for our technologies and know-how. For example, in the context of global climate change and declining natural resources, STFC's Food Network+ is building an interdisciplinary community working to address the need for a sustainable, secure supply of safe, nutritious and affordable high-quality food using less land and other inputs. A recent analysis of our investment portfolio identified hundreds of case studies where STFC's unique capabilities have delivered progress on effective solutions to global challenges in energy, healthcare, environment and security, working with companies including Siemens, Pfizer, GSK and many others.

We will build on these firm foundations to grow areas of strength in our community, where we can respond to challenges to help generate timely real-world benefits, deliver competitive advantage for the UK in international markets, stimulate economic growth and create jobs. Devising the innovative approaches needed to support the UK's industrial strategy and pursue the United Nations' Sustainable Development Goals by tackling global development challenges will demand, amongst other things, new technologies and research infrastructure.

We will apply our proven and established toolkit of networking, collaborative research and innovation programmes to widen our approach and work with new and existing stakeholders in academia, government and industry. Using this toolkit we will target our capabilities at developing a greater understanding of the challenges and how our community can play a greater role in developing solutions. In parallel, we will support UK growth by offering industry access to world-leading analytical and computing facilities to deliver competitive advantage in emerging international markets.

Credit: Diamond Light Source



Modern batteries are a transforming technology that has revolutionised our lifestyles through ubiquitous consumer electronics. Future battery applications will be even more diverse, from very-low-power applications in areas such as sensors and biomedicine through to high-power technologies including grid storage and automotive power trains. STFC's Batteries Network will seed lasting collaborations, delivering cutting-edge science and engaging with industry.

Technology originally developed for exploring Mars has been adapted for a range of commercial applications including monitoring greenhouse gases, studying air quality and measuring emissions from industrial processes. New company MIRICO was established in 2015 with an initial £1 million investment from Longwall Ventures and the Rainbow Seed Fund (now UKi2S). Based on research carried out at STFC's RAL Space, the company is developing new analytical instruments for gas analysis that deliver laboratory standard performance in a highly compact design. The company has developed a prototype system for remote detection of emissions for use in industrial facilities and scientific applications around the world. In 2018 they secured a follow-on investment of £3.5 million, drawing in new investors Foresight Williams Technology EIS Fund, enabling MIRICO to complete product development and build manufacturing capability.

Credit: Pixabay

Strategic themes

Developing advanced technologies

The construction of the ESS in Sweden, the ATLAS detectors underground at CERN and the detection of gravitational waves from far-off colliding stars at LIGO – these all involve highly sophisticated technologies developed by STFC and our partners. Operating at the leading edge of technological and engineering possibilities, we translate research into practical applications and exploitable outcomes to address the most important industrial and societal challenges of our time.

Ambition

Deliver cutting-edge technology programmes to strengthen our world-leading research, the productive exploitation of research facilities and the UK's leadership in advanced technologies.

Key objectives

- Increase our world-leading capability in key technologies where the underpinning technical skills and expertise have been established within our national laboratories.
- Work with our community to develop an inventive and strategic programme that leads the world in adopting, adapting, developing and exploiting the detectors and instrumentation, accelerators, specialist engineering and optics required by our world-leading research programme.
- Seize the opportunity to lead novel technology and engineering projects that support our broader science goals.
- Support UK leadership of advanced technologies and their translation into marketable products, working with partners in UK Research and Innovation, other government departments and industry.

Context

The success of our research depends on the delivery of large-scale science facilities and experiments that rely, in turn, on development of leading-edge technologies and expertise. Our needs often go far beyond the state of the art, so off-the-shelf solutions can rarely satisfy. It would have been impossible to observe the gravitational waves arising from the collision of two black holes without the novel technologies developed by STFC and our partners as an integral part of our research.

We have become world-renowned suppliers of leading research instrumentation, engineering and facilities, and have built an enviable track record in this area. Driven by increasing complexity and cost, the recent shift to fewer, more complex instruments and facilities involving global partners has encouraged us to strengthen our design, project management and systems engineering expertise. This brings UK researchers considerable influence in major multinational projects, provides a place at the forefront of data exploitation and secures high-profile leadership roles in international science projects. Crucially, this also brings competitive advantage to the UK by providing a wealth of emerging, disruptive technologies and expertise applicable to commercial and public-policy challenges, for example through spin-out companies such as KEIT Ltd and Cobalt Light Systems.

STFC's Programmatic Review pinpointed five key technology areas – detectors and instrumentation; accelerators; specialist engineering, such as cryogenics and extreme environments (including space); optics; and e-infrastructure (including software and algorithms). These are all central to our core, long-term mission where our needs cannot be met cost-effectively and reliably on the open market and where we possess international-class capabilities. Because of its rapid growth and importance, e-infrastructure is specifically addressed through our data-intensive science strategic theme.

To ensure a reliable and timely supply of these technologies, we continue to sustain a critical mass of technology and engineering capabilities at our user facilities, partner universities and – where a university department cannot support the strength or depth needed – at our national laboratories. The Programmatic Review concluded that this diversity of approach and application is a major strength. We will adopt a more strategic and managed approach, developing a plan for each of the five technology areas to focus our efforts and build synergies. Through this approach we will engage external partners, address skills shortages and future-proof our key technological capabilities through partnerships between our national laboratories, international facilities, wider academia and industry.

In 2016, the LIGO international science collaboration announced the first-ever direct detection of gravitational waves – the final remaining unconfirmed major component of Einstein's general theory of relativity, with a Nobel Prize following in 2017. LIGO's technical upgrade – relying heavily on intellectual, technical and manufacturing expertise from UK universities and our laboratories – increased the sensitivity of its detectors tenfold and made this discovery possible. STFC-funded researchers have since used the key technology, expertise and knowledge developed for LIGO to develop commercial applications including a low-cost and portable microelectromechanical system gravimeter, approximately 100,000 times more sensitive than those in current use in the best smartphones.

In 2017, UK researcher Richard Henderson received a Nobel Prize for work on CryoEM. CryoEM has transformed structural biology and aided drug development. STFC worked with Professor Henderson to develop the high-resolution electron camera systems required for this technique. These 'sensors' are based on systems originally designed by STFC technologists to support our frontier science mission in space and particle physics.

Credit: STFC/Katherine Barnes

Strategic themes

Research and innovation campuses

Since their inception 10 years ago, our campuses have achieved remarkable success. World-leading science, innovation and entrepreneurship converge on Sci-Tech Daresbury and the Harwell Campus in a unique environment that delivers business growth and high-value jobs. We will accelerate the development of our campuses, optimising the contribution of STFC's research facilities and as assets for UK Research and Innovation, to produce economic growth, collaboration and investment.

Ambition

Establish our research and innovation campuses as internationally renowned locations for innovation, high-tech industry and research.

Key objectives

- Catalyse the development of economically productive clusters of leading businesses that exploit our multidisciplinary research strengths, facilities and technology capabilities.
- Attract the investment needed to sustain the success of the research and innovation campuses, unlocking their regional and national economic potential.
- Continue to develop our research and innovation campuses as key assets to support the delivery of UK Research and Innovation's Strategy and the industrial strategy.

Context

Since their inception 10 years ago, our research and innovation campuses have achieved remarkable success. These national assets have reached a level of maturity and critical mass that means they are now primed for the next stage of growth.

The combination of world-class research facilities and expertise with private-sector investment and development skills can achieve growth that would elude any one agency working in isolation. By taking this approach, Sci-Tech Daresbury and the Harwell Campus now host over 300 high-tech enterprises and support more than 6,000 jobs. Both are designated as Enterprise Zones and continue to grow as locations of regional, national and international significance.

We will actively promote and develop clusters of interconnected businesses, organisations and institutions to take advantage of our science and technology assets – building on the already strong connections between research, academia and business. By providing direct access to new ideas, capabilities and skills – which business would otherwise have to develop independently – we are enabling companies to be more productive and flexible. We see great potential for establishing a UK Research and Innovation network of research and innovation campuses, to capitalise on local strengths, and will share our experience to develop best practice.

Campuses provide a unique environment, hosting businesses at every stage of growth from technology start-ups through to SMEs and mature companies.

They offer first-rate business support and incubation programmes to enable business development and scale-up. Collaboration is fundamental to this process. At Sci-Tech Daresbury nearly 80% of companies collaborate with either STFC or a university, while almost 60% collaborate with another company on-site. High levels of collaboration translate into strong business growth, high-value job creation and high levels of commercial innovation.

With both Sci-Tech Daresbury and the Harwell Campus starting to implement ambitious long-term masterplans to support their growth, there is a huge opportunity to demonstrate, on a global stage, the benefits that UK Research and Innovation's new approach can bring.

Credit: Sci-Tech Daresbury

In 2017, Sci-Tech Daresbury won the UK Science Park Association award for 'setting the pace' in innovation and for supporting the growth of knowledge-based firms. The campus is a joint venture between STFC, Halton Borough Council and Langtree, a commercial property company. It is currently home to more than 120 research organisations and high-tech businesses employing 1,000 people, and there are ambitious plans for further growth.

Centred around STFC's long-established RAL Space laboratory, the Space Cluster at Harwell also comprises other key players including: ESA's European Centre for Space Applications and Telecommunications; the Satellite Applications Catapult; and the ESA Business Incubator Centre managed by STFC. This constitutes a powerful attractor to businesses wanting to exploit the UK's considerable national heritage in space. Leading global space technology companies such as Airbus, Lockheed Martin, Thales Alenia Space and Elecnor Deimos have established significant operations at Harwell. Overall, the Space Cluster has grown from just three space-related organisations employing 200 people in 2010, to 80 organisations employing around 800 people in 2017. One third of these represent foreign direct investment into the UK.

Strategic themes

Inspiring and involving

We love to communicate our work. This means sharing the curiosity, excitement and ambition that drive us: to make new discoveries about the Universe, to develop the incredible technologies and facilities that make those discoveries a reality, and to explain how the outcomes of our work have improved all our lives. Our science amazes people, encourages all age groups to explore ideas and inspires the next generation. Working with our partners will ensure that we bring these benefits to a wider range of audiences than ever before.

Ambition

Encourage society to value and participate in scientific endeavour, and inspire the next generation to see themselves as the scientists and engineers of the future.

Key objectives

- Inspire all sectors of society to value and participate in scientific discovery through the awe and wonder of our frontier science, engineering and technology.
- Enhance public awareness of the economic, international and wider public benefits of investment in science and technology, using STFC's science as an exemplar.
- Target hard-to-reach groups to increase the diversity of the future UK science and engineering community.
- Encourage the next generation to study and work in science and technology.

Context

Our science is incredible. From the infinitesimally small world of sub-atomic structure to the inconceivably vast scale of cosmological phenomena, STFC's scientists and engineers are tackling big questions that we know attract children to science and keep them asking questions throughout their lives. What's in outer space? How did the Universe begin? What are we made of?

STFC is recognised and sought-after as a leader in STEM engagement and we have long-standing expertise in showcasing the remarkable range of our work. We use our stories, communities and facilities to inspire and involve the public, enabling them to understand how science changes lives for the better and explore science and technology for themselves.

Our public engagement plays a specific but crucial role in growing the UK's STEM talent pool, helping young people and their families to see that modern STEM is exciting, relevant and diverse. From the first dramatic observation of two neutron stars colliding, to building a rover vehicle with an autonomous navigation system that can explore the surface of Mars, or the discovery of the Higgs boson, our work seizes people's imaginations, encourages them to ask questions, and inspires future generations of students to study and work in STEM subjects as a route to a hugely rewarding future.

Speaking to people about science is one thing, but experience tells us that the public wants to see it first-hand. STFC's laboratories and campuses are unique in the UK and provide us with a fantastic opportunity to let people experience the remarkable scale, ambition and achievement of UK science. We have welcomed tens of thousands of people, including thousands of school students and teachers, through the doors of our facilities in the past five years, and the feedback we receive is overwhelmingly positive.

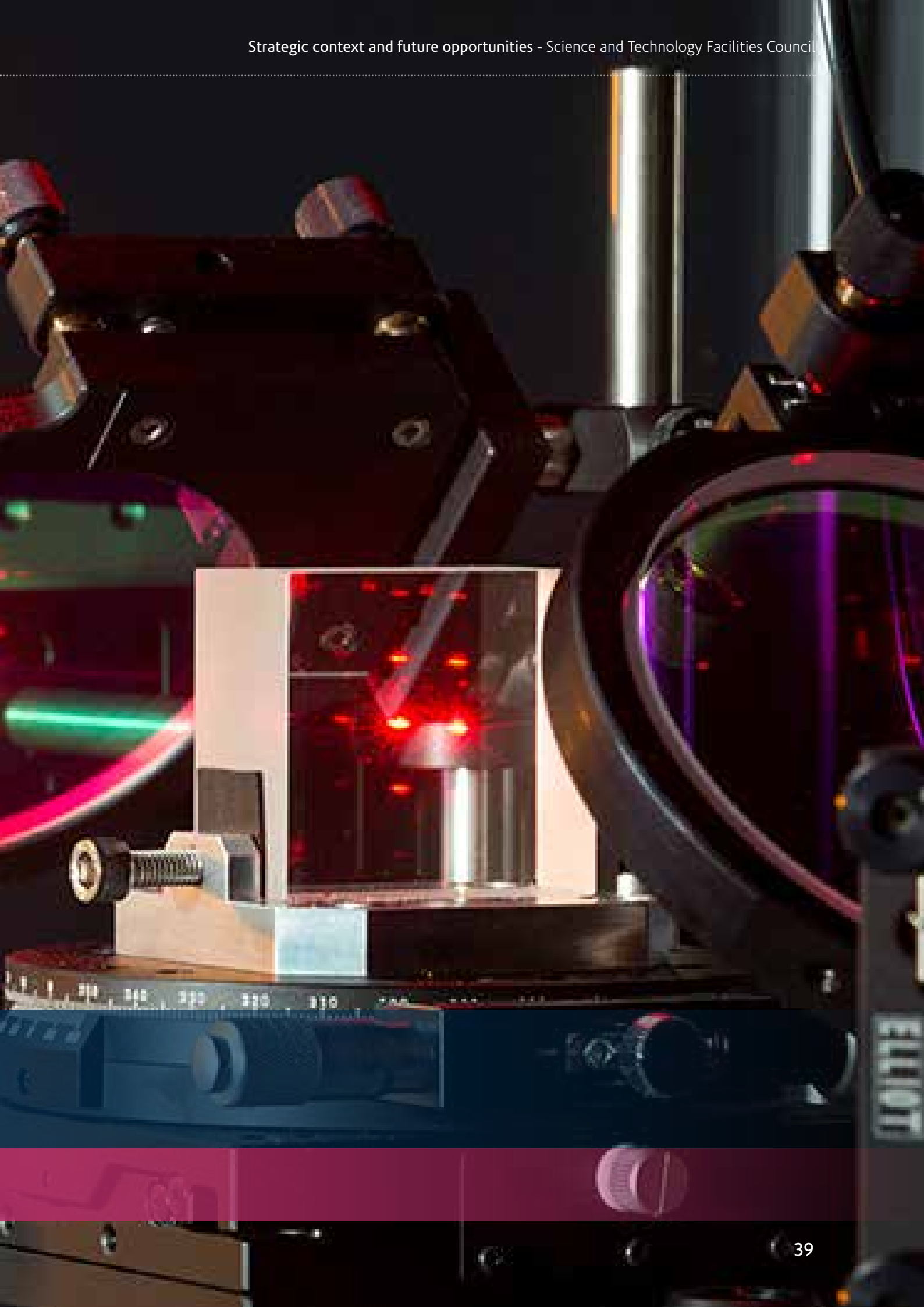
Public engagement in the UK exists in an increasingly rich and interconnected landscape. To improve the future impact of our work we will work in carefully selected, mutually beneficial partnerships. The breadth of these partnerships will reflect the strength of our public engagement. We will add our influence to the continued development of the UK's excellent reputation in conceptualising high-quality public engagement. We will work across the boundaries of universities, industry, charities, museums, science centres and community groups to develop new and impactful collaborations. We will also be proactive in ensuring that UK Research and Innovation provides high-profile public engagement leadership nationally and internationally.

We are always excited to invite the public to explore and be inspired by STFC's science and technology. Our Open Weeks at Rutherford Appleton Laboratory and Daresbury in 2015 and 2016 welcomed a total of 25,000 people. As part of Edinburgh's annual Open Doors Weekend, the UK-ATC reaches over 3,000 people every year.

Working with the Association for Science and Discovery Centres, STFC has developed the Explore Your Universe programme which inspires people through our science. The programme runs in 29 science centres, facilities and universities across the UK, allowing children and their families to experience science in new ways and meet real scientists and engineers, and directly reaching around 350,000 people. Four out of every five participants said they were more interested in science after attending. Girls and boys equally said the programme had increased their interest in science, and in careers based on science and technology. Evaluation by King's College London found the programme to be highly cost-effective in engaging a large number of students and families.

Strategic enablers

We will enable the successful delivery of our goals and themes by fostering collaboration, working together with our community and creating an outstanding organisation.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Strategic enablers

Fostering collaboration

Collaboration underpins everything we do and is vital to accomplishing our science and innovation goals. We work with thousands of different stakeholders within the UK and across the world to deliver our programme. This approach will be even more important in the future and will be enabled by the formation of UK Research and Innovation. Only by continuing to build the right collaborative teams will we be able to strengthen our global portfolio, and extend our multidisciplinary approach to address the challenges of the 21st century.

Ambition

Strengthen existing partnerships and develop new relationships and approaches to ensure we build the right collaborations to deliver our science, societal and industry-relevant goals.

Key objectives

- Build productive collaborations, based on complementary strengths and expertise, to deliver our programme and contribute to innovation and growth.
- Develop new strategic approaches to sustaining the research infrastructure critical to UK research, whether located in the UK or overseas.
- Maximise the opportunities, enabled by the creation of UK Research and Innovation, to build stronger interdisciplinary research and innovation partnerships.
- Build mutually beneficial relationships with the industrial research community to exploit the UK research base and enhance productivity.

Context

STFC collaborates with thousands of scientists and hundreds of scientific institutions across the globe to deliver our outstanding science programme. The combination of individual creativity and large-scale collaboration is the hallmark of modern science and innovation, and will become even more important in the future. In addition to the influence of our research programme across the UK's collaboration landscape, our national laboratories draw upon a significant supply chain for the delivery of science infrastructure and an even bigger innovation community spanning many sectors. This community already benefits from the unique knowledge, experience, technology and multidisciplinary skills that STFC has developed by being right at the vanguard of science and technology.

Through collaboration, we can deliver more research of the highest quality, solve bigger problems, provide better access to world-leading facilities in the UK and beyond, and deliver greater economic benefit for the UK. Our collaborators span the public, private and third sectors and include universities, high-tech businesses, international scientific organisations, government departments, local enterprise partnerships and our research and innovation campus joint-venture partners. Further development of our portfolio of collaborators is key

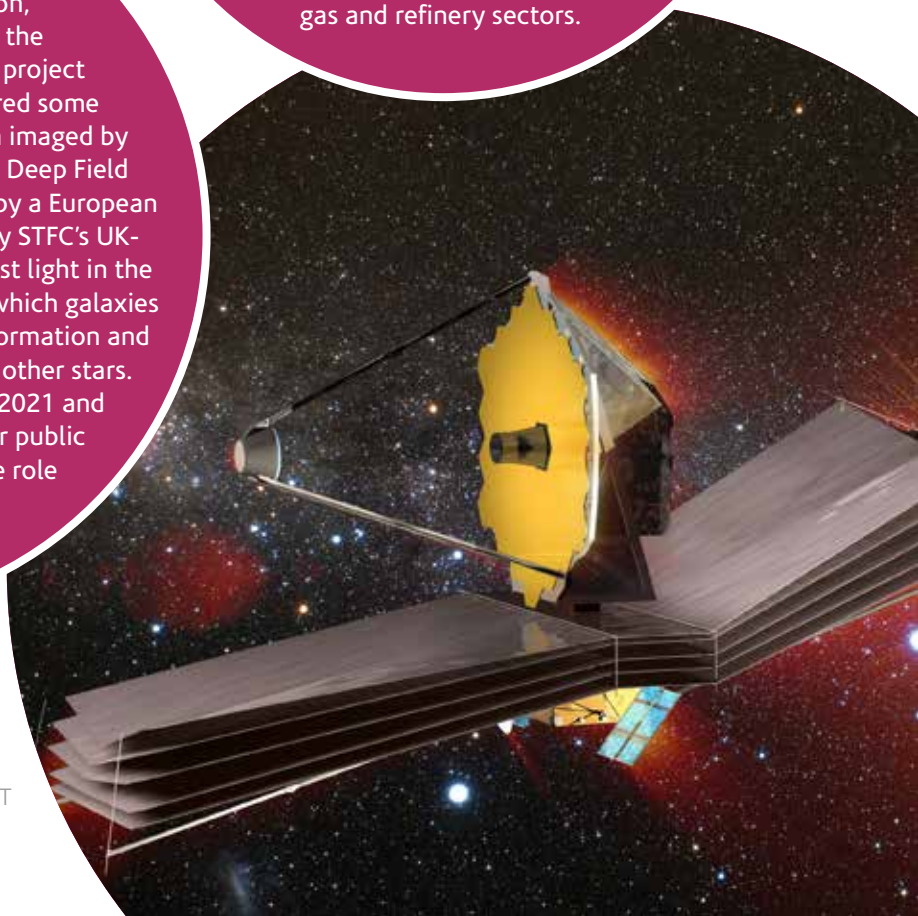
to propelling forward our ambition to become a global innovator. We will develop our partnerships with the industrial research base to demonstrate the capabilities of our science, technology and expertise as a valuable resource to address challenges faced by business. These strong partnerships between the academic and industrial research base will be a central part of delivering on the government's ambition to increase overall investment in UK R&D.

We will work with others to enhance collaboration and joint relationship management across UK Research and Innovation, opening up new opportunities to achieve shared ambitions, for instance in skills and training and simplifying the interfaces with the research base for our partners and collaborators.

We will help the UK extend its strong network, building on the expertise of world-leading research endeavours and leveraging support from new sources of funding to enable and enhance collaboration with developing countries. We also need to understand – and seize – the opportunities presented by a UK industrial landscape that is more responsive to changes in government industrial strategy and to disruptive innovation, and where demand is increasing for neutral locations, such as our research and innovation campuses, that support open innovation and enable it to succeed.

Johnson Matthey collaborates with scientists across STFC's facilities and laboratories, providing access to cutting edge experimental tools, advanced computational modelling and world-class expertise to enhance and complement their in-house R&D activities. This close relationship, underpinned through jointly appointed staff, makes a significant contribution to the company's R&D programmes and ongoing product development. Johnson Matthey spends around £200 million per year on R&D and its technologies are used in environmental, automotive, chemical, medical, recycling, oil, gas and refinery sectors.

MIRI is one of four instruments for NASA's flagship astronomy mission, the James Webb Space Telescope, the successor to the Hubble. The 30-year project was conceived after the Hubble captured some of the most distant galaxies to have been imaged by an optical telescope in its now legendary Deep Field Image. MIRI was designed, built and tested by a European consortium of 10 member countries, led by STFC's UK-ATC in Edinburgh. MIRI will examine the first light in the Universe, play a key role in demonstrating which galaxies are undergoing their first episodes of star formation and examine the formation of planets around other stars. The telescope is due to be launched in 2021 and exciting plans are being developed for public engagement activities based on the role played by the UK.



Credit: NASA, JWST

Strategic enablers

Working together with our community

Our community are recognised for their expertise, for their collaborative work and for delivering major national and international projects that further the success of STFC and the UK. A strong community and powerful engagement are integral to the planning and delivery of our activities. To maintain UK science leadership, STFC must build a sustainable future – setting high expectations, equipping, empowering and ensuring a culture where everyone's contribution is valued.

Ambition

Develop and support a vibrant and diverse community, including STFC employees, sustaining the long-term scientific, technological and leadership capabilities to deliver the UK's science and innovation ambitions.

Key objectives

- Provide high-quality strategic leadership, using our convening power to co-design solutions and responses to scientific and industrial challenges, policy questions and initiatives.
- Harness the expertise of the wider research community in deciding where to invest our resources.
- Develop capability and wellbeing in our community by removing barriers to diversity wherever we find them, and by supporting everyone to perform at their best.
- Communicate openly and honestly, ensuring our staff and wider community are fully engaged in everything we do.

Context

Our thriving community includes the researchers and students that we fund, the academic, industrial and international users of our facilities and STFC's own staff. We currently support a broader community of over 6,000 including our 2,000 staff. Passionately committed to delivering and supporting world-class science and innovation, they offer a valuable and varied array of skills, talent and experience. Many people simultaneously feature in more than one of these groups; for example, we share joint appointments with universities and members of our staff hold visiting professorships. The synergies that result are vital for our success.

We have an ongoing commitment to raising expectations across our community regarding continuous improvement, career development, equality and diversity as a means to nurture talent and support everyone to perform at their very best. We measure ourselves against a range of recognised standards on equality, diversity and inclusion and use the findings to continuously improve the working environment for all our staff. For example, as part of our work with the Athena SWAN Charter, we reflected upon our organisational practices and identified cultural changes that create a better working environment for all.

In the wider community, we are committed to removing barriers that stand in the way of a more diverse research base and affect wellbeing – opening up our processes and decision-making, encouraging flexibility in career pathways and promoting inclusivity in all aspects of our work.

This approach will help us to build and maintain national research capability and international competitiveness as a core part of the UK research endeavour. Working in collaboration, we will support our community to find solutions to the biggest challenges – placing science and innovation at the heart of achieving societal benefit and economic growth – and harness their knowledge to develop our approach and help us take investment decisions.

STFC is committed to fostering greater equality and diversity: in our own practices, our research community, and our engagement with public audiences. We are one sponsor of the award-winning SMASHfestUK programme, now in its fourth successful year. Designed to widen participation and increase diversity in STEM and the arts, in 2017 the festival engaged over 13,000 people, many coming from demographics currently under-served by STEM engagement.

Running a comprehensive and robust programme evaluation allows STFC to maintain the vitality of our research portfolio and deliver our mission within our financial envelope. It also enables us to feed peer-reviewed advice and recommendations into planning and decision-making processes. Working with our community, we review each discipline area once every three years and assess the balance of research, innovation and skills opportunities between disciplines to ensure we are maximising the impact of our portfolio. By working closely with experts in our community through our Advisory Panels, we can develop and use roadmaps to assess the strategic direction, balance and breadth of different parts of our programme and underpinning technology areas.

Strategic enablers

Creating an outstanding organisation

UK Research and Innovation aspires to be an outstanding organisation that ensures world leading research and innovation continues to grow and flourish in the UK. Leadership, as well as structural, physical and technological dimensions, creates the essential cultural backdrop to delivering a safe, productive and resilient environment that is also a great place to work. We will build on STFC's strengths to help UK Research and Innovation create the best environment in which the UK's science ambitions can flourish.

Ambition

Build on STFC's strengths and play an active role in creating an outstanding working environment within UK Research and Innovation.

Key objectives

- Work in partnership to deliver a safe, productive and resilient environment for UK Research and Innovation that is also a great place to work.
- Strengthen the management of our strategic approach to programme planning and investment.
- Create the essential cultural backdrop and underpinning processes to drive and support strategic change.

Context

A key foundation of any outstanding organisation is its working environment. This encompasses many facets, from the infrastructure at our laboratories to our office technology, and from organisational leadership, enabling systems and environmental best practice to health & safety. All are vital to optimising our investments and ensuring STFC remains a safe, stimulating and rewarding place to work.

Over the last five years, we have improved the working environment at all our sites, refurbishing parts of our ageing estate to create a modern and productive science and business environment. To underpin the long-term, strategic nature of our organisation, we have redesigned our leadership and structural environment to improve the delivery of our mission. This has resulted in greater coherence and clarity of responsibility and more agility in decision-making. Our departmental structures and systems have also evolved to facilitate greater collaboration and cross-fertilisation of ideas, increasing both our capacity and our capabilities..

Our organisation is committed to implementing environmental best practice right across our laboratory, office and campus sites, where we have a proven track record in embedding energy-

saving measures and cutting carbon emissions, water consumption and waste generation – all reducing our estates' environmental footprint. Our employees, meanwhile, regard our refreshed approach to internal communications as a great success.

Our working environment and the underpinning systems associated with it are vital to our ability to deliver the most from our investments. We will go on driving improvements in efficiency and effectiveness spanning everything we do, by simplifying and optimising operational processes, moving to consistent frameworks and, where beneficial, introducing shared systems and platforms to realise synergies. These changes underpin the long-term, strategic nature of our organisation and will be critical to the delivery of this Strategy.

The formation of UK Research and Innovation has generated further impetus for sharing best practice and working together to achieve common goals. Our ambition and determination to become an outstanding organisation will help equip us to meet tomorrow's challenges and embrace future opportunities.

Across STFC's campuses and facilities, there are many complex buildings with unique environmental requirements. We are introducing schemes for on-site generation of power and recovery of thermal energy. For example, the combined heat and power project at our ATLAS building is expected to produce savings of £100,000 per annum, reducing energy requirements and energy loss and cutting carbon emissions.

Credit: STFC/ Gordon Fawley

STFC delivers a diverse and challenging portfolio of advanced technology and long-term projects to ensure the success of its world-leading frontier science programme, large-scale facilities, and research and innovation campuses. These projects are delivered through many routes, at our own laboratories, UK universities and international institutions. The portfolio's complexity and importance require project management as a STFC core competency. We have developed a specific Project Management Framework, underpinned by a training programme and aligned with the professional qualifications of the Association for Project Management – who we support through corporate membership. As a consequence, our scientists and engineers are recognised internationally for their expertise and reliability and we continue to deliver projects, like ISIS Target Station 2, our Space Integration and Test Facility and our contribution to the upgrade of LIGO, on time and to budget.

Key priorities

- Work effectively as part of UK Research and Innovation to develop an improved research and innovation system in the UK that is greater than the sum of its parts.
- On behalf of UK Research and Innovation, lead the development of a coherent national roadmap for leading-edge research infrastructure and e-infrastructure, complementing European and global initiatives, and maximising opportunities for the UK to lead and host international infrastructures.
- Work with our community, Government and other international funders to make the case for and develop the single and multidisciplinary facilities and experiments needed to keep UK science at the leading edge.
- Ensure that the impact of new and developing facilities, such as the SKA, are fully realised by co-ordinating the UK's collective interests in their science, industrial opportunities, public engagement and technology challenges.
- Define and support a scientific programme to discover the secrets of the Universe, investing in the highest-priority projects in particle physics, astronomy and nuclear physics and the enabling technology, accelerator and computing programmes needed to further enhance the UK's world-leading status in these fields.
- Keep the multidisciplinary facilities accessed by UK researchers across the full spectrum of science at the leading edge to deliver against the UK's industrial strategy and advance the understanding of interdisciplinary domains.
- Increase the UK's global impact by growing the number of international science and technology projects with substantial UK involvement.
- Develop and maintain a strategy for each of our five technology areas to focus our efforts, build synergies and guide investment.
- Work with our partners in UK Research and Innovation, government and industry to accelerate our portfolio of extraordinary, potentially disruptive technologies emerging from large science projects and ensure these capabilities are exploitable by UK industry.
- Develop and deliver a prioritised plan to tackle 21st century challenges using our facilities, technology and skills to address both the UK's industrial strategy priorities and the United Nations' Sustainable Development Goals.
- Develop and implement strategic plans for our Sci-Tech Daresbury and Harwell Campuses, key assets for UK Research and Innovation, with the ambition to deliver a step change in investment, high-value job creation and economic growth.
- Expand our doctoral training programme to provide the skills needed to manage, analyse and interpret increasingly complex datasets, supporting approaches across UK Research and Innovation to drive future economic growth.
- Further develop our approaches to the recruitment, retention and training of our workforce to ensure we have the technical skills required to operate, maintain and upgrade our facilities for the future.
- Fully implement our Public Engagement Strategy to showcase our remarkable and awe-inspiring science so that people value and pursue careers in science, technology and engineering.
- Increase the diversity and inclusion of both our workforce and the communities we fund.
- Build on our successful approach to collaborative working to develop, as part of UK Research and Innovation, more productive partnerships between academia, government, industry and our national laboratories.

Glossary

ALMA Atacama Large Millimeter/submillimeter Array
CCLRC Council for the Central Laboratory of the Research Councils
CERN European Organization for Nuclear Research
CLF Central Laser Facility
CryoEM Cryogenic Transmission Electron Microscopy
DiRAC Distributed Research utilising Advanced Computing
DUNE Deep Underground Neutrino Experiment
FAIR Facility for Antiproton and Ion Research
ELT Extremely Large Telescope
ESA European Space Agency
ESFRI European Strategy Forum on Research Infrastructures
ESO European Southern Observatory
ESRF European Synchrotron Radiation Facility
ESS European Spallation Source
ILL Institut Laue-Langevin
LHC Large Hadron Collider
LIGO Laser interferometer Gravitational-wave Observatory
MIRI Mid-Infrared Instrument
NASA National Aeronautics and Space Administration
NERC Natural Environment Research Council
OECD Organisation for Economic Co-operation and Development
PPARC Particle Physics and Astronomy Research Council
PRaVDA Proton Radiotherapy Verification and Dosimetry Applications
RI Research Infrastructure
SHE Safety, Health and Environmental
SKA Square Kilometre Array
SME Small and Medium-sized Enterprises
STEM Science, Technology, Engineering and Mathematics
STFC Science and Technology Facilities Council
T2K Tokai to Kamioka
UK-ATC UK Astronomy Technology Centre
XFEL European X-Ray Free-Electron Laser

Credit: STFC/John Willoughby

Establishments at Boulby Underground Laboratory, Cleveland; Chilbolton Observatory, Hampshire; Daresbury Laboratory, Cheshire; Polaris House (STFC headquarters), Swindon; Rutherford Appleton Laboratory, Oxfordshire; UK Astronomy Technology Centre, Edinburgh.

Science & Technology Facilities Council