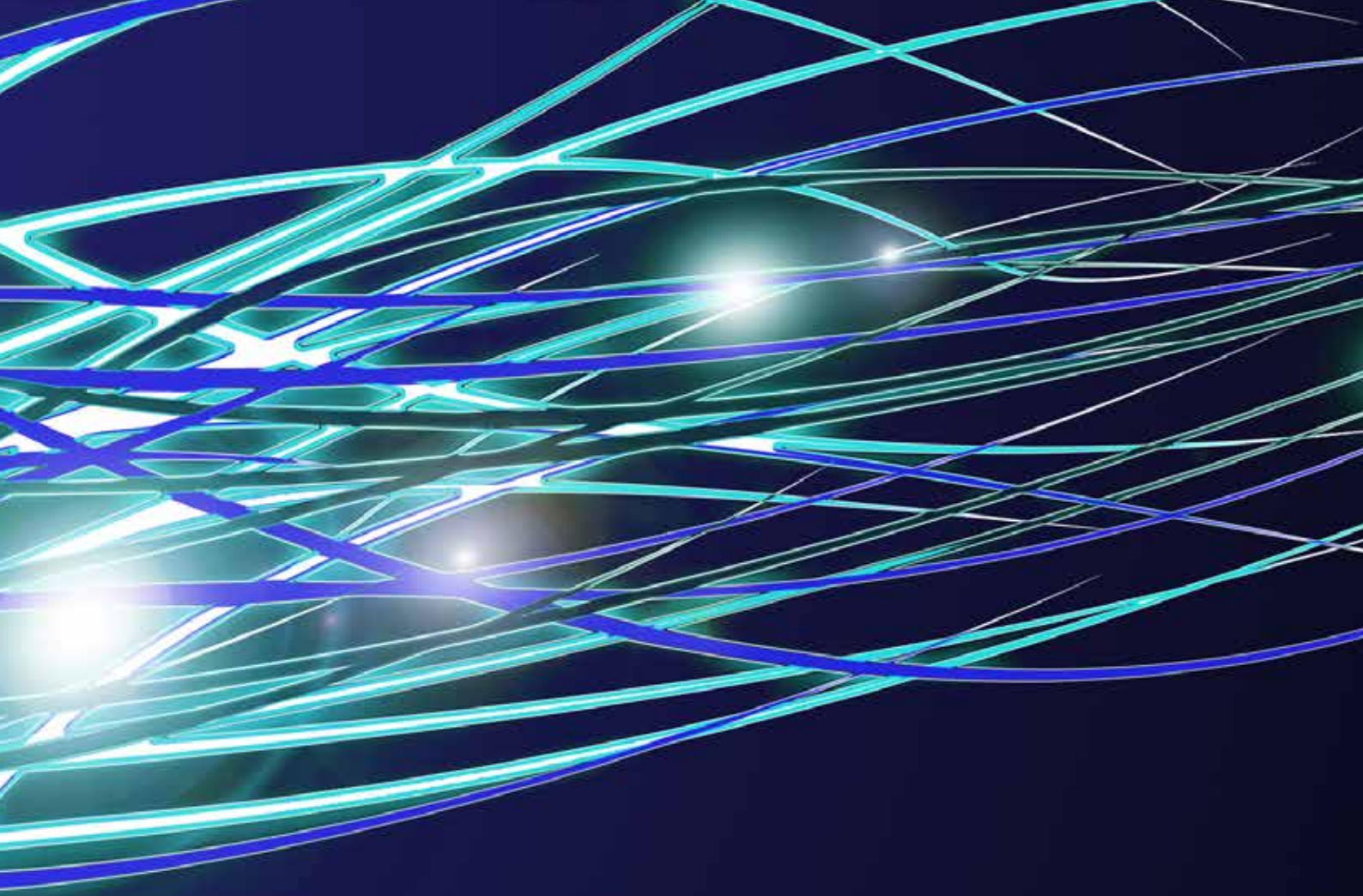


Oxford Instruments and STFC
Forty Years of Collaboration

Science & Technology Facilities Council

Since the 1970s, the Science and Technology Facilities Council (STFC) and Oxford Instruments have developed a mutually beneficial relationship building on scientific discoveries and their industrial application to create technological benefits for both organisations, and creating impact for the UK's economy and society.

This case study illustrates how the UK's publicly-funded science base, coupled with the entrepreneurial vigour of technology-based companies such as Oxford Instruments, can result in visionary, world-beating technology, with consequently significant benefits. Those benefits were facilitated by long-term collaborations between STFC (and its predecessor organisations[1]) and Oxford Instruments, allowing knowledge to be shared and potential application areas to be identified and explored over a 40-year period.

Financial benefits have accrued over many decades, and have incorporated inventions and developments from both organisations. As a consequence, quantification of such benefits is not straightforward. **However, Oxford Instruments is estimated by the authors to have gained a cumulative financial benefit in excess of £100 million**, though it could be considerably higher.

One of the most notable impacts from this relationship has come from the early development of superconducting wire. This has been applied to various fields of scientific research, most notably for medical use in MRI scanners. The collaboration between Oxford Instruments and STFC laid the foundations for the now worldwide MRI industry, whose cumulative contribution to UK GDP was estimated at £111 million in 2010, supporting 2,200 jobs[2]. MRI has led to improved healthcare and is particularly important for the diagnosis and treatment of conditions such as cancer and dementia. Over 2.5 million MRI scans are performed in the UK each year.

In addition, some of the major challenges of the 21st century are being addressed by technologies (such as superconducting magnets) developed by the two organisations: infectious diseases, radioactive waste, information storage, energy supply and many others have been beneficiaries. It is expected that the societal benefits resulting from applications of these technologies will continue to be significant for many decades to come. As a consequence, Oxford Instruments considers that partnership with STFC will be a productive and rewarding part of its development strategy.

Introduction

Oxford Instruments is a leading UK technology company with a turnover in excess of £360 million in 2013/14. It designs and manufactures high-technology tools and systems capable of fabricating, analysing and manipulating matter at the nanoscale. The company has worldwide sales to the science, energy, environmental, health and security industries.

STFC is a public body funded mainly by the UK Government's Department of Business, Innovation and Skills (BIS). STFC supports fundamental research in the fields of particle physics, astronomy and nuclear physics; it operates or contributes to major UK research facilities such as Diamond Light Source; and it manages subscriptions to leading international science facilities including CERN and major astronomical telescopes overseas.

Oxford Instruments and STFC (and its predecessors[1]) have collaborated over many decades on topics including superconducting wire and magnets, particle accelerators and applications of cryogenic technology. Some of the resultant benefits are discussed in this case study.

The Early Years

From the early 1960s, fundamental research was being carried out at STFC's Rutherford Appleton Laboratory (RAL) investigating how superconductivity could be applied to particle accelerators. From this work, much of it led by Martin Wilson, emerged a means of fabricating superconducting wire to make it practical for scientific and industrial use. This unique cable design is now known world-wide as the 'Rutherford Cable'. Some of the RAL research, particularly on means of joining superconducting wires, was an important enabling technology for Oxford Instruments' NMR and MRI businesses. The first superconducting magnet was manufactured by Oxford Instruments around 1962. The significance of the work was summarised by Martin Wilson: **"I think it is fair to say that the development of filamentary wires by Rutherford … revolutionised the superconducting magnet business."**

Figure 1, the first superconducting magnet manufactured by Oxford Instruments.
Credit: Oxford Instruments

Credit: Dreamstime.com

In the mid-1980s, Oxford Instruments entered a lengthy and intensive collaboration with RAL and Daresbury Laboratory to allow the company to develop a product for IBM known as Helios – a compact accelerator which was intended to show how X-ray lithography could allow higher performance in semiconductors. The expertise gained was used to underpin Oxford Instruments' beamline business.

In a collaborative project which began its design phase in 1987, Oxford Instruments designed, constructed and supplied superconducting magnets to the Synchrotron Radiation Source (SRS) at Daresbury Laboratory, expanding the range of applications to which the SRS could be applied. As an indirect result, research facilities, many of them overseas, purchased similar magnets for their synchrotron light sources.

Current Collaborations

Oxford Instruments is a key supplier to STFC's ISIS neutron scattering facility and Diamond Light Source, providing superconducting magnets to extend the capabilities of these two major international facilities. The design and manufacture of these magnets has been carried out with considerable exchange of knowledge between the facilities and Oxford Instruments.

The liquid cryogens required by the current generation of superconducting magnets is becoming increasingly expensive, and Oxford Instruments has invested considerable resource in cryogen-free refrigeration. ISIS has collaborated with Oxford Instruments to design and test dry cryostat technology. As a result Oxford Instruments released a product in 2013 called ISISstat, which is being marketed for other neutron scattering experiments (see Figure 2).

Credit: Oxford Instruments

Looking to the Future

Collaborative, forward-looking programmes continue to involve both Oxford Instruments and STFC. For example, a joint project between Oxford Instruments, the Hitachi Laboratory at Cambridge, and STFC developed platform technology for quantum computing, which could revolutionise computer performance. It uses Oxford Instruments' world-leading, cryogen-free refrigerators, which can reach extremely low temperatures.

The early research has also contributed to a major international programme: nuclear fusion technology is being explored at ITER, a European facility in the south of France. If successful, it will offer almost limitless energy, but practical applications are many years in the future. The process being used at ITER requires very strong magnetic fields, and Oxford Instruments won a major contract to supply superconducting strand to ITER. Although the structure of this strand has evolved considerably since the earliest multifilamentary wire designed by Martin Wilson and his colleagues at RAL, the design can still be seen as a long-term beneficiary of the innovations made there.

Figure 2, ISISstat was developed through a collaborative project between ISIS and Oxford Instruments.
Credit: Oxford Instruments

Direct Economic Impact

Listed below are examples, quantified where possible, which illustrate how contributions from STFC have led to direct economic benefits for Oxford Instruments. Throughout, it should be recognised that whilst significant research breakthroughs were made within STFC, it was only by the application of substantial development by Oxford Instruments and its partners that those inventions could be commercially exploited by Oxford Instruments.

It is estimated by the authors that over the last 40 years, technology which has had its origins in, or has been assisted by, STFC has contributed to Oxford Instruments' product and service mix by at least £100 million of the company's revenue. This includes:

- Oxford Instruments' beamline business, which drew on expertise gained in the development of Helios, is estimated to have generated revenue of £20 million to £30 million over 5 – 10 years.
- Sales of the Helios lithography equipment to IBM, valued at about £18 million.
- Sales of magnets and associated equipment directly supplied to the SRS, Diamond Light Source and ISIS Neutron Scattering Facility (all funded wholly or partly by STFC) amounted to more than £2 million.
- Building on the success of the sales to ISIS, Oxford Instruments has supplied similar equipment to comparable research institutions overseas, with benefits to Oxford Instruments' revenue stream and the UK's balance of trade.

In addition, it is estimated that the supply of superconducting wire to ITER, the nuclear fusion research facility, has contributed more than **£30 million in revenue to Oxford Instruments.** The design of such wire has developed greatly from, but still has its origins in, the early research at RAL.

Wider Social and Economic Impact.

Collaborations between Oxford Instruments, STFC, academia and other companies have contributed to wider and indirect societal and economic benefits as well as the direct mutual benefits achieved by Oxford Instruments and STFC described above.

Although Oxford Instruments sold its share of the Magnetic Resonance Imaging (MRI) magnet business in 2003, the company was a significant early force in a business which made a direct value-added contribution to UK GDP of about **£111million and supported 2,200 jobs in its supply chain in 2010.**

The cumulative contribution of the industry to UK GDP in the years 2011 – 2015 is estimated[2] by Oxford Economics to be of the order of £300 million, with over 2.5 million MRI scans performed in the UK each year.

In addition, MRI has led to improved healthcare through its special capabilities in imaging soft tissue, particularly important for the diagnosis and treatment of conditions such as cancer and dementia. The Oxford Economics study also estimates that the economic impact of the availability of MRI for just one common condition (surgical treatment of prolapsed discs) is estimated to be around £166 million per annum.

Facilities, some funded by STFC, used Oxford Instruments' superconducting technology to support drug discovery, disease investigation and similar life-enhancing scientific developments. **The work at the SRS, using Oxford Instruments' magnets, allowed investigation of environmentally significant issues such as the determination of arsenic in plants and water, and the treatment of radioactive waste.**

More generally, Oxford Instruments has invested in widespread public engagement and involvement including numerous publications, and 14 Queen's Awards for Enterprise, seven of which related to technology described in this study. Many staff have also transferred between Oxford Instruments and STFC, including Martin Wilson, whose work was highly significant in making possible the commercial use of superconducting magnets.

Credit: STFC/John Willoughby

Overview

The diagram below shows, in schematic form, a number of the inputs from STFC technology which have benefited elements of Oxford Instrument's business.This diagram does not show direct cause and effect; nor does it indicate the magnitude of the inputs or outputs. It does show the multi-faceted nature of the co-operation over many decades, and the breadth of science and application areas made accessible by the two organisations working together.

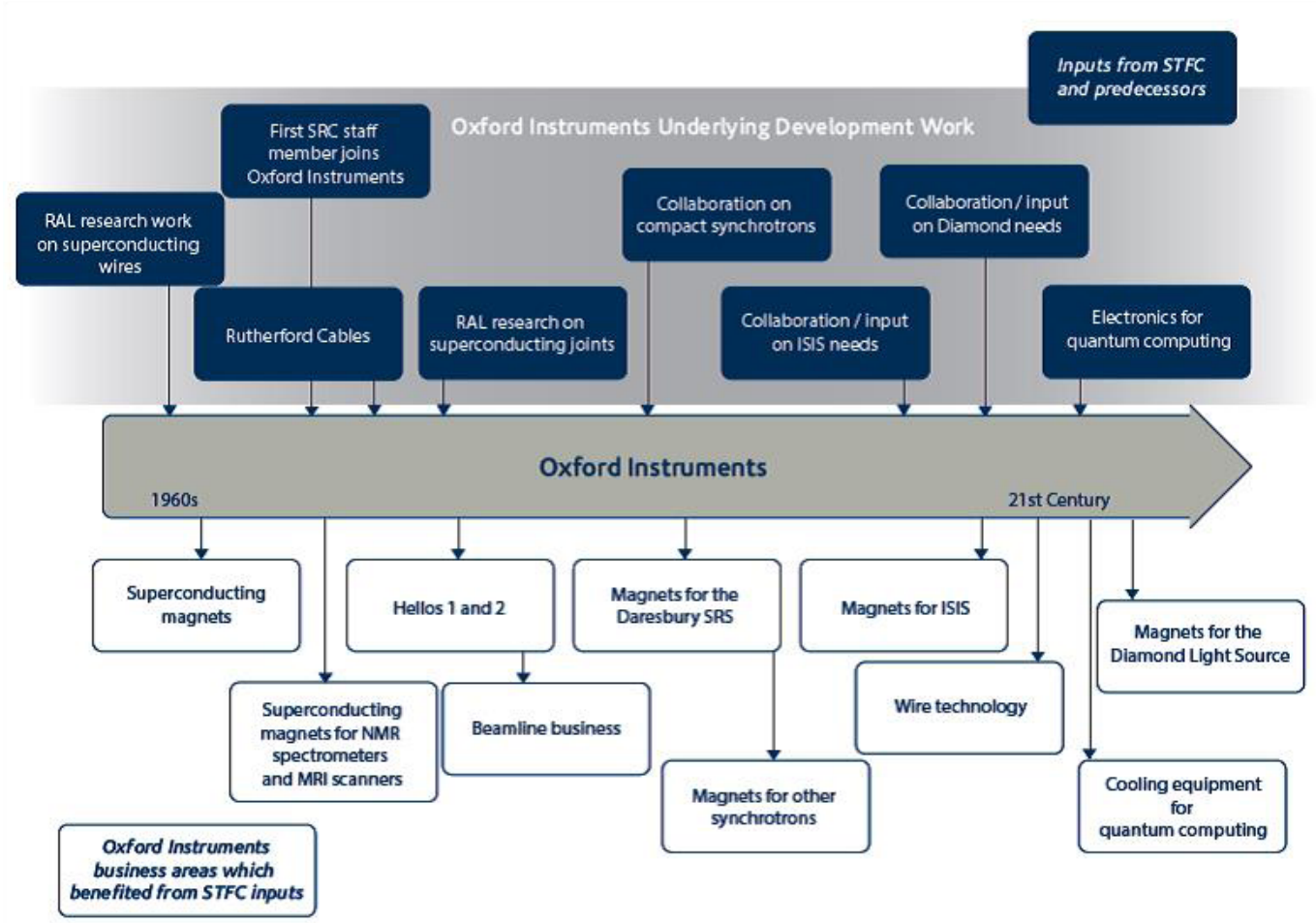
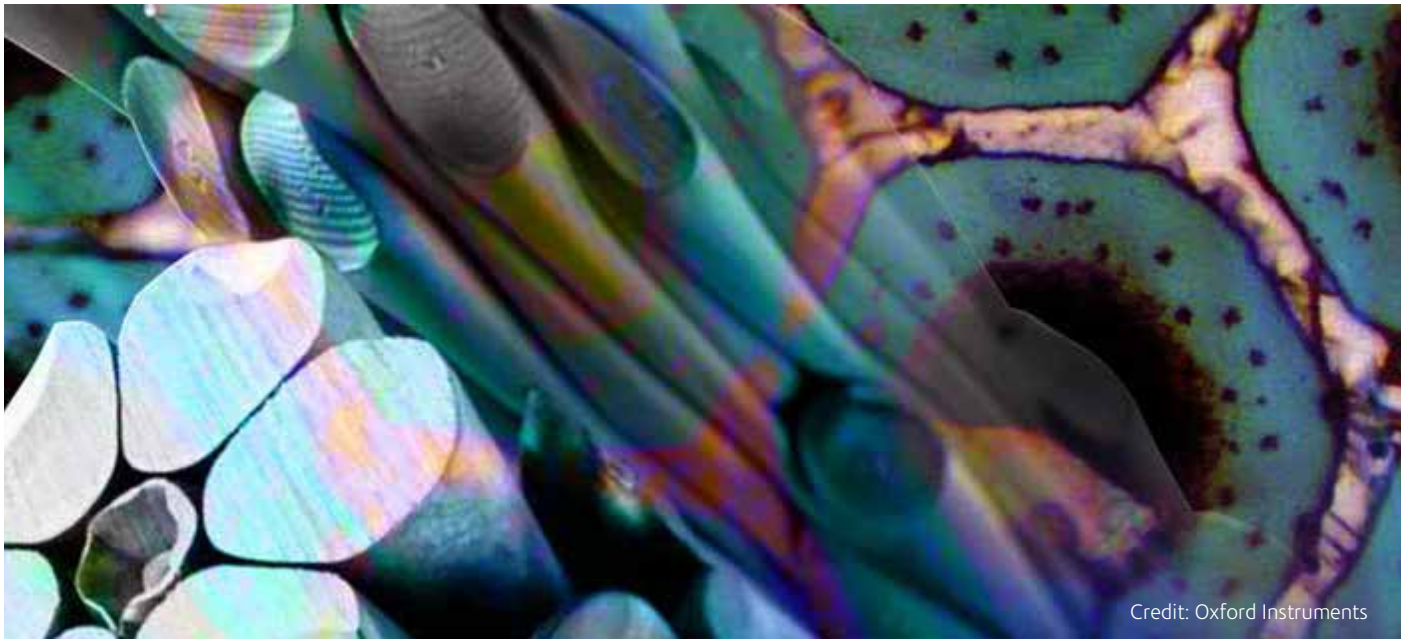


Figure 3, Schematic Representation of STFC Inputs to Oxford Instruments. Credit: STFC


Credit: Oxford Instruments

Conclusion

This case study illustrates how the UK's publicly-funded science base, coupled with entrepreneurial technology-based companies such as Oxford Instruments, can result in visionary, world-beating technology, with consequently powerful economic and societal benefits.

Oxford Instruments has benefited by exploiting early stage, intrinsically high-risk, technology from early STFC research which had an uncertain outcome, unquantifiable benefits and no guarantee of any financial return at its conception. In turn, STFC has benefited from Oxford Instruments' growing capabilities not just in magnet research, but also in, for example, cryogen-free refrigeration. It is estimated by the authors that Oxford Instruments has gained a cumulative financial benefit in excess of £100 million, though it could be considerably higher.

The science emerging from the combined efforts of Oxford Instruments and STFC has been applied to a remarkably diverse range of uses, including elucidation of protein structures, design of novel materials and otherwise intractable medical diagnoses. The most notable impact from the collaboration has been the development of MRI technology, which has supported an industry that made a direct value-added contribution to UK GDP of £111million and supported 2,200 jobs in its supply chain in 2010. MRI also has significant social impact with 2.5 million scans performed in the UK each year; it is a key tool in the imaging and treatment of many conditions.

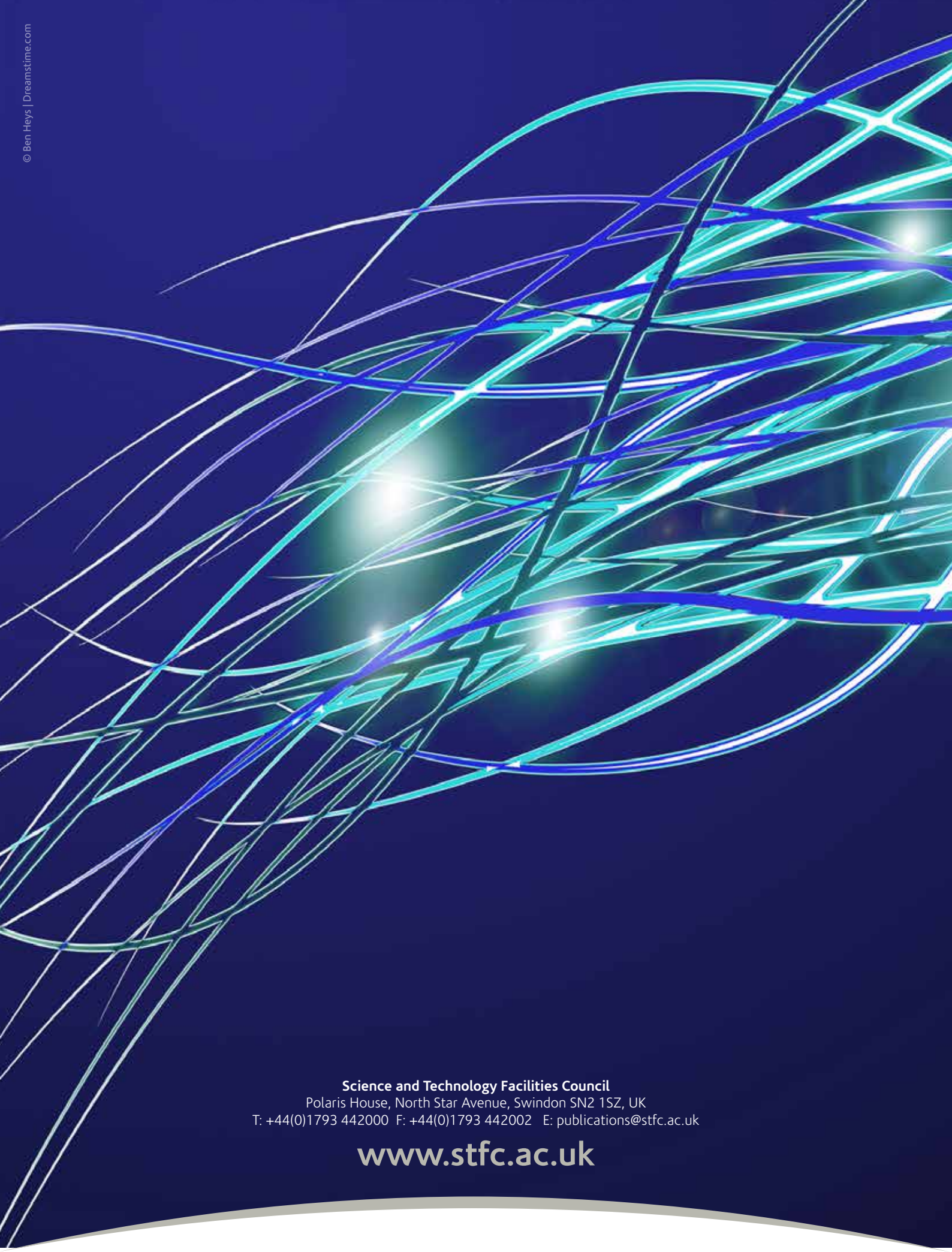
Oxford Instruments continues to be a significant partner to STFC, using its expertise to expand the capability of some of STFC's large facilities – a collaboration which continues to the present day. It is expected that the societal benefits resulting from applications of these technologies will continue to be significant for many decades to come.

References:

[1] In this document, STFC should be understood to mean the Science and Technology Facilities Council and its predecessor bodies including the Science Research Council (SRC), the Council for the Central Laboratory of the Research Councils (CCLRC), the Particle Physics and Astronomy Research Council (PPARC) and the Science and Engineering Research Council (SERC).

[2] 'The economic impact of physics research in the UK: Magnetic Resonance Imaging (MRI) Scanners Case Study', Oxford Economics on behalf of STFC (2012).

ISIS and Diamond Light Source. Credit: STFC



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