

RESEARCH PERFORMANCE & **ECONOMIC IMPACT REPORT**

2011/2012



CONTENTS



Summary	1
Routes to Impact	4
Supporting Excellent Research	5
Contributing to Growth Through Focus on Challenges	8
Developing and Sustaining Research Leaders	14
Actively Encouraging Knowledge Transfer	16
Methodological Developments and Future Challenges	22
Metrics	24
Bibliography/References	26

SUMMARY

EPSRC delivers impact and enables growth through active sponsorship of its £3.3 billion portfolio of research and training which provides new ideas, innovative technologies and skilled people. We maximise the opportunities for impacts to be achieved through partnership working: in addition to key partners such as the Technology Strategy Board (with whom we have invested over £130 million) we have over 2,000 companies and other organisations engaged in our research and training activities; currently 44 per cent of our research portfolio is collaborative with users. A recent independent study demonstrated that maths research alone was worth over £200 billion to the UK economy in 2010. People are also key: EPSRC supports high quality, internationally-leading researchers throughout their careers through innovations such as EPSRC Centres for Doctoral Training (CDTs) and flexible support packages. Currently we support 5,500 researchers on grants and over 9,300 doctoral students. EPSRC researchers have a strong track record in delivering impact through excellent research: this report describes how we are continuing to build on past successes as well as developing new opportunities.

Engineering and physical sciences will play an important part in the government plans for growth, particularly in knowledge intensive sectors, which accounted for around a third of UK output and a quarter of total employment in 2011¹. EPSRC has strong, internationally leading research and postgraduate training portfolios in these sectors, for example:

Advanced manufacturing

- Aerospace
 - EPSRC portfolio of over £100 million in aerospace and defence research.
 - Strategic partnerships involving joint investment of £14 million with leading aerospace manufacturers including Rolls-Royce and BAE Systems.
 - Partner in the recent investment of £7.5 million in aerodynamics and aerospace announced by the government in July 2012².
- Automotive
 - Investment of over £100 million in transport and vehicle research.
 - Strategic partnership with leading manufacturer – Jaguar Land Rover.
 - Long-term EPSRC support for Warwick Innovative Manufacturing Research Centre³ (more than £16 million over ten years) has enabled establishment of £92 million National Automotive Innovation Campus at Warwick as part of the government's £1 billion investment in research infrastructure.

Information economy

- The RCUK Digital Economy Theme, led by EPSRC, has invested £138 million (since its inception in 2008) in building the capacity and expertise needed to realise the transformational impact of digital technologies on aspects of our society and economy through three research hubs and training a new generation of digital economy researchers through seven Centres for Doctoral Training in areas as wide-ranging as digital entertainment, including computer animation, financial computing and digital technologies for the creative sector.
- The theme has leveraged an additional £25 million through contributions from over 600 partners.

Energy

- EPSRC leads the RCUK Energy Programme which is investing more than £625 million in research and skills to deliver this low carbon future.

¹ BIS Economics Paper No 18 Industrial Strategy: UK Sector Analysis Sept 2012

² <http://www.epsrc.ac.uk/newsevents/news/2012/Pages/aerospace.aspx>

³ <http://www.epsrc.ac.uk/newsevents/news/2012/Pages/scienceinfrastructure.aspx>

£3.3b

portfolio of research and training

5,500

researchers supported

9,300

doctoral students supported

2,000

companies/organisations engaged in research and training activities

£200m

investment in aerospace and defence and transport and vehicle research

Over 600

partners in Digital Economy

Over 1,000

active collaborative projects in Energy

£500m

invested in pioneering healthcare technologies

- The Energy Programme is helping the UK Government to develop policy: there is a long standing relationship between the programme and the Department of Energy and Climate Change (DECC) policy team who draw on the work of the programme and the expertise of its research leaders, for example, the Bioenergy Strategy published in 2012 drew on the work of SUPERGEN, an initiative within the Energy Programme.
- The Energy Programme works closely with more than 500 public and private sector organisations and has 1,100 active collaborative projects. Major partnerships include £14 million joint funding with E.ON to develop low carbon energy solutions, and with EDF to reduce energy demand in buildings.

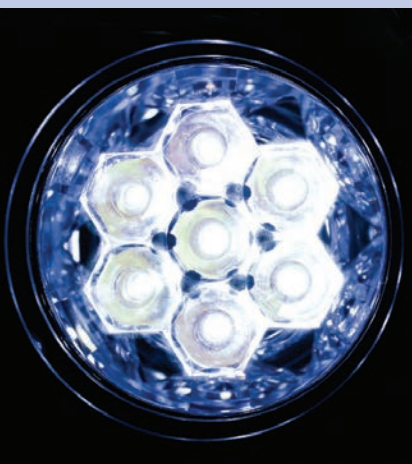
Healthcare

- EPSRC investment of over £500 million in a host of pioneering healthcare technologies for the life sciences sector, from drugs and imaging technology to medical devices, cell-based therapies and cloud-based information networks.
- Support for healthcare-focused Innovative Manufacturing Centres in areas such as low-cost pharmaceutical products (involving 25 partners) and Regenerative Medicine (involving over 30 industrial partners).
- Highly successful spinouts arising from EPSRC-supported research include Apatech, a world leader in synthetic bone material, which was sold for \$330 million in 2010, and cell-based therapy specialist, Tissue Regenix, which raised £25 million through a share placing in 2011.

Emerging technologies

EPSRC also plays a key role in delivering the technologies with potential to have a material effect on future growth rates, areas identified by the Government such as synthetic biology, graphene, intelligent sensor networks and service robotics. These are all areas where engineering and physical sciences continue to play an important part, for example, long-term investment by EPSRC over more than a decade, allowed Professors Geim and Novoselov to undertake their ground-breaking work which led to their Nobel-prize winning discovery of graphene. EPSRC is continuing to build on that success by investing further in research into manufacturing processes and technologies linked to graphene in order to accelerate the development and generation of novel devices, applications technologies and systems as part of a £50 million government investment to establish the UK as a global hub and ensure it remains at the forefront of graphene research and technology.

Some other significant achievements from 2011/12 are highlighted below.



SUSTAINED EPSRC INVESTMENT LEADS FROM INITIAL SPARK TO ENERGY EFFICIENT LIGHTING

A new technique that paves the way for manufacturing affordable LED light bulbs will be exploited in the UK: a team led by Professor Sir Colin Humphreys at the University of Cambridge, has developed a new cost-effective method of producing gallium nitride crystals used in LEDs. This will be commercialised by a new arm of Plessey, called Plessey Lighting, which will initially make LEDs on silicon for external manufacturers, but in time hopes to develop its own light bulbs in-house. EPSRC has supported the research which has led to this innovative breakthrough for over ten years. Minister for Universities and Science David Willetts said: "Professor Humphreys' work shows the potential of science to drive growth and create the high-tech jobs of the future. Not only could his research result in a highly marketable, low carbon alternative to the everyday light bulb, but he has worked closely with industry to ensure that the commercialisation process also happens in the UK."

<http://www.epsrc.ac.uk/newsevents/news/2012/Pages/allsetandreadytoglow.aspx>



SUCCESSFUL SPIN-OUT BASED ON EPSRC-FUNDED RESEARCH ENDS 2011 ON A HIGH

Tissue Regenix, a spin-out company from the University of Leeds, has successfully raised £25 million through a share placing to invest in further research and development. The company hopes to create around 30 specialist jobs as a consequence. Tissue Regenix's dCELL technology is based on licensed patents arising from EPSRC-funded research at Leeds conducted by founding directors Professor John Fisher and Professor Eileen Ingham. The process removes cells and other components from human and animal tissue and allows them to be used to replace worn out or diseased body parts – without the need for anti-rejection drugs. In August 2012 Tissue Regenix was described by City analysts Peel Hunt as: "One of the most exciting medical device opportunities." Following placement and completion of the investment, the market capitalisation of the Tissue Regenix Group will be between £90 and £100 million. The successful fund-raising comes hard on the heels of a major Queen's Anniversary Prize awarded to the EPSRC-funded Institute of Medical and Biological Engineering (IMBE) at the University of Leeds.



EPSRC KNOWLEDGE TRANSFER SUPPORT ENABLES NEW LOW-COST BABY SCANNER

Sonar expert Jeff Neasham at the University of Newcastle has made an inexpensive scanner which can plug into a laptop and produce pictures of the unborn child on the computer screen. EPSRC knowledge transfer funding allowed him to build a prototype of the hand-held USB device, which is roughly the size of a computer mouse and works in a similar way to existing ultrasound scanners, using pulses of high frequency sound to build up a picture of the unborn child on the computer screen. But, unlike the technology used in most UK hospitals costing between £20,000 and £100,000, this scanner can be manufactured for as little as £30-40. Spurred on by the funding from the EPSRC, the team manufactured the scanners at a low enough cost for doctors in developing countries – supplying vital antenatal information that could save the lives of thousands of women and children. (UN statistics estimate more than 250,000 women die annually from complications during pregnancy or childbirth, almost all of them – 99 per cent – in developing countries. Most of these deaths are avoidable and a lack of access to equipment is cited as one of the key factors.)

EPSRC-SUPPORTED PHD STUDENTS DEVELOP AWARD-WINNING CLIMATE CHANGE WEBSITE

Myths circulating online about climate change cause misplaced apathy or alarm. A website built to be the antidote has won a major global award for a team from the University of Southampton.

Globe-Town.org won third prize in the first international 'Apps for Climate' competition (#Apps4Climate) held by the World Bank, presented at a ceremony in Washington DC. By opening up the facts of climate change in different countries, Globe-Town shows how no one is isolated from the consequences in an interdependent world. The site also reveals how responding to climate change presents a world of opportunities to inspire individuals and entrepreneurs. The application was conceived by web science and sustainability researcher Jack Townsend and developed with a team including four other PhD students from the Web Science Doctoral Training Centre in Southampton's prestigious department of Electronics and Computer Science (ECS). It was funded by the EPSRC-led RCUK Digital Economy Theme.

Prize winner in
'Apps for Climate'
competition

ROUTES TO IMPACT

The routes by which impact is realised are varied and complex, however, there are some key themes which are common in many cases:

- Sustained funding – successful impacts tend to be built on long-term, sustained funding, often over a decade or longer, by EPSRC and others.
- Flexible support – often a variety of support mechanisms, including funding focused on individuals such as PhD students.
- Active involvement of research users in the development of a programme, for example through collaborative grants, secondments etc.

The following case studies illustrate these features.

“Research support from EPSRC over many years has been vital to our progress.”

Professor Jennifer Kirkham
University of Leeds

LONG-TERM EPSRC SUPPORT FOR FUNDAMENTAL RESEARCH LEADING TO INNOVATIVE APPLICATION

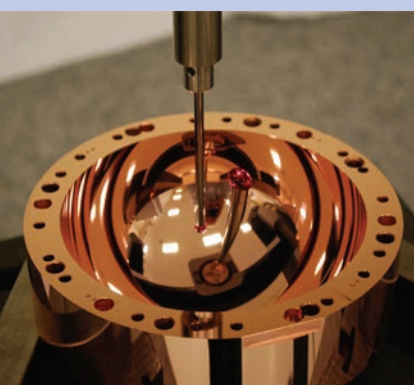
Fundamental research in the 1990s at Leeds into peptides and tooth development was taken forward by EPSRC-supported research grants and the Innovation and Knowledge Centre: it has now delivered a ‘non-invasive’ treatment for tooth decay. The key is a new generation of bioactive materials which simulate normal tooth enamel development through biomimetic ‘scaffolds’ capable of inducing the mineral deposition required for repair of tooth decay. Leader of the research, Professor Jennifer Kirkham, said: “Research support from EPSRC over many years has been vital to our progress. The early grants, including an EPSRC CASE award in 2003, enabled us to develop our fundamental research breakthrough while the support from EPSRC and the TSB for major IKC funding up to 2014 has given us the opportunity to intensify the drive to application and extend the dental product range.” The licence to use the process in dentistry has been granted to spin-out company Credentis. The peptide material has now received its CE label and is approved for use by dentists in Europe and Switzerland, being marketed as ‘Curodont’. Credentis, which has established a new UK base, has recently obtained approval to market the product in Canada, opening up the North American market. Other exciting potential for the research includes use of peptides in the repair and regeneration of bone.

EPSRC SUPPORT ENABLES RESEARCH LEADING TO WORLD-CLASS FABRICATION CAPABILITY

In the late 1970s SERC, the forerunner of EPSRC, funded Cranfield to build a large-scale diamond turning machine to produce mirrors for X-ray space telescopes. The machine tool technologies pioneered then, along with more recent developments from a Cranfield spin-out company and the Cranfield-led Ultra Precision Surfaces Innovation Knowledge Centre have resulted in a world-leading capability to fabricate master tool drums for producing structured ultra-precision film.

The EPSRC and Welsh Assembly Government funded IKC was initiated in 2007 with £7 million support and enabled the team to move on from leading research to establishing a world-class manufacturing fabrication capability based at Technium OpTIC. By 2010 the facility began landing contracts, delivering over £1.5 million worth during a period when it had established its capability and grown its international customer base. The manufacturing supply chain includes two English manufacturers of diamond tools, a Welsh fabricator of the drums and another Welsh company producing the high-quality coatings onto the drums. The strength of this manufacturing provision is based not only on its own skills but also the key know-how of its supply chain.

The economic potential is significant: the advanced films span a vast array of products – from children’s toys and computers, to TVs and large advertising displays. Benefits derived from the new techniques include lower energy consumption, greater illumination and longer battery life. Improved visual quality and new developments in 3D and security features are also made possible. Harvesting solar power at lower cost is another example of the potential economic benefit. Another opportunity is producing films and tools for the fabrication of luxury fabrics for the fashion industry.

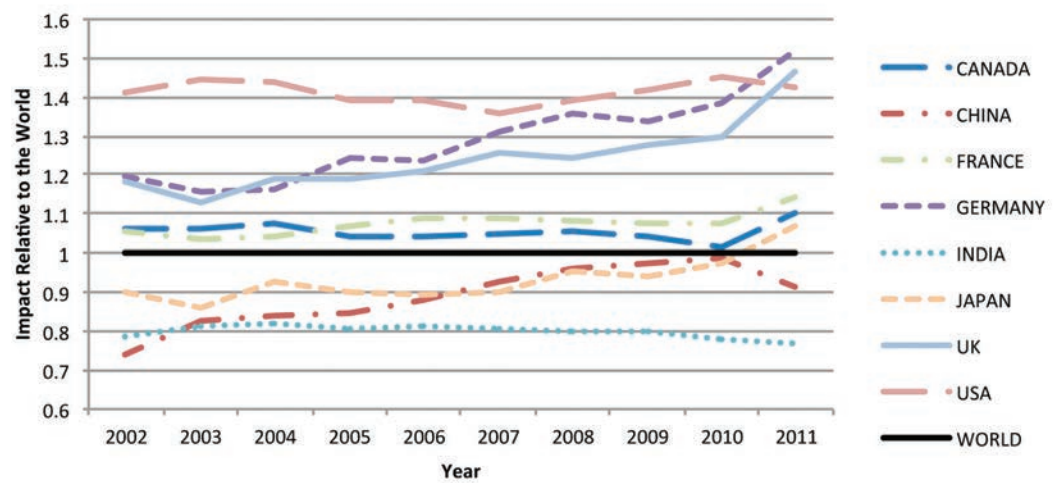


SUPPORTING EXCELLENT RESEARCH

In engineering and physical sciences the UK's citation impact is second in the world

Research is a vital component in the UK innovation landscape, as highlighted within the Innovation and Research Strategy for Growth Economics Paper⁴. EPSRC is instrumental in shaping the research landscape to play an important role in innovation through the research we fund, the infrastructure we support, the talents we develop and help prosper, as well as the partnerships with business and government that we forge on behalf of UK research. EPSRC delivers impact through continued investment in high quality research. To maintain the UK's global research standing in light of increasing international competition, and with limited funding available, EPSRC is focusing its investments on excellent research in areas that are of long-term strategic importance to the UK to ensure a balanced portfolio which enables ground-breaking transformative research to be fully encouraged and supported.

EPSRC supports excellence across its portfolio: analysis undertaken by EPSRC demonstrated that, collectively in the research areas that fall primarily within our remit, the UK's citation impact has overtaken the USA and is second in the world.



Tackling challenges through international partnership

Research is international and many challenges that we face are global. As well as maintaining the strength of UK research, EPSRC encourages its researchers to collaborate with leading groups around the world: over 40 per cent of the papers published in 2011 which acknowledged EPSRC support had at least one international co-author. As well as providing funding for UK researchers to collaborate internationally with their chosen partners, EPSRC also engages with key research agencies in target countries to develop joint programmes of support. Most recently we have engaged with the National Natural Science Foundation of China (NSFC) to fund joint research projects into smart energy grids: this new initiative was announced in January 2012 by the Chancellor of the Exchequer, Rt Hon George Osborne MP, during his visit to China. It follows a series of previously supported calls for collaborative research with China in areas such as renewable energy generation, carbon capture and storage and cleaner fossil fuels. As a result of these calls the RCUK Energy Programme, led by EPSRC, currently has 24 collaborative research projects with China, five of which are jointly funded with NSFC.

Over 40% EPSRC papers are internationally co-authored

⁴ Innovation and Research Strategy for Growth Economics Paper (No 15)

<http://www.bis.gov.uk/assets/biscore/innovation/docs/e/11-1386-economics-innovation-and-research-strategy-for-growth.pdf>

India-UK
collaboration involves
over 200 scientists in
both countries

We have also worked closely with our counterparts in India, particularly in the digital economy area: this has culminated in a £10 million investment in India-UK ICT research collaboration, involving 200 scientists in both countries, which was announced in April 2012 by the UK's Minister for Universities and Science David Willetts, during a meeting with India's Science and Technology Minister Vilasrao Deshmukh in London. This is the second phase of the joint activity which was initiated in 2009. More recently EPSRC has launched a call with DST to stimulate proposals to address Advanced Manufacturing Research Challenges.

Encouraging creative solutions

EPSRC works closely with its researchers to encourage creative ideas to flourish, as often it is these 'high-risk, high-return' approaches which can transform our understanding and lead to a wide range of unforeseen outcomes. Under the umbrella of our IDEAS Factory we have been exploring a number of different approaches over the last decade, all aimed at supporting and enabling people to express their creative and transformative ideas. We have pioneered the model of 'Sandpits' – proactively bringing together researchers and research users from different areas and perspectives to drive lateral thinking and radical approaches to addressing particular research challenges. Sandpits lead to a variety of outcomes including research projects, feasibility studies and networking activities. They have resulted in some ground-breaking research in areas ranging from tackling gun-crime to the psychological impact of disaster⁵. These leading edge, innovative processes are now also widely used by others such as UK Universities, other research councils and funding agencies worldwide, including the US National Science Foundation (NSF), NASA and FRENZ (Facilitating Research co-operation between Europe and New Zealand).

Over the last year we have continued to encourage innovative proposals through sandpits in areas such as Innovative Solutions to Flood Risk. We have also piloted other approaches including the Big Pitch which involves a 'Dragons' Den-style' presentation (to date, we have managed two Big Pitch calls for radical ideas in diverse topics of Frontier Materials Manufacturing and Chemistry and Beyond), Creativity@home, and Dream Fellowships which enable talented researchers to pursue new research directions which have the potential to lead to high impact and/or disruptive outcomes.

Building capacity through sustained support

EPSRC provides sustained funding to the best researchers and groups to enable them to undertake longer-term programmes of cutting-edge research, to develop capacity through building teams of leading people, and to respond quickly to exciting opportunities as they arise. During 2011/12 we awarded over £93 million in programme grants alone, in areas including infrastructure systems, nanostructures, number theory and social machines.

Future success is also dependent on developing strengths in emerging technologies, putting the UK at the forefront, so they are well positioned to be able to capitalise on the potential applications. For example, synthetic biology – the application of engineering tools and principles to the design and manufacture of biologically based parts, devices and systems – is an emerging technology with the potential to address a range of important challenges, including healthcare, manufacturing, novel materials, bio-fuels/energy, bio-remediation/clean water. The UK is second only to the USA in terms of publication output; in part, this is because EPSRC has made some high quality investments in the area, including the establishment in 2009 of the Centre for Synthetic Biology and Innovation (CSynBI) through an EPSRC Science and Innovation award that aims to build new activity in areas of national strategic importance, with a particular focus on supporting new research leaders, and transformative research in partnership with the US NSF. EPSRC is continuing to build on those investments with the provision of major funding of £5 million to establish platform technology which will enable synthetic biology applications to be produced and commercialised.

⁵ <http://www.epsrc.ac.uk/funding/grants/network/ideas/Pages/whatisasandpit.aspx>

“The IDEAS Factory Sandpit mechanism is unique and has already shown a universally positive impact for those attending.”

Independent Evaluation Panel

Over £90m awarded
in 2011/12 for longer-
term programmes of
cutting edge research

Synthetic biology research is already delivering outcomes, for example, researchers funded by EPSRC have successfully demonstrated that they can build some of the basic components for digital devices out of bacteria and DNA, which could pave the way for a new generation of biological computing devices. The researchers, from Imperial College London, have demonstrated that they can build logic gates, which are used for processing information in devices such as computers and microprocessors, out of harmless gut bacteria and DNA. Although still a long way off, the team suggests that these biological logic gates could one day form the building blocks in microscopic biological computers. Their work was announced through a paper published in *Nature Communications* and later covered by the *Financial Times Magazine*. Radio 4's programme *Click On* featured an interview with members of the team⁶.

Importance of cutting edge facilities for research excellence

Access to cutting-edge facilities is vital for our researchers to maintain programmes of world-leading research delivering a broad range of impacts. We have continued to deliver major developments in e-infrastructure and management of capital equipment. Two recent examples are included below.



Minister launches next generation of supercomputing for UK researchers

The launch of HECToR Phase 3 supercomputing facility, funded by a £13.9 million grant from EPSRC, took place in February 2012. At the launch event, jointly hosted by the University of Edinburgh and the UK Research Councils, Minister for Universities and Science David Willetts said: "E-infrastructure is fundamental to modern research and development. It helps our world-leading science base achieve breakthroughs across a range of important disciplines and helps industry design and manufacture new products."⁷

Unique new UK imaging facility

EPSRC-supported micro-vis X-ray imaging facility at the University of Southampton produces high-resolution 3D images that enable the internal structures of objects to be studied in incredible detail without damaging them. The centre's facilities have already been used to:

- scan contemporary aircraft materials, revealing damage processes vital to future air safety;
- generate 3D images of bone grafts to show how they are 'taking' to human tissue;
- examine the Staffordshire hoard which is the largest ever find of Anglo-Saxon gold;
- study plant roots to understand how these might be affected by climate change and what this might mean for crop productivity and food security; and
- examine fossilised crocodile dung from Africa, providing insights into the local water conditions where bipedal apes may have first evolved.

X-ray imaging
facility helping to
keep air travel safe

⁶ <http://www.epsrc.ac.uk/newsevents/news/2011/Pages/computermaygrow.aspx>

⁷ <http://www.epsrc.ac.uk/newsevents/news/2012/Pages/nextgenerationsupercomputerlaunch.aspx>

CONTRIBUTING TO GROWTH THROUGH FOCUS ON CHALLENGES

In addition to supporting excellent research across all areas of its portfolio, EPSRC focuses support on tackling some of the most serious challenges facing the UK, including the need to build a strong economy, produce sustainable low-carbon energy, develop a resilient integrated national infrastructure and a healthy society with personalised healthcare for everyone. Currently we are focusing our resources on supporting four main themes: Manufacturing the Future, Energy (an RCUK cross-Council initiative), the Digital Economy (an RCUK cross-Council initiative), and Healthcare Technologies.

Advanced manufacturing

Advanced manufacturing has been identified by the Government as a key sector for focus within its Industrial Strategy as it offers significant potential for economic growth. The UK enjoys world leadership in established manufacturing industries such as aerospace and pharmaceuticals and in emerging fields including electronics design and advanced materials such as graphene. Manufacturing accounts for just over 40 per cent of innovation in the UK market sector, due partly to the relatively high investment in knowledge by this sector⁸.

To ensure that we can maintain our competitive advantage, EPSRC is investing over £380 million in cutting-edge manufacturing research with additional leveraged funding of over £160 million from 1,100 collaborating companies and other external organisations including key players such as Rolls-Royce, Jaguar Land Rover, BAE Systems and GlaxoSmithKline. In addition we support over 2,000 doctoral students in areas related to manufacturing, many of whom work on industrially related projects. In January 2010, three EPSRC Centres for Innovative Manufacturing were launched as part of a £70 million government commitment to UK manufacturing. In March 2011, nine further EPSRC Centres for Innovative Manufacturing were announced as part of the Advanced Manufacturing strand of the Government's Growth Review. The £55 million portfolio of EPSRC Centres (which build on the previous highly successful Innovative Manufacturing Research Centres⁹) is supported by 165 separate companies, including Airbus, Renishaw, Rolls-Royce, BAE Systems, SPI Lasers, AstraZeneca, GlaxoSmithKline, GE Healthcare, Carl Zeiss, Delcam, Unilever and Ford. EPSRC is currently building on this critical mass of expertise through a call for further centres in identified areas including future electronics, healthcare technologies, and resource efficiency in manufacturing. The selection process is underway and EPSRC plan to announce support for four new centres in spring 2013.

To meet the manufacturing challenges of tomorrow we need to transfer industry best practice to the academic world: to enable this, in the last 12 months EPSRC has introduced Fellowships in Manufacturing, for outstanding individuals with a strong industry background to enable them to become international research leaders, able to set and drive new research agendas, bring together multidisciplinary teams to solve real-world problems, and influence, inspire and motivate a wide sphere of stakeholders. The first four recipients were announced in May 2012¹⁰ and another call is currently underway. To supply UK industries with the skilled researchers they need to drive growth, EPSRC has also been investing in Centres for Doctoral Training, including five Manufacturing CDTs with funds of £14 million which were announced by Minister for Universities and Science David Willetts in September 2012.

Through the Manufacturing the Future theme, EPSRC is:

- investing in a new generation of centres to become national foci within their research fields;
- developing a balanced portfolio of long-term, speculative research as well as research where the benefits and manufacturing outcomes are clearly evident;
- encouraging research into identifying and progressing long-term research fields, manufacturing informatics, sustainable manufacturing;
- developing leaders in manufacturing research with credibility with industry and policymakers;
- encouraging co-production with business partners particularly in relation to major investments such as the Centres for Innovative Manufacturing;
- working with partners such as TSB.

⁸ Driving economic growth: Innovation, knowledge spending and productivity growth in the UK – Jonathan Haskel et al January 2011 (NESTA)

⁹ A recent study has shown that EPSRC-supported manufacturing research centres delivered gross impacts of around 16 times the EPSRC investment: Economic Impact of the Innovative Manufacturing Research Centres: Final Report, DTZ, 2011

¹⁰ <http://www.epsrc.ac.uk/newsevents/news/2012/Pages/manufacturingfellows.aspx>

£380m invested to maintain competitive advantage in advanced manufacturing

Additional £160m leveraged from 1,000 collaborating companies

EARLY BENEFITS FROM EPSRC MANUFACTURING CENTRE

In its first year of operation, the EPSRC Centre for Innovative Manufacturing in Photonics at the University of Southampton won a six-figure research contract from an SME, Fianium, to develop advanced optical fibres for its business. The UK company, competing in the high-tech industrial laser sector, has previously had to source abroad for many of its fibres. A fibre delivered six months into the project was deemed so successful that it was incorporated into one of the company's products. The EPSRC centre is continuing to work with the company developing additional fibres, to return the manufacturing of these key components back to the UK.

Technology for a sustainable economy

Barack Obama stated in 2009 that "New clean energy technologies developed through research and development funding will power our long-term prosperity". This is equally true for the UK as for the United States: the UK has set itself the target of reducing emissions by 80 per cent by 2050, an enormous task requiring systemic changes to every sector of energy generation and use. This trend towards tougher environmental standards and the likely increase in international agreements will drive demand for low carbon goods and services, including green energy generation. New technologies are key to meeting new green demand, and UK venture capital investment in cleantech, including green energy, was around £400 million in 2011, the third largest in the world. New export opportunities are likely to appear with an international transition to greener economies. EPSRC leads the RCUK Energy Programme which is investing more than £625 million in research and skills to deliver this low carbon future. The Energy Programme works closely with more than 500 public and private sector organisations and has 1,100 active collaborative projects. Major partnerships include £14 million joint funding with E.ON to develop low carbon energy solutions, and with EDF to reduce energy demand in buildings. The Energy Programme is also helping the UK Government to develop policy: there is a long standing relationship between the programme and the DECC policy team who draw on the work of the programme and the expertise of its research leaders, for example, the Bioenergy Strategy published in 2012 drew on the work of SUPERGEN, an initiative within the Energy Programme.

We are forging major international links to address global energy challenges, for example with China on renewable energy systems and cleaner use of fossil fuels. The programme is also investing over £80 million to generate the skilled researchers and business leaders needed to drive the transition to a low carbon future, by supporting over 900 PhD students working on energy research including 13 specialist centres providing doctoral and industrial training in energy systems, low carbon technology, nuclear, renewables and demand reduction.

During the last year EPSRC has continued to strengthen the key role of the RCUK Energy Programme through further developments such as:

- The establishment by EPSRC in partnership with the DECC of a £13 million UK Carbon Capture and Storage (CCS) Research Centre which will bring together over 100 of the UK's world-class CCS academics and provide a national focal point for CCS research and development¹¹. The Carbon Plan (DECC 2011) stated that CCS was one of the three low carbon technologies for the future; worldwide up to \$40 billion has been committed by governments to support CCS projects and, if CCS opportunities develop as anticipated, benefits for UK-based firms have been estimated to be up to £6.5 billion a year by the late 2020s¹².
- Developing leaders in manufacturing research with credibility with industry and policymakers.
- The funding of a new SUPERGEN Bioenergy Hub which will investigate the efficiency and whole-life impact of a variety of bioenergy techniques and accelerate the deployment of sustainable bioenergy. It is supported by a £3.5 million grant from EPSRC and spans six research institutions and involves ten industrial partners¹³.

¹¹ <http://www.epsrc.ac.uk/newsevents/news/2012/Pages/newccscentre.aspx>

¹² DECC (2012) Learning by doing – launching the CCS Commercialisation Programme <http://www.decc.gov.uk/assets/decc/11/cutting-emissions/carbon-capture-storage/4900-ccs-roadmap-ccs-commercialisation-programme.pdf>

¹³ <http://www.epsrc.ac.uk/newsevents/news/2012/Pages/supergenhub.aspx>



UK Carbon Capture and Storage Research Centre established with DECC - bringing together over 100 leading UK researchers

900

PhD students working in energy research

Examples of the impacts arising from previous support in this area are given below.



UK'S FIRST NEARSHORE WAVE ENERGY DEVICE BASED ON EPSRC RESEARCH

The UK's first nearshore wave energy converter is based on the 'Oyster' device which originated from EPSRC-funded research at Queen's University Belfast. Oyster is designed to capture the energy found in nearshore waves up to depths of 10-12 metres. A commercial farm of just 20 devices could provide clean renewable energy to a town of 6,500 homes. In June 2012 the first electrical power was supplied to the grid from a fully operational second-generation Oyster 800 wave energy machine, installed by company Aquamarine Power at the European Marine Energy Centre in Orkney. The company is planning to install the next-generation Oyster 801 next to Oyster 800 – the first step in demonstrating how a wave farm of multiple Oysters will operate.

EPSRC-supported research has also led to a marine technology device which is claimed will produce the world's first domestically affordable electricity from a tidal source within the next year. Nautricity, the spin-out company, has completed the proof of concept testing of its second generation device and has been awarded £1.4 million from Scottish Enterprise, which will be used towards the total cost of building and testing its tidal current turbine.

AWARD-WINNING ENERGY STORAGE SOLUTIONS DEVELOPED BY EPSRC-SUPPORTED RESEARCHERS

An innovative energy storage project co-developed by EPSRC-supported researchers at the University of Leeds with project partner, Highview Power Storage, is being used to provide electricity to the National Grid from a pilot facility near Slough. The system stores off-peak energy, using liquefied air as the storage medium. Hosted by the utility company Scottish & Southern Energy (SSE), the 300-kilowatt demonstration plant is connected to the grid on the Slough Trading estate and is large enough to meet the power needs of several hundred houses for at least eight hours. The project won the ultimate accolade, the Grand Prix, at The Engineer Magazine's 2011 Technology and Innovation Awards, and was also winner of the Energy category.

Technology and
Innovation Award
winner

Digital economy

The rapid changes and global take-up seen in ICT offer significant opportunities to the UK. The UK computer software industry is estimated to be worth £9.2 billion and is currently the second largest market by value in the EU, and accounts for five per cent of the worldwide market. The UK ICT industry, including software and IT services, cyber security and telecoms, has a strong reputation for innovative technology and design as well as high-end security activities. This is backed by strong research and science capability which ensure that UK companies stay at the forefront of this highly versatile sector, contributing to over seven per cent of UK GVA¹⁴.

The UK Government is putting a considerable resource into digital activities and for this investment to be successful a high quality research base is essential: the RCUK Digital Economy theme, led by EPSRC, aims to fulfil that role by supporting research to rapidly realise the transformational impact of digital technologies on aspects of community life, cultural experiences, future society and the economy. Since its inception in 2008, the RCUK Digital Economy theme has invested £138 million in building the capacity and expertise needed to realise the digital economy through three research hubs and training a new generation of digital economy researchers through seven Centres for Doctoral Training.

¹⁴ BIS Economics Paper No 18 Industrial Strategy: UK Sector Analysis Sept 2012

£9.2b

estimated value of UK
computer software
industry

Digital Economy Review - 'good evidence of early impacts'

EPSRC, on behalf of the UK research councils, conducted a review of the impact of RCUK-supported digital economy research in May 2012. As well as looking at scientific impact, such as the development of new tools or collection of new data that would accelerate or otherwise benefit future research, the panel looked for wider forms of impact, including influence on government policy and the creation of new cultural and social experiences for society at large. The Review Panel found good evidence of early impacts arising from the Digital Economy theme and were confident that further significant impact could be anticipated as the work funded by the theme matured. There were good examples of strong user engagement, for example, the UCL Financial Computing CDT has strong user engagement with financial user groups and institutional support (giving leverage of four times EPSRC investment), and the Oxford Healthcare Innovation CDT shows good evidence of working with clinicians.

Recent developments include an investment of £10 million in the India-UK Advanced Technology Centre (IU-ATC), a collaborative programme funded by EPSRC and the Indian DST together with industrial partners in both countries. The centre will be focusing its efforts on developing low-cost solutions for rural access to broadband, improved use of available spectrum as well as applications for rural health monitoring, emergency and disaster communications, social TV-Virtual Classrooms and other services. The ultimate aim of the IU-ATC is to develop solutions that can benefit the lives of millions of users as well as the digital economy in both the UK and India¹⁵.



EPSRC-LED DIGITAL ECONOMY PROGRAMME DEVELOPS ELECTRONIC CHEQUES

An electronic cheque which eliminates the need for costly processing by banks but preserves the simplicity and ease of a traditional cheque book has been designed by a team from York, Newcastle and Northumbria universities. The 'digital cheque book' is part of world-leading research at Newcastle University relating to ageing and health. According to Age UK, over 70 per cent of people over 65 still frequently use cheques.

The system devised by the project team, which is funded by the RCUK Digital Economy theme, led by EPSRC, uses a cheque book identical to those currently issued by banks. The only difference is that each cheque has a greyish background – which is in fact billions of tiny dots laid out in a specific pattern. Using widely available digital pens, a camera in the pen 'tracks' the cheque as it's written. Once complete, the account holder ticks a box – the only difference from a normal cheque – and the information is transmitted directly to the payee's bank account.

Newcastle University's Dr John Vines says: "The beauty of this system is that it provides a safe and cheap electronic transaction for the banks but it's a physical paper-based transaction for the customer." Regarding next steps for this technology, Dr Vines comments: "We are speaking in depth with one large British bank at a more detailed level about how the technology we have developed can integrate into their existing technical infrastructure. We have also started putting into place a collaboration with a large housing association to perform a pilot study of using the digital cheque books with their older residents who pay their rent and utility bills with cheques."

Cyber security

As society becomes increasingly dependent on IT networks, it brings not only a wealth of opportunities but also significant risks from cybercrime. Of the £27 billion lost through cybercrime in 2010, over three quarters was lost by industry (through theft of IP, customer data and price-sensitive information). EPSRC has been supporting research and training underpinning cyber security for over 20 years and currently invests over £70 million in cyber security research, with over £23 million additional funding leveraged from over 220 collaborators. As a result the UK has the world-class research base needed to meet cyber threats and enhance our security. The UK has attracted many companies involved with the cyber security area, including multinationals such as Hewlett-Packard, Thales and Microsoft.

¹⁵ <http://www.epsrc.ac.uk/newsevents/news/2012/Pages/indiaukict.aspx>

£70m

invested in cyber security research with over £23m additional funding leveraged from over 220 collaborations

With total funding of £30 million over five years from EPSRC and others, including industry collaborators, the Centre for Secure Information Technologies (CSIT) brings together research specialists in complementary fields such as data encryption, network security systems, video analytics and intelligent surveillance technology; it creates the security infrastructure needed to safeguard the trustworthiness of information stored electronically, both at home and in the workplace. In 2012, it brought together leading international cyber security research, industry and government experts for a global summit to identify, map out and ultimately combat the biggest threats to online security.

EPSRC is also supporting a multi-million pound international centre for postgraduate training in security and crime science at University College London – the first of its kind in Europe.

Pioneering healthcare technologies

The life sciences industry is highly innovative and dynamic – it is growing faster than the economy as a whole and is a key source of high-skill, high-tech jobs. Pharmaceuticals, medical biotechnology and medical technology sectors together comprise around 4,500 firms, with an annual turnover of over £50 billion and an R&D spend of nearly £5 billion. In the future the sector is likely to benefit from the disproportionate increase in demand due to rising incomes and an ageing population, leading to commercial applications in food, agricultural and pharmaceuticals sectors. The Government highlighted the key role of the life science industry in its Life Sciences Strategy, published in December 2011, which proposed measures to ensure that the UK is the best place in the world for companies to invest in the discovery, development and commercialisation of medical innovations. In recognition of this importance, EPSRC has introduced a new Healthcare Technologies challenge theme which looks across the entire EPSRC research and training portfolio from drugs and imaging technology to medical devices, cell-based therapies and cloud-based information networks, providing solutions that underpin the healthcare and life sciences sector, including the pharmaceutical and medical technology industries and the NHS. Our aim is to focus our portfolio in this area, which currently exceeds £500 million, to build greater critical mass, where UK research is internationally strong, and to increase industrial connectivity.

To help ensure the life sciences sector has the tools and techniques it needs, EPSRC is making a number of significant investments in the area including:

- A further round of cancer imaging centres (in partnership with Cancer Research UK) following on from a multi-partner investment worth £50 million in four large cancer imaging centres established to serve as focal points of world-class research using a variety of imaging techniques, such as Magnetic Resonance Imaging (MRI) and Positron Emission Tomography (PET), and five cancer imaging research programmes.
- Partnering with MRC and BBSRC in a £25 million UK Regenerative Medicine Platform (UKRMP) to address the technical and scientific challenges associated with translating promising scientific discoveries in this area towards clinical impact.
- Up to £25 million to support three interdisciplinary research collaborations to address research challenges in disruptive sensing systems (within Healthcare) which will enable approaches to prediction, diagnosis and monitoring of disease, in real time and/or at point of care.
- A Centre for Innovative Manufacturing in Healthcare Technologies.

EPSRC has supported collaborations between universities and over 650 non-university partners. Major strategic partnerships have been forged with the medical profession, the NHS, and others, including £41 million with the Wellcome Trust in four EPSRC Medical Engineering Centres of Excellence focusing on finding new solutions for arthritis, personalised healthcare, new medical devices and regenerative therapies; £24 Million in biopharmaceuticals design and manufacturing research, jointly with BBSRC and 20 partner companies; and £16.2 million with RCUK/TSB on nano-enabled transformative diagnostics and therapies.



650

collaborations supported
by EPSRC in healthcare
technologies

Over 40 per cent of all UK medical technology companies were formed in the past decade, including some significant examples where the original research was funded by EPSRC, such as PowderJect Pharmaceuticals, from the University of Oxford, which was sold for \$800 million in 2004, Apatech, from Queen Mary, University of London, a world leader in synthetic bone material, which was sold for \$330 million in 2010, and cell-based therapy specialist, Tissue Regenix, from the University of Leeds, which successfully raised £25 million through a share placing to invest in further research and development at the end of 2011 and hopes to create around 30 specialist jobs as a consequence.



EPSRC-FUNDED RESEARCH LEADS TO START-UP DRUG DELIVERY COMPANY

In 2003, EPSRC-funded research led by Professor David Barrow, of Cardiff University, inspired him to co-fund a pioneering biopharmaceutical company, Q Chip Ltd, to commercialise the technology he invented. This microsphere technology not only makes it possible to control the rate of release of a drug in the patient's body, but also ensures that it is only active in the target area, for example, cancerous tissue. The start-up project received backing from one of the UK's most high profile venture-capitalists, Jon Moulton. Moulton continues to invest in Q Chip, which has grown into an international business focusing on microcapsule-based applications in drug delivery, diagnostics and cell therapy. The Cardiff-based company now has its first overseas base in the Netherlands and maintains strong links with researchers at Cardiff. Q Chip has recently been awarded further funding of £250,000 from the Technology Strategy Board.

LONG-TERM SUPPORT FROM EPSRC FOR MEDICAL MONITORING TECHNOLOGY

Professor Lionel Tarassenko, a pioneer in medical monitoring technology, has received long-term support from EPSRC which has helped him to develop technology which empowers patients to manage their conditions themselves, for example, at home. He has founded three companies, including Oxford Biosignals, which pioneered an award-winning electronic monitoring system used to manage critically ill patients. The system has been installed in over a dozen hospitals in the UK.

Award-winning
monitoring system

DEVELOPING AND SUSTAINING RESEARCH LEADERS

EPSRC trains and supports some of the best scientists and engineers in the world. They all have a positive impact on our world – throughout their careers. They are fuelling industry with new ideas, driving forward some of our most innovative companies and providing answers to some of society's most important challenges.

For the UK to retain its position as a leader in science and technology, we need to invest not only in the future generation of researchers, but also in the highly skilled workforce which will be needed to drive the economy. Many key sectors of the UK economy are heavily dependent on engineering and physical science doctoral graduates; nearly half of all EPSRC-supported students find employment in business and public services. Manufacturing, business, finance and IT are the biggest employers of doctoral graduates in engineering and physical sciences, representing around 75 per cent of those going into industry/public services.

Clear evidence of the value of doctoral graduates was provided through a study¹⁶ commissioned by EPSRC which showed that:

- doctorate-holders are vital for competitiveness in key sectors of the UK economy – in terms of their contribution to commercial performance and improved position relative to competitors; and
- doctorate holders significantly enhance the capabilities of their companies (for example, through technical expertise, innovation/creative thinking and problem-solving abilities).

EPSRC doctoral training – delivering the skills to meet future challenges

EPSRC spends over £130 million each year in doctoral training, delivered through three main routes: Doctoral Training Grants, Centres for Doctoral Training and Industrial CASE. In 2009 EPSRC funded 45 new Centres for Doctoral Training. These included a number of Industrial Doctorate Centres (IDCs) based on the engineering doctorate model, centres focussed on EPSRC priority areas (digital economy, nanoscience to nanoengineering, and energy), and also centres in core EPSRC disciplines. The centres bring together diverse areas of expertise to train engineers and scientists with the skills, knowledge and confidence to tackle today's evolving issues, and future challenges. They also provide a supportive and exciting environment for students, create new working cultures, build relationships between teams in universities and forge lasting links with industry.

A review of EPSRC Doctorate Centres was held in 2011 with a focus on assessing progress and impact. The review panel agreed that the CDT approach was an effective way of training a cohort of students and allowed students more time to gain some specific skills. It noted that many of the centres had succeeded in leveraging substantial industrial funding using a variety of approaches. It also noted that many universities and other funders were adopting a cohort or centre-based approach to supporting PhD students. Finally, the panel noted that the centres can act as a catalyst for bringing people together, and can act as a nucleation site for a range of activities.

Following this review EPSRC has commenced planning for a new CDT call to be issued early in 2013. We have started engaging with key stakeholders on priority areas and are considering methods of alignment with other research investments (EPSRC and other sources) which was highlighted as a benefit by the review panel.

DOCTORAL TRAINING BRINGS MATHS TO MEDICINE

Cancer treatments tailored to individual patients' genetic makeup is now a step closer thanks to training provided through an EPSRC Life Sciences Interface Doctoral Centre which enabled Dr Christopher Yau to focus his mathematical skills on real-life medical challenges. Following the four-year training, Dr Yau was able to take forward his idea through the development of diagnostic tools for clinicians whilst supported jointly by EPSRC and MRC on a Special Training Fellowship. "These statistical methods were part of my PhD initially, but have since been expanded into use for diagnosis tools and been developed commercially by pharmaceutical companies, Pfizer and Roche for example," says Dr Yau.

¹⁶ The Value of PhDs: the Impact of Doctoral Education in Research Intensive Employers – DTZ 2011

Nearly half of
EPSRC PhD
students are
employed in
business/public
services

Commercially
developed by
pharmaceutical
companies

400

Research Fellows supported

EPSRC supports world-leading individuals who are delivering the highest quality research to meet UK and global priorities. We are developing the next generation of researchers with the greatest potential across the postdoctoral, early and established career stages. Currently we are supporting nearly 400 Research Fellows at various stages in their careers; increasingly these will be working in areas where growth is required and where they can integrate their work into the wider landscape.



EPSRC LEADERSHIP FELLOW FLIES HIGH

A taste for science where 'the answer really mattered' was the early-career inspiration for Dr David Dye to become a leading player in superalloys research worth billions of pounds to the aero industry. EPSRC support for this success in cutting-edge materials science began with an EPSRC/Rolls Royce Doctorate in 2003 and Dr Dye has since risen to a prestigious EPSRC Leadership Fellowship in 2011. This is enabling him to pursue leading edge research on new families of alloys which can reduce engine mass and thus improve engine efficiency: "Small percentage fuel savings in jet engines – now running at two per cent a year – are vital for the economics of the UK's largest exporter, for the economics of flying and reducing the carbon dioxide emissions of air travel," explains Dr Dye. The US airline industry spent some \$47 billion on fuel in 2011¹⁷ so savings of two per cent would be very significant.

¹⁷ <http://www.transtats.bts.gov/fuel.asp>

ACTIVELY ENCOURAGING KNOWLEDGE TRANSFER

45%

of EPSRC portfolio is collaborative

£400m

additional funding leveraged from industry

The strengthening of knowledge exchange between the research base and research users, such as those in industry, is an important part of EPSRC's strategy to achieve greater economic impact from the research we fund. EPSRC works across sector boundaries and disciplines to engage with users at a range of levels to understand their priorities, connect them with the wider UK academic community and work in partnership with universities to maintain a high level of collaboration between users and the research base. Currently almost 45 per cent of our research portfolio is collaborative, with additional funding of £400 million leveraged from industry, charities and public sector organisations¹⁸.

A major development is our £60 million three year investment in Impact Acceleration Accounts: these build on our partnerships developed with universities and the successes we have seen with previous support for knowledge transfer (through Knowledge Transfer Accounts (KTA) and Knowledge Transfer Secondments (KTS)). Impact Acceleration Accounts provide highly flexible funding for the activities we know help to deliver impact (such as people mobility and proof of concept) and have been introduced to complement 'pathways to impact' support on research grants.

Knowledge transfer support offers flexibility for researchers to take forward their findings through a range of different routes, for example through people exchange/secondments, through seed funding/follow-on support and through spin-outs. In the latter case KT funding can enable researchers to develop their product into a commercial offering. Some examples of how knowledge transfer support has been successfully used are included below.



COMPUTER ANIMATION SPIN-OUT SUCCESS

Dr Alexandre Pechev, working at the University of Surrey on satellite control systems, realised that the solution he had developed could be extended to computer animation. Dr Pechev launched a spin-out company, Ikinema, and using EPSRC KT funding he has been able to develop the technology further and work with a range of contacts in industry to produce cross-platform applications for a variety of markets, from animators to end-users. So successful has he been that one of the world's largest visual effects firms, Framestore, the animation company behind effects in movies such as the most recent Batman movie (The Dark Knight) has chosen this technology as it will shave 'days and weeks off' production time.



CLEARING LANDMINES

EPSRC KTA funding provided vital support to an initiative to tackle the legacy of landmines: there are at least 110 million active landmines in place across the world. It is estimated it would take £19 billion and over 1,000 years to clear them using current technologies. The EPSRC funds enabled the University of Manchester to undertake initial concept and feasibility projects to explore the potential for applying imaging technology developed for other applications such as airport scanners to the challenge of mine detection. The research is now being taken forward with support from the Find A Better Way charity and has also received support and donations from the risk management industry, led in particular by A-On, with £1 million pledged on an annual basis for the next three years.

The role of the EPSRC knowledge transfer funding is highlighted in a short video at: <http://www.manchester.ac.uk/business/kt/casestudies/>

¹⁸ This figure is based on the total value of 'user' contributions on collaborative grants and through co-funding as at 1 April 2012

INSPIRING SCHOOL CHILDREN

Bath University has used EPSRC KT funding to work with teachers and a scientific equipment supplier to help enthuse school students by bringing mobile sensing technology (for example for measuring atmospheric pollutant levels) into the classroom. 'Plug back into Science' was a project that engaged over 70 teachers and 50 PGCE students directly. It has increased the level of use of mobile sensing technologies in the schools involved, as well as establishing effective ongoing links. The project also involved Professor Rose Luckin of the Institute of Education, London, as the KT Mentor to influence the national policy agenda around the use of new technologies for science education.

Another way in which EPSRC encourages research results to be taken forward is through Innovation and Knowledge Centres (IKCs). These provide a shared space and entrepreneurial environment in which researchers, potential customers and skilled professionals from academia and business can work side by side to scope applications, business models and routes to market. To date EPSRC has funded six IKCs in areas ranging from smart infrastructure and construction to regenerative therapies and devices. These centres are delivering significant impacts, several of which are highlighted below.

SOLAR ENERGY SPIN-OUT COMPANY

Eight19 Ltd is a solar energy spin-out company, established in 2010 from the Cambridge IKC (Advanced Manufacturing Technologies for Photonics and Electronics), that builds on the development of clean technology to enable a new generation of low-cost, flexible plastic solar cells that have the potential to dramatically reduce the manufacturing cost and increase the throughput of solar technology. The Indigo pay-as-you-go solar technology product, developed by Eight19, has had instant success. It won the World Business and Development Award at the RIO+20 UN Climate Conference in June 2012, and is currently being used in Kenya, Malawi, Zambia, South Sudan, Uganda and South Africa. Eight19 has set up a new company, Azuri Technologies Ltd, which was launched in summer 2012. Azuri has raised capital from IP Group plc to scale-up the deployment of its Indigo technology to bring power to off-grid customers worldwide, providing basic needs that are regarded as routine in developed countries.

EPSRC-SUPPORTED INNOVATION AND KNOWLEDGE CENTRE OFFERS LIFE-CHANGING REGENERATIVE TECHNOLOGY

World-leading research in regenerating human tissue using bio-scaffolds, at the EPSRC-supported IKC at Leeds University, offers potential life-changing technology to millions and billion-dollar markets for economic success. This foundation research, supported by EPSRC for over 11 years, has led to a patented technology promising to benefit patients with 'natural' replacement tissue ranging from heart valves to parts of the skeleton. Leader of the research, Professor Eileen Ingham spells out the long-term vision for building on the already productive research platform. "Now our creation of a successful spin-out company is in place, we are looking forward to tremendous potential for growth and the development of a full portfolio of commercial products for tissue repair in many medical technology markets. Our plan is to drive forward the research 'pipeline' ranging from two dimensional scaffolds and membranes, to 3D scaffolds for musculoskeletal soft tissue repair, and then on to tackle challenges such as bone tissue repair," she explains.

Solar technology product wins World Business and Development Award



“The support from EPSRC...over many years has been crucial.”

Professor Eileen Ingham
University of Leeds

Managing Director of Tissue Regenix, Antony Odell, emphasises the importance of the credibility of the Leeds research team in helping raise the finance needed for commercial success. “The pedigree they have built up through years of innovative research has been an important factor in raising over £34 million of investment – without it we simply would not have got the required support. Also important is that the researchers do not ‘sit in a bubble’ and ensure the research is commercially relevant and is translatable to the company”, he says. In addition to vascular patches, he sees huge potential in knee damage repair, heart valves, and advanced wound care for leg ulcers.

“The support from EPSRC and other funders, including the TSB, over many years has been crucial in enabling us to pursue the basic technology and then drive forward its potential”, says Professor Ingham. Basic research was funded through an EPSRC Platform grant in 2000-03, a Portfolio grant in 2003-08 and a further Platform award for 2008-13. “We were able to use these flexibly enabling continuity of employment for key researchers”, adds Professor Ingham.

Working in partnership with the Technology Strategy Board

EPSRC works with the Technology Strategy Board (TSB) to ensure that there are initiatives and opportunities to improve the commercialisation of research, for example through Knowledge Transfer Networks, Knowledge Transfer Partnerships, collaborative R&D funding and Innovation and Knowledge Centres (see above). By working strategically with the TSB we are improving the journey towards commercialisation in key areas, for example, the development of the Catapult Centres. EPSRC and the TSB have complementary roles within the innovation system. The TSB has key strategic areas of focus where there are well-evidenced technology and innovation opportunities for UK wealth creation. EPSRC funds a broader research base, and aims to provide flexible support for a variety of purposes, including the commercialisation of research developments as they emerge, working with the TSB and other partners when appropriate. EPSRC spent £23 million in collaboration with the TSB in 2011/12 in key areas such as advanced manufacturing and energy. For example, EPSRC and TSB launched a joint £7 million investment through a staged approach in 2010 to transfer world class knowledge from universities into business-led early stage projects, to research the use of nanoscale technologies in the next generation of solar energy harvesting. The purpose was to connect UK based supply chains and position industry as a dominant force in next generation solar energy harvesting for worldwide markets. Building on the success of this competition, EPSRC and TSB teamed up to deliver a joint £9 million investment in nano-enabled healthcare diagnostics and targeted delivery of therapeutics in November 2011 (see case study below).

EPSRC/TSB supporting scale-up of nanoscience technologies

In February 2012 EPSRC and TSB announced joint support of over £6.5 million for seven business-led projects focused on developing therapeutic agents and diagnostics based on nanoscale technologies. The investment built on earlier funding from EPSRC to two of the university partners: the current projects were designed to scale-up the technologies developed in the first stage and are a good example of pulling nanoscience research originally funded by the research councils through to application by co-funding with the TSB. The projects are led by companies including Critical Pharmaceuticals Ltd, Johnson Matthey plc, Nanometrics Ltd, Renishaw Diagnostics Ltd and Sharp Laboratories of Europe Ltd. The aim of the investment is to help ensure that the UK can become an early competitive adopter of these novel technologies and rapidly meet the urgent and difficult challenges posed within the worldwide healthcare sector, by translating world-class early stage ideas from academia and commercialising them through building supply chains with innovative businesses. Key challenge areas include the earlier and better detection and diagnosis of disease, leading to marked improvements in patient outcomes, and highly effective treatments that are tailored to patients’ needs, and which either modify the underlying disease or offer potential cures.

Pulling EPSRC-funded nanoscience research through to application by co-funding with the TSB

New Centre for Synthetic Biology launched

Over £320m

joint investment with leading partner organisations

We have also worked closely with TSB, particularly in the development of the Catapult Centres in high value manufacturing, offshore renewable energy, cell therapy, connected digital economy, future cities and transport systems. We have provided significant analysis of relevant strengths within the research base which enabled selection of the most suitable areas for Catapults and we are ensuring appropriate alignment and engagement with the priority themes in our portfolio.

We have also continued the dialogue with TSB on potential areas for future Innovation and Knowledge Centres (IKCs) which provide a focus for the development of emerging technologies. The creation of a new IKC in synthetic biology was recently announced by the Business Secretary, Vince Cable (September 2012). IKCs were established by EPSRC as centres of excellence with five years' funding to accelerate and promote business exploitation of an emerging research and technology field. The Innovation and Knowledge Centre for Synthetic Biology will be the seventh IKC.

Shared focus with research users

EPSRC has continued to engage with key user organisations at a strategic level to ensure a shared focus on user-inspired challenges. We have partnerships with leading organisations including Rolls Royce, Procter & Gamble, GlaxoSmithKline and the MOD: total joint investment to date in jointly developed activities exceeds £320 million, of which over a third has come from partners. We have been continuing to develop a cross-sectoral approach to these partnerships, for example, in August 2011 we formed a strategic partnership with eight other organisations¹⁹ including six industrial partners, to fund novel research in autonomous and intelligent systems. Robotics research and the development of intelligent autonomous systems, such as unmanned aircraft, are vital to many major UK companies, emerging industries, and SMEs, from advanced manufacturing to oil and gas exploration, nuclear energy to railways and automotive, healthcare to defence. As a result we have been able to provide support worth £16 million in total to support 22 projects covering topics including:

- **Building vehicles with legs** – looking at how visual information is used to adapt to changing terrain and environment by studying how humans behave via head-mounted cameras. This could speed up the development of vision control for land-based vehicles with wheels or legs.
- **Accessing Hazardous Environments** – exploring how multi-unmanned vehicles can be coordinated to act together to perform different tasks and intelligently navigate without access to aids like GPS. This work can have applications in areas such as remote inspection in hostile environments, autonomous urban driving, defence, logistics, security and space robotics.
- **Improving Human Autonomous Systems interaction** – testing different models of information gathering, communication and decision-making between humans and autonomous systems with the aim of improving reaction speed, safety and reliability.
- **The self-drive submarine** – demonstrating how Autonomous Underwater Vehicles (AUVs), performing inspection and investigation missions, can cooperate and pool information to achieve success when communications are intermittent and external control restricted, this could apply to space or other hostile environments.
- **Novel Sensing Networks for Intelligent Monitoring** – developing a revolutionary autonomous, intelligent condition/structural health monitoring system with specific applications for railways and Non-Destructive Evaluation for nuclear applications.

¹⁹ The partners are BAE Systems, Schlumberger, National Nuclear Laboratory (NNL), Sellafield Ltd, Network Rail, SCISYS, DSTL and the UK Space Agency

“...autonomous and intelligent systems are going to be an integral part of our infrastructure and society...”

James Baker, Managing Director of BAE Systems

The awards were announced by Minister for Universities and Science David Willetts who said: “Robotics and autonomous intelligent systems are areas of science in which the UK has world class expertise, but to reap the full benefits for the economy and society we need to get better at applying the technology to industry. This £16 million investment will bring together leaders from the research base and business to develop systems for a range of important sectors, from transport to aerospace.” Commenting on behalf of the six industry partners, James Baker, Managing Director of BAE Systems’ Advanced Technology Centre, said: “It is vital for the universities to work with industry to drive these technologies forward as autonomous and intelligent systems are going to be an integral part of our infrastructure and society in the near future.”

EPSRC supported research and training delivers impact in a broad range of areas of societal importance such as health, security, energy, transport and the environment. We work closely with key government departments and public and third sector organisations, for example through strategic partnerships, analogous to our relationship with companies. For example:

- EPSRC leads interactions with the Ministry of Defence and Defence Science and Technology Laboratory (DSTL) on behalf of all research councils (we currently have a £14 million collaborative portfolio with DSTL);
- we also maintain good engagement with Department for Transport, Department for Energy and Climate Change (DECC), Department for Communities and Local Government;
- EPSRC currently chairs the Low Carbon Innovation Coordination Group;
- Energy Strategy Fellow working on road mapping with DECC and joint funding of Carbon Capture and Storage with DECC.

EPSRC also plays a key role in supporting and enhancing the capability and expertise of our leading researchers, so that they can provide expert input to government in policy development.

Engaging the public

EPSRC encourages researchers to consider two-way engagement with the public through interaction and dialogue to inform their research. We are integrating public engagement activities across all of our research and training priorities with the aim of building a high quality portfolio that is more closely linked to the research we fund, encompassing a greater section of the research community and ultimately having the potential for much greater impact than a dedicated funding scheme. Examples of how EPSRC-supported researchers are engaging effectively with research users including the public are provided below.

PROFESSOR NICK TYLER from University College London researches how people interact with the environment. This has led him to set up the Pedestrian Accessibility and Movement Environment Laboratory (PAMELA). To maximise the impact of his research he has engaged with both users and the public leading to a collaboration with Thameslink2000 train link in London resulting in national impact for train design in the UK.

PROFESSOR RHODRI WILLIAMS from the University of Swansea changed the direction of his research from the rheology of industrial engineering fluids to rheology of blood coagulation through a chance meeting. As a result, Swansea is now seen as a world-leading centre in this field and he and his colleagues have two spin-out companies and are having a clinical impact in local hospitals. He now regularly engages with a wide variety of users including the general public, as the feedback he receives from them has been invaluable to his research.

Additionally, EPSRC engages in strategic activities which are broader than a single project and specific to engineering and physical sciences. This includes projects like those described below:

COMPUTER SCIENCE FOR FUN (CS4FN)

EPSRC worked with the innovative creators of an online and physical magazine and resource aimed at engaging and exciting pupils about computer science. The project also involved the British Computer Society and the Higher Education Academy. The resources are used widely in schools and by individuals globally. Teachers use them to enthuse students and as part of classroom activity. Individuals who are interested in computer science read them for fun and to help with their learning.

<http://www.cs4fn.org/>



BLOODHOUND

EPSRC was a founder sponsor and continues to support the exciting Bloodhound project. Using the challenge of building a car capable of exceeding 1,000mph, this project's aim is to excite and enthuse a generation of school children about the possibilities of engineering. Working with some of EPSRC's key universities the team has recently hit the news with the testing of its pioneering rocket system, but more importantly has visited over 4,000 schools and engaged many more children and adults alike at events around the country. The project also engages the broader population in the UK and the world with its interactive online presence.

<http://www.bloodhoundssc.com/news-events>

METHODOLOGICAL DEVELOPMENTS AND FUTURE CHALLENGES

Understanding the routes to impact

We have continued to build our understanding of the ways in which impact can be realised and assessed. Following on from our previous studies of the economic benefits arising from chemistry research, Doctorates, and the EPSRC Innovative Manufacturing Research Centres (IMRCs), working in partnership with the Council for the Mathematical Societies (CMS) we commissioned Deloitte to undertake an independent study to assess:

The economic benefits of mathematical sciences research in the UK

The study considered economic impact in terms of quantitative indicators (Gross Value Added, Jobs/employment) and qualitative evidence. A methodological approach was developed which identified occupations involved in the generation or application of mathematical sciences research (MSR) and then allocated them across sectors of the economy (ie using a SIC-SOC matrix). The data showed that in 2010, there were 2.8 million people in the UK in occupations which either entail MSR, or which directly require the usage of MSR-dependent tools and techniques. Direct GVA associated with MSR is estimated to be £208 billion in 2010, with further significant benefits coming through supply chain and consumer spending effects.

The qualitative assessment demonstrated that MSR has tangible impact on the UK economy and society through three main routes.

- Using maths to make sense of data and better understand the world:
 - o identifying trends and insights from increasingly large datasets and using algorithms to improve commercial processes and assist in developing competitive advantages.
- Using maths to safeguard society:
 - o in areas of medical and pharmaceutical research, to improve cyber security and to inform policy responses.
- Using maths to forecast, address uncertainty and optimise processes:
 - o generating forecasts which are used across industry; improving productive and managerial processes.

This study has proved valuable in extending our capability for demonstrating the impact arising from broad areas of engineering and physical sciences research. The report was published in December 2012 and can be found at: <http://www.epsrc.ac.uk/newsevents/pubs/reports/Pages/maths.aspx>

CIHE-UK IRC Enhancing Value Task Force


EPSRC has been continuing to partner with the Council for Industry and Higher Education (CIHE), the UK-Innovation Research Centre, the Technology Strategy Board, Higher Education Funding Council for England and other organisations in the Enhancing Value Task Force which is addressing the following fundamental question: how do we make the most of the UK research base? Three reports have been published: The R&D Landscape; Enhancing Impact: The Value of Public Sector R&D and Enhancing Collaboration Creating Value: Business Interaction with the UK. The conclusions and recommendations of the Enhancing Value Task Force are expected to be finalised by end of 2012.

Maximising the value of EPSRC-sponsored research and training

EPSRC has been working with its Strategic Advisory Network to explore issues relating to 'Maximising the value to the UK of EPSRC sponsored research and postgraduate training'. We are developing think pieces in five areas:

- national policy
- the innovation process
- IP policy
- global industry
- sME ecosystem

The issues raised and changes we propose to make to our support for delivering impact will be presented to our Council in December. Our SAN subgroup includes Professor Alan Hughes from UK-IRC and we are drawing on the work of the UK-IRC Enhancing Value taskforce.



Impact reviews

We have continued to build our knowledge of the impacts arising from our portfolio of research and training through evaluations and reviews. The following reviews have been undertaken and the findings are referred to in relevant sections of this Impact report.

A mid-term review of the EPSRC Centres for Doctoral Training was held in 2011 which required the centres to demonstrate acceptable progress and impact in their areas. EPSRC has 80 centres, 59 of which (ie those at an appropriate point) were reviewed. As this was a mid-term review, it focused on intermediate indicators of impact, such as collaboration and leverage. The review noted that many of the centres had succeeded in leveraging substantial industrial funding using a variety of approaches and that the centres were effective in acting as catalysts to bring good people together.²⁰

EPSRC led the **RCUK Digital Economy Impact Review** which took place in May 2012, looking at the impact of RCUK-supported digital economy research. The review encompassed both the impacts of the research to date as well as how the potential for impact was being addressed. It was conducted by a panel of 12 leading experts drawn from academia, business and other users: they took a very broad view of impact, based on the RCUK impact criteria. As well as looking at scientific impact, such as the development of new tools or collection of new data that would accelerate or otherwise benefit future research, the panel looked for wider forms of impact, including influence on government policy and the creation of new cultural and social experiences for society at large. To provide a guide to possible immediate, medium and long-term outputs and outcomes, an Impact Framework was developed, based on the RCUK definition of impact. The framework identifies a number of elements under each of the four broad impact headings (Capability; Economy; Knowledge and Society) and suggests quantitative and qualitative indicators that could be used for each.

The outcomes of the review were discussed at the Digital Futures 2012 All Hands event in October 2012 and published on the RCUK website.

Research Outcomes System

EPSRC has continued to work with four of the other research councils (AHRC, BBSRC, ESRC and NERC) on the development of the cross-council Research Outcomes System (ROS) which went live in November 2011. Over 15,000 outputs/outcomes arising from EPSRC grants have been recorded so far, including over 11,000 publications, over 100 examples of IP and exploitation, over 600 examples of further funding and nearly 500 references to collaboration activities. Selected information from ROS (including key findings and impact summaries) is now available to see and search through the EPSRC Grants on the Web. Further development work is underway to make more of the ROS information available externally through the RCUK Gateway to Research.

²⁰ <http://www.epsrc.ac.uk/newsevents/news/2012/Pages/cdtoutcomes.aspx>

	METRICS			Definition/Comments
	2009/10	2010/11	2011/12	
Total Funds Available	836	855	831	
Budget Allocation	799	817	804	
Leverage	37	38	28	
Of Which Private	9	8	5	
Of Which From Other Research Councils	21	16	15	
Of Which From Other Source	7	14	8	
Of Which Private	1%	1%	1%	
Of Which Other Research Councils	2%	2%	2%	
Of Which Other	1%	2%	1%	
Total Expenditure	836	855	831	
Of Which Research Grants	530	550	536	
Of Which Postgraduate Awards	257	261	241	
Of Which Other Components	49	45	54	
Of Which Research Grants	63%	64%	64%	
Of Which Postgraduate Awards	31%	30%	29%	
Of Which Other Components	6%	5%	6%	
Human Capital				
Principal Investigators	3,530	3,313	3,083	Principal Investigators as at 1 April each year. The total number of investigators (ie principal and co-supported on 1/4/12) was 5504
Research Fellowships	388	353	326	Total number of research fellowships on 1 April each year (excluding Academic Fellowships which are administered by EPSRC on behalf of RCUK)
Knowledge Generation				
Number of Grants Assessed for Reporting	1,394	1,306	1,317	Number of grants assessed to which the outputs reported refer
Refereed Publications	9,475	11,223	10,743	Number of papers published in peer reviewed journals
Non Refereed Publications	13,566	16,660		Publications other than those included under refereed publications (above)
Co-authorship of Refereed Publications - International	41%	43%	44%	



Human Capital				
Number of New PhD Student starts	3160	2944	2450	Number of New PhD students supported each year
Total Number of Students Supported	10,415	10,176	9,358	
Finishing Rates	80%	82%	80%	% of PhD students submitting within six years of commencement of support (recognising that EPSRC PhD financial support is increasingly flexible). The completion rate is based on studentships reported as completed.
Knowledge Transfer and Exchange				
Patent Applications	224	243	286	
Patents Granted	25	55	56	Number of patents granted each year
Spin-outs/New Businesses Created	16	21	42	Number of new spin-outs reported
Human Capital				
Destinations of Doctoral Graduates				
Of Which University %	35%	39%	41%	
Of Which Wider Public Sector %	5%	4%	4%	
Of Which Private Sector %	42%	39%	35%	
Of Which Unknown or Other %	9%	11%	12%	
Of which Unemployed %	9%	8%	8%	

BIBLIOGRAPHY/REFERENCES

- ¹ BIS Economics Paper No 18 Industrial Strategy: UK Sector Analysis Sept 2012
- ² <http://www.epsrc.ac.uk/newsevents/news/2012/Pages/aerospace.aspx>
- ³ <http://www.epsrc.ac.uk/newsevents/news/2012/Pages/scienceinfrastructure.aspx>
- ⁴ Innovation and Research Strategy for Growth Economics Paper (No 15)
<http://www.bis.gov.uk/assets/biscore/innovation/docs/e/11-1386-economics-innovation-and-research-strategy-for-growth.pdf>
- ⁵ <http://www.epsrc.ac.uk/funding/grants/network/ideas/Pages/whatisasandpit.aspx>
- ⁶ <http://www.epsrc.ac.uk/newsevents/news/2011/Pages/computermaygrow.aspx>
- ⁷ <http://www.epsrc.ac.uk/newsevents/news/2012/Pages/nextgenerationsupercomputerlaunch.aspx>
- ⁸ Driving economic growth: Innovation, knowledge spending and productivity growth in the UK – Jonathan Haskel et al January 2011 (NESTA)
- ⁹ A recent study has shown that EPSRC-supported manufacturing research centres delivered gross impacts of around 16 times the EPSRC investment: Economic Impact of the Innovative Manufacturing Research Centres: Final Report, DTZ, 2011
- ¹⁰ <http://www.epsrc.ac.uk/newsevents/news/2012/Pages/manufacturingfellows.aspx>
- ¹¹ <http://www.epsrc.ac.uk/newsevents/news/2012/Pages/newccscentre.aspx>
- ¹² DECC (2012) Learning by doing – launching the CCS Commercialisation Programme
<http://www.decc.gov.uk/assets/decc/11/cutting-emissions/carbon-capture-storage/4900-ccs-roadmap-ccs-commercialisation-programme.pdf>
- ¹³ <http://www.epsrc.ac.uk/newsevents/news/2012/Pages/supergenhub.aspx>
- ¹⁴ BIS Economics Paper No 18 Industrial Strategy: UK Sector Analysis Sept 2012
- ¹⁵ <http://www.epsrc.ac.uk/newsevents/news/2012/Pages/indiaukict.aspx>
- ¹⁶ The Value of PhDs: the Impact of Doctoral Education in Research Intensive Employers – DTZ 2011
- ¹⁷ <http://www.transtats.bts.gov/fuel.asp>
- ¹⁸ This figure is based on the total value of ‘user’ contributions on collaborative grants and through co-funding as at 1 April 2012
- ¹⁹ The partners are BAE Systems, Schlumberger, National Nuclear Laboratory (NNL), Sellafield Ltd, Network Rail, SCISYS, DSTL and the UK Space Agency
- ²⁰ <http://www.epsrc.ac.uk/newsevents/news/2012/Pages/cdtoutcomes.aspx>

EPSRC

Pioneering research
and skills

Polaris House
North Star Avenue
Swindon, SN2 1ET
T: 01793 444000
www.epsrc.ac.uk

December 2012