EPSRC

Engineering and Physical Sciences Research Council

EPSRC

Economic Impact Baseline

2010 update

July 2010

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Executive Summary

Engineering and the physical sciences (EPS) are fundamentally important to the UK economy because of the way they contribute to innovation in products, processes, services, and public policy – one study[1] has estimated that the sectors which depend most heavily on EPS account for 30% of UK GDP, 40% of all investment, 75% of all industrial R&D, and over 80% of manufacturing exports. The same study also found that the sectors with the highest dependency on engineering and physical sciences are those with by far the fastest growth of value-added per employee since the 1990s. EPSRC supports excellent research and training which has a broad impact in many areas; recent examples include:

- Computational fluid dynamics techniques developed by EPSRC-funded engineering students at the University of Southampton has recently been used by the British Skeleton team - helping to contribute to the first British individual Winter Olympics gold in 30 years.
- The design of a new type of air-fuelled battery that has the potential have up to ten times the energy storage of designs currently available. This step-change in capacity could pave the way for a new generation of electric cars, mobile phones and laptops.
- The development of new technology that improves the sensitivity and reduces the costs of MRI scans[2].
- The development of the world's first fully operational and fully functional sustainable Formula 3 racing car[3].

World's first sustainable Formula 3 racing car

EPSRC makes an important contribution to the UK economy through the provision of a skilled workforce:

- EPSRC funds 35% of all PhDs in Engineering and Physical Sciences.
- EPSRC supports a fifth of postdoctoral researchers in all subjects.
- Many key sectors are heavily dependent on EPS PhDs and demand has been increasing in areas such as pharmaceuticals, aerospace, computing, telecommunications and finance[4].
- Over half of EPSRC-funded PhD students take up employment in business or public services.

EPSRC ensures that its training programmes have maximum impact through the involvement of user organisations in collaborative training, often focused in centres.

- The level of user engagement in EPSRC's collaborative training is significant (with over 1,000 organisations being engaged in collaborative training). Nearly one quarter of the total investment in collaborative training coming from employers in 08/09 (i.e. ~£13.3 million).
- EPSRC has added to the investment of £280 million in Centres for Doctoral Training (CDTs) made in December 2008, with the funding of three further CDTs in the area of Mathematical Sciences, bringing the total number of centres to 52 and our total investment in CDTs to £304 million. The initial 45 centres opened in October 2009, attracting high levels of both informal and formal user engagement (industrial doctorate training)[5].
- In March 2009, EPSRC announced support for the first of a new generation of EPSRC grants that will bring researchers and industry together to create technology products of the future and will foster the creation of an environment in which impact and knowledge transfer are valued and encouraged. The Knowledge Transfer Accounts (KTAs) began in October 2009 and will produce a step change in knowledge transfer from EPSRC funded research[6].

EPSRC maximises the opportunities for its investment to have impact by working in partnership with others such as the Technology Strategy Board and through the Energy Technologies Institute. EPSRC has strengthened engagement with research users through an expanding programme of strategic partnerships with a range of industries from large aerospace/defence companies (e.g. Airbus, BAE Systems) through those in energy (e.g. E.ON), home and personal care (Procter & Gamble) and pharmaceuticals (GlaxoSmithKline, Pfizer, AstraZeneca)[7]. There is evidence[8] that strategic partnerships with EPSRC have allowed partner organisations to develop a greater research range and have provided them with access to more basic research (in addition to the applied research they fund themselves). Five new partnerships were formed in 2009/10, with over £114 million research funding from EPSRC and £77 million from the partners. Partnerships have promoted engagement with universities by showing how university research can be relevant to the business, and has changed thinking about the approach to partnering and collaboration. A recent survey undertaken by EPSRC has demonstrated the value that partner organisations place on their partnerships with EPSRC.

"The partnership has given us the ability to develop a strategic approach to our research programme, as well as find out how we can get more value for money, and has increased the profile of running research in the UK. This has allowed us to get more support from our US based managers and increased the credibility of UK based research. We have greatly expanded the amount and quality of research we have been able to support thanks to the help from our EPSRC partners." Dr David York, Procter and Gamble.

*"GSK organic chemists have changed how they think about some of their research challenges, by working with them (*EPSRC*) closely we have changed that cultural mindset within GSK such that the chemists now think more broadly about the scientific challenges they are attempting to address. Our strategic partnership has stimulated areas of research within academia and conversely has introduced new ideas to the industrial chemists through two-way exchange of information."* Malcolm Skingle (Director, external science and technology, GlaxoSmithKline).

Successful outcomes arising from strategic partnerships include:

- The development of software that will help the emergency services in the immediate aftermath of natural disasters or terrorist attacks. The award-winning ALADDIN project, involves researchers at the universities of Bristol and Oxford and Imperial College London in partnership with BAE Systems.
- The development and exploitation of low carbon aircraft engine technology as a result of a partnership between Rolls-Royce, EPSRC and the Technology Strategy Board.
- The training of the next generation of world-class materials scientists and metallurgical engineers through an innovative Doctoral Training Partnership with Rolls-Royce.
- The MESSAGE project, arising from EPSRC's strategic partnership with the Department for Transport has led to the development and deployment of mobile sensors across the UK, revolutionising the way air quality is monitored and managed in urban areas.
- Innovative projects funded through the ETI that will help to ensure that the UK meets its challenging energy and climate change targets.
- Over 40 UK companies will benefit from a £18 million joint investment in regenerative medicine research and development by EPSRC, BBSRC, Technology Strategy Board and the Medical Research Council.

There are many examples of new businesses arising from EPSRC-supported research and training: 179 spin-out companies were reported in the last four years. Successful spin-out companies have been formed in areas as diverse as pure software (Autonomy Corporation), production of carbon negative products (Novacem), nanoelectronics (Nano ePrint Ltd) and the diagnosis of genetic diseases (D3 Technologies).

EPSRC continues to focus on the key challenges facing society through programmes in priority areas such as Energy, Digital Economy and Next Generation Healthcare. By working closely with its sister research councils, key government departments and other public and third sector organisations EPSRC maximises its investment and delivers impact in a broad range of areas of societal importance, examples include:

"Oyster"

- improved security (e.g. the development and exploitation of "nanotag" technology that is leading to an increase in successful gun crime convictions);
- health benefits (e.g. the development of new software that is significantly improving the lives of people suffering from chronic illnesses); and
- sustainable energy technologies (e.g. the development of the "Oyster", a new type of wave power device that has been generating power for the National Grid since November 2009).

EPSRC has also announced an investment of £11 million to fund four ground-breaking projects in which teams of researchers will use the tools and techniques of complexity science to address some of the fundamental issues facing society today (such as healthcare, banking systems, natural disasters including flooding, sustainable communities and immigration)[9].

EPSRC-funded researchers have contributed to policy development in areas such as climate change (contributing valuable evidence to the Copenhagen summit), energy (the Stern Review which led to the Climate Change Act passed in 2008) and transport (Crossrail Act) and have also influenced the introduction of government policies and regulations (for example, the cross-government strategy for food research and innovation led by Professor John Beddington).

EPSRC plays a key role in maintaining and extending the excellence of the research base, ensuring that the UK continues to attract R&D investment from leading hi-tech companies, such as those in the pharmaceutical, aerospace and electronics sectors.

EPSRC Economic Impact – Summary of progress since 2007 baseline

Delivering highly skilled people to the labour market

	2006/07	2007/08	2008/09
Proportion (and number) of EPSRC-funded PhDs taking up employment in business or public services	39% (~1000 students)	49% (>1300 students)	**53%** (>1300 students)
Net spend on PhDs	£93.9M	£99.6M	**£102.7M**
Contribution of employers to collaborative postgraduate training	£16.8M	£17.9M	**£104M ***

Improving the performance of existing business and creating new businesses

	2006/07	2007/08	2008/09
EPSRC spend on collaborative research with users (and as a % of total research grant spend)	£151M (36%)	£178M (37%)	**£199M (43%)**
Number of user organisations collaborating on current research grants	~2000	~2300	~**2300**
Number of licences and patents reported (2005-2007)	172	297	**401**
Number of spinout companies reported (2005-2007)	104	130	**179**
Spend on programmes to promote commercialisation and enterprise	£1.3M	£2.9M	**£4.7M**
Percentage of projects reporting co-publications with industry	30%	27%	**27%**
Value of investment with TSB	£20M	£61M	**£90M**

Improving public policy and public services

	2006/07	2007/08	2008/09
Value of grants involving govt/public sector organisations	£399M	£422M	**£431M**
Number of strategic partnerships with govt/public sector organisations	4	10	**10**

Attracting R&D investment from global business

	2006/07	2007/08	2008/09
UK ranking in citation impact among G8 countries	Mathematics – 1st Physical Sciences – 2nd Engineering – 3rd	Mathematics – 2nd Physical Sciences – 1st Engineering – 3rd	Mathematics – **2nd** Physical Sciences – **3rd **** Engineering – **3rd**

*This figure includes £89 million in collaborative investments committed by the project partners on the Centres for Doctoral Training announced in December 2008.

** Differences in the top three ranked countries are marginal (Germany 1.67, USA 1.65 and UK 1.63).

Introduction

The first baselines were published as part of the research council delivery plans in November 2007 and EPSRC published an update alongside its Delivery Report in July 2009. This document provides further information on how EPSRC is delivering a significant increase in the economic impact of its investment in research and training.

Our focus is on delivering high economic impact from excellent research and training.

EPSRC invests in high quality research and training which has significant impact across a wide range of areas of crucial importance to the UK including: health, energy, security, economic prosperity, climate change and the environment. Impact is achieved through different routes including:

- provision of highly skilled people into the wider economy;
- delivering improvements to existing businesses;
- creation of new businesses;
- attracting inwards investment to the UK; and
- delivering benefits to government and the public through impacts on policy and public services.

This baseline update demonstrates how EPSRC investment is achieving significant and increased impact through all of these routes.

Delivering highly skilled people to the labour market

EPSRC makes an important contribution to the UK economy through the provision of a skilled workforce: over half of our PhDs are employed in business or public services. Many key sectors are heavily dependent on Engineering and Physical Sciences PhDs and demand has been increasing in areas such as pharmaceuticals, aerospace, computing, telecommunications and finance[4]. In 07/08, over a quarter of EPS PhDs entering the private/public sector took up employment in those industries[10]. EPSRC is a significant funder of PhDs in the UK, currently supporting 35% of research PhDs in Engineering and Physical Sciences. EPSRC supports 50% of Research Council funded PhDs.

EPSRC has invested £304 million in Centres for Doctoral Training since 2008.

EPSRC ensures that its training programmes have maximum impact through the involvement of user organisations in collaborative training: over 1,000 industrial companies and other organisations are currently engaged[11]. Currently, 72% of EPSRC's Strategic Partners are formally involved in collaborative training provision.

Centres are an important way in which EPSRC maximises the impact of its user-focused training:

- The recent CBI report "Stronger together: Business and universities in turbulent times"[12], cited EPSRC's Engineering Doctorate scheme as "an excellent example of partnership between business and universities in research and training".

- Building on the success of the Engineering Doctorate and other similar schemes, EPSRC has invested £304 million in Centres for Doctoral Training (CDTs) since 2008, which engage users both directly (industrial doctorate training) and indirectly. Over a third of the new centres are Industrial Doctorate Centres (IDCs) – where students spend up to 75% of their time in an industrial environment. The multidisciplinary 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 societal challenges. CDTs have been established in the areas of crime and global security, green energy, carbon capture, healthcare and metallic systems to strengthen high value UK manufacturing. They also create new working cultures, build relationships between teams in universities and forge lasting links with industry. The initiative is widely supported by business and industry.

Arup is a partner on one of the new EPSRC centres which aims to create zero-carbon buildings. It will be based at the University of Reading and will develop and exploit technology that will reduce carbon emissions in construction, integrate zero-carbon energy sources, such as solar cells and combined heat and power systems, with demand reduction tools including smart meters and consumption feedback devices.

"*Businesses like Arup need a good supply of highly-qualified scientists with the right skills to further innovation in the design of sustainable towns, cities and the wider environment. They need to understand how business works and also be able to turn their best ideas into a successful business proposition."* Professor Jeremy Watson, global director of research at Arup.

- Improving the level of interactions between business and the research base and increasing the uptake and exploitation of our investments is very important to EPSRC. Our vision is for the UK to be as renowned for knowledge transfer and innovation as it is for research discovery. In March 2009, EPSRC announced funding of £44 million to support 12 Knowledge Transfer Accounts (KTAs). These accounts, which began in October 2009, provide funding to ensure that the research and training we support is fully exploited and will contribute to the creation of a culture in which knowledge transfer is valued and encouraged just as much as the generation of original results. Use of KTA resources to leverage and/or build on funding from other funders is actively encouraged. As part of our investment in Knowledge Transfer Accounts, the EPSRC has continued to sponsor Knowledge Transfer Partnerships (KTP) - Europe's leading programme helping businesses to improve their competitiveness and productivity through the better use of knowledge, technology and skills that reside within the UK Knowledge Base. EPSRC also provides grants to support the secondment of EPSRC-funded staff into organisations that can exploit their research results. Knowledge Transfer Secondments (KTS) can also be used to host researchers from industry working on specific projects which build on the results of earlier EPSRC funded research. EPSRC invested £11 million in KTS in 2009/10.

£55 million to support knowledge transfer.

Autonomy Corporation plc

The impact of EPSRC's investment in training is far reaching. The Autonomy Corporation plc, a company founded by Mike Lynch OBE (Cambridge) out of his SERC-funded PhD thesis and EPSRC-funded research projects has made considerable economic impact.

- After only a decade, the company is now the largest pure software company in the UK, the second largest in Europe and a member of the FTSE100.
- Over 90% of the "Fortune 1,000" companies are Autonomy customers and more than 2 billion people rely on Autonomy's software every day.
- At a time of global economic turmoil, the company has delivered an 80% increase in profitability.
- Autonomy's existence has contributed over £1.3 billion to HMRC.
- Autonomy's activities in Cambridge contribute over £10 million to the local economy each year.
- Each year Autonomy recruits over 50 top graduates from UK universities.

- EPSRC's Industrial CASE scheme enables businesses to take the lead in arranging projects with an academic partner of their choice. Pilkington UK regularly uses EPSRC for collaboration purposes, taking on several new CASE collaborations each year. This has given the company access to expertise which has assisted in the development of innovative, life-saving products such as fire-resistant glass.

Progress since last baseline

- EPSRC has continued to support significant numbers of high quality PhDs: the total number supported was ~8,000 in 06/07 and over 8,200 in 07/08 and 9,100 in 08/09.
- Building on the success of our existing Industrial Doctorate and Engineering Doctorate centres, we have funded 52 new Centres for Doctoral Training. Over the next 5 years, the new centres will deliver some 2,200 PhDs with skills required by industrial employers in areas such as wind energy, security science, biomedical engineering and water management.
- Of those graduating, the proportion of EPSRC funded students entering business or public services rose from 39% in 06/07 to 53% in 08/09 – (equivalent to ~1,000 students in 06/07 and >1,300 students in both 07/08 and 08/09).
- EPSRC's spend on collaborative training is significant (£56 million in 08/09).
- 2,500 PhD students (including 1,000 project students) were supported by collaborative schemes in 07/08. Nearly 1,400 students were registered on collaborative schemes as at 31 March 2009 (this figure will increase as further data is submitted by universities via the DTA reporting tool).

EPSRC adds value by working closely with users to understand and meet their needs and by offering flexibility in its support for training. EPSRC and its academic advisory group (Technical Opportunities Panel) and business advisory panel (User Panel) recently reviewed its support for people activities, the aim being to align our people related activities more closely to our strategy and ensure that the necessary mechanisms were in place to support people through every stage of their research careers. These bodies contain a high level of user representation enabling them to comment on the relevance of EPSRC's programme to the needs of users in industry, commerce, government and the service sector. EPSRC has now developed detailed action plans that will take forward the recommendations of the review.

There is evidence to support the fact that PhD students generate significant wealth for the economy. A recent article featured in Chemistry World written by David Lathbury, head of process chemistry at Astra Zeneca reported that the numerous medicines and treatments developed by PhD-holding organic chemists in the pharmaceutical industry have considerably enhanced the health and vitality of the UK and its bank balance (with annual sales of such products being in excess of £10 billion). He concluded that:

"PhD students produced by our higher education sector (once placed in industry) create far more monetary wealth than that associated with the particular project funded in their university department".

In July 2009, the Royal Society published the findings of a major study on the role of science in services sector innovation. Entitled "Hidden Wealth: the contribution of science to service sector innovation", the report highlights the wider significance of science, technology, engineering, and mathematics (STEM) to the services sector, which makes up around three quarters of the UK economy. The report concluded that STEM is deeply embedded within the UK service sectors and has an extensive impact on service innovation processes, which is often hidden. As an example of an important recent STEM-based technological advance the report cited the development of a hand held portable device which detects faults in cables (the "CableSniffer") developed by researchers at UMIST, through a post graduate training programme funded by the EPSRC, the Department for Business, Innovation and Skills and EA Technology. The device significantly reduces the costs associated with fault detection and reduces the environmental damage associated with more traditional methods of fault detection. The research work undertaken by a PhD student led to the development of a prototype which was subsequently brought to market by the company.
Other examples of where EPSRC-funded training has had significant monetary and societal impact include:

- A new core technology, originally developed by EPSRC-supported student Dr Mark Grubb to monitor the health of workers in metal foundries is being used to monitor the heart beats of newborn babies who need resuscitation. Phase one patient trials began in 2008 using stable newborn babies in the intensive care unit of Nottingham Queen's Medical Centre. Phase two successfully tested the sensor on newborn babies delivered by elective caesarean. Phase three trials due to be completed in 2010 will focus on premature babies in the delivery room immediately after birth. Dr Grubb's ground-breaking work has been recognised for entrepreneurial research by the Royal Academy of Engineering and Nottingham University's Institute for Enterprise and Innovation. The team expect to commercialise the device and estimate the annual EU and US market could be £18m.

- Rolls-Royce plc, the engine manufacturer, has recently won a $2 billion (£1.2 billion) contract to supply United Airlines with Trent aero-engines. Colin Small of Rolls-Royce was quoted as saying that**, "without work done by EPSRC funded students, the Trent 900 engine wouldn't have flown."**

Improving the performance of existing business

EPSRC-supported research and training leads to business benefits through: improvements to existing products/services/processes, creation of new products/services/processes and improvements to business innovation capacity. EPSRC maximises the opportunities for its

investment to have impact by working in partnership with others, such as the Technology Strategy Board and Energy Technologies Institute (ETI).

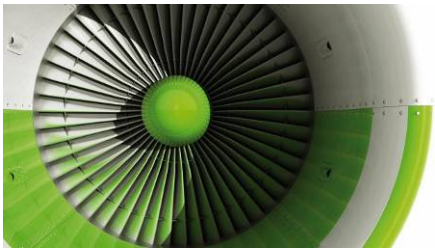
EPSRC has taken steps to re-focus its support of manufacturing research through the transition to a new Innovative Manufacturing Research Centre (IMRC) operating model. On 7th January the Prime Minister, Lord Mandelson and EPSRC Chief Executive Professor David Delpy announced £15 million funding for 3 new EPSRC Centres for Innovative Manufacturing[13]. The centres are a key element of a £70 million programme of Government funding designed to create technology products of the future, attract investment and underpin manufacturing growth. These centres will help ensure a prosperous future for the UK by creating new industries and new jobs through innovative manufacturing businesses by:

Prime Minister Gordon Brown at the UK manufacturing launch event in London, January 2010.

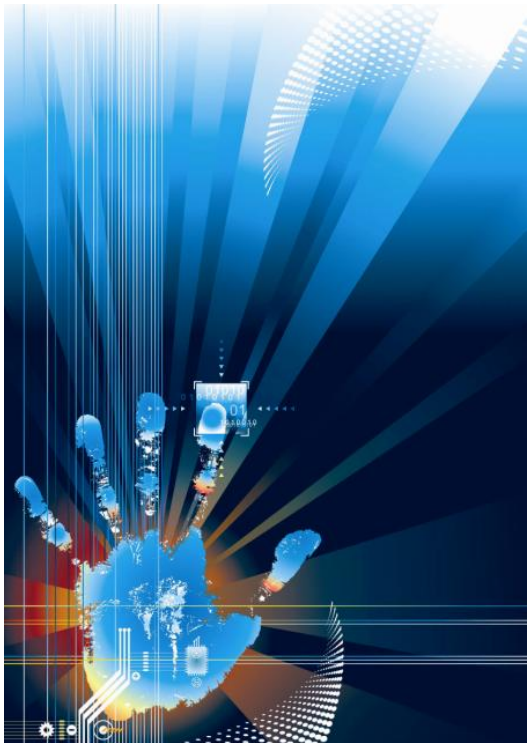
- Providing cohesion and leadership within manufacturing research.
- Building and sustaining relationships with industry and with funders and sponsors within the research domain and internationally.
- The delivery of excellent, long term transformational research with global significance and impact.

The centres will be based at the universities of Southampton (Photonics), Loughborough (Regenerative Medicine) and Brunel (Liquid Metals).

- EPSRC is making a step-change in the way in which knowledge transfer from EPSRC funded research is supported. In March 2009, EPSRC announced funding of £44 million to support 12 Knowledge Transfer Accounts with an additional £11 million investment in Knowledge Transfer Partnerships. The KTAs, which began in October 2009, will stimulate an environment and engender a culture to overcome barriers to better exploit EPSRC-funded research. They will foster the creation of an environment in which impact and knowledge transfer/exchange are valued and encouraged, just as much as is the generation of original research results. As part of our investment in Knowledge Transfer Accounts, the EPSRC will continue to support Knowledge Transfer Partnerships (KTP) - Europe's leading programme helping businesses to improve their competitiveness and productivity through the better use of knowledge, technology and skills that reside within the UK Knowledge Base.
- EPSRC has developed and maintained strategic partnerships with a range of industries from large aerospace/defence companies (e.g. Airbus, BAE Systems) through those in energy (e.g. E.ON), home and personal care (Procter & Gamble) and pharmaceuticals (GlaxoSmithKline, Pfizer, AstraZeneca). These partnerships provide a framework for sharing information and strategy, working together to support each other's objectives and jointly supporting research, training and other activities in UK universities in strategically important gap areas. We now wish to deepen our existing partnerships to maximise the value we and our partners gain from partnership, to restructure to broader sector-wide and cross-sector partnerships where appropriate, and to focus on building a small number of new partnerships in strategically important gap areas, to create a manageable portfolio.



- EPSRC also enhances knowledge-exchange through the promotion of collaborative research, for example, through programmes, which are designed to foster collaboration between academics and users around a particular challenge, such as Energy and the Digital Economy.



Centre for Secure Information Technologies (CSIT)

EPSRC invested in Innovation and Knowledge Centres (IKCs) which are aimed at accelerating and promoting business exploitation of emerging research and technology fields. Each of the five centres receives up to £6.95 million funding over 5 years with a further £2.5 million from the Technology Strategy Board. The Centre for Secure Information Technologies (CSIT) at Queen's University Belfast, is an IKC set up to exploit the university's international research expertise in high performance data and network security and intelligent surveillance. To date, 20 organisations have committed to support CSIT's work over the next five years including industrial partners such as BAE Systems and Thales UK as well as government agencies and international research institutes. A team of researchers at the centre is working to develop futuristic communications systems that could help protect frontline troops. Building on work completed recently for the UK Ministry of Defence, the project is aimed at investigating the use of arrays of highly specialised antennas that could be worn by combat troops to provide covert short-range person-to-person battleground communications. Details of the project have just appeared in IEEE Communications Magazine - one of the most authoritative international academic publications in the field.

Progress since last baseline

- By the end of 2008/09 EPSRC had contributed in excess of £90 million towards activities in partnership with the Technology Strategy Board. New areas supported include low carbon engine technology, fuel cells and hydrogen technologies, secure information technologies and innovative lighting.
- The number of EPSRC grants involving the Technology Strategy Board (as co-funder or collaborator) was 32 in 06/07, 79 in 07/08 and 126 in 08/09. The total value of the investment has risen from £20 million in 06/07 to £90 million in 08/09.
- Since 2007 EPSRC has also played a key role in establishing the £1 billion Energy Technologies Institute (ETI) and developing its research strategy**.** In 2009, EPSRC contributed to four innovative ETI projects announced that will receive ETI funding totalling approximately £20 million and will help to ensure that the UK meets its challenging energy and climate change targets.
- EPSRC has developed partnerships with key user stakeholders to ensure combined focus on priority areas. The number of organisations engaging with EPSRC through strategic partnerships is now 29 (15 in 06/07)[1].
- EPSRC expenditure on collaborative research with users has increased from £151 million in 06/07 to £199 million in 08/09.
- The number of user organisations collaborating on research grants was ~2,000 in 06/07 and over 2,300 in 07/08 and 08/09[1].
- Despite the challenging economic climate, the percentage of projects reporting co-publications with industry has remained at approximately 30% over the last three years[1].
- The number of licences and patents reported has grown to nearly over 400 in the last three years[1].

Large, multinational businesses are keen to work with the EPSRC to ensure that they are partnering with and procuring the very highest quality of cutting-edge research results and accessing some of the brightest people UK academia has to offer as well as working together to shape the future research agenda; this underpins our strategic partnership approach. Recent examples include:

- The formation of a Doctoral Training Partnership with **Rolls-Royce** in the field of Structural Metallic Systems for Gas Turbine Applications. Researchers at Rolls-Royce and the universities of Cambridge, Swansea and Birmingham will undertake the fundamental materials research necessary to improve the efficiency and environmental sustainability of gas turbine engines and will also train the next generation of world-class materials scientists and metallurgical engineers in structural metallic systems that will be critical to the future health of the discipline in UK academia and industry. EPSRC has invested £6.8 million in the partnership that has attracted £50 million total investment. Rolls-Royce are also set to play centre stage in an investment programme totalling £40 million that aims to strengthen the supply chain for the UK's aero-engine industry and accelerate the development and introduction of low carbon aircraft engine technology. The Research and Development programme will be supported by the EPSRC and the Technology Strategy Board.
- The Innovative Manufacturing and Construction Research Centre at Loughborough, in partnership with **Reebok**, has developed pioneering rapid manufacturing techniques allowing world-wide customisation of innovative sports equipment.

However, many of the most significant impacts felt by our partner companies are intangible: for example, as part of the recent strategic partnership survey undertaken by EPSRC many reported that their employees had been encouraged to enhance their strategic thinking, leading to greater creativity and competitive advantage for the company.

Creation of New Businesses

- EPSRC supported outputs are not only taken up by or carried out in conjunction with existing business but in a significant number of cases, new businesses are started. An example of a high profile spin-out is **Plastic Logic,** a University of Cambridge spin-out rooted in EPSRC-supported research raised £50.6 million to establish the world's first plastic electronics factory; it is estimated the industry will be worth some £15 billion by 2015. However, a significant number of successful spin-outs are bought up by larger organisations once the proof of concept has been demonstrated; so, whilst the absolute magnitude or turnover of spin-outs may not be large, they do make a significant contribution to the innovation ecosystem as a whole. The number of spin-out companies reported rose from 104 (05-07) to 179 (05-09)[1]. Significant high-profile successes include:

179 spin-out companies reported (05-09)

- **ApaTech Ltd** A rapidly growing international orthobiologics company specialising in the production of bone graft technologies with a major manufacturing plant in the UK and growing sales of its products worldwide. It was created in 2001 and is based directly on knowledge transfer and IP arising from research funded by major EPSRC investment in the Interdisciplinary Research Centre at Queen Mary University of London from 1991 to 2002 and has been named as Europe's fastest growing company in its category in the Deloitte 2009 Technology Fast 500 for Europe, the Middle East and Asia. It has recently been announced that the company, is to be sold to Baxter for $330 million ($290M plus $90M against sales milestones).

- **Micrima Ltd** A spin-out company from the University of Bristol formed to commercialise an innovative breast-imaging device developed by EPSRC researchers which uses radio waves and therefore has no radiation risk unlike conventional mammograms.

- **SciSite Ltd** Set up to exploit technology developed at Keele University which can test stretches of motorway for corrosion in steel reinforcement without the need to rip off the surface. This non-destructive technology, which is being used to detect structural damage in stretches of the Hammersmith Flyover in West London, is estimated to save the UK £500 thousand per year in traffic management costs.

- **Avacta** A biophysics company which provides expert services and innovative technologies to the pharmaceutical, defence and clinical industries has seen a revenue growth of 100% in 2009. The company was spun out by EPSRC-funded researchers from the University of Leeds in 2004.

- **Critical Pharmaceuticals** This biotechnology company which spun out of the University of Nottingham in 2002 recently secured an order from the Wellcome Trust to develop a nasal spray of Human Growth Hormone (hGH) using its proprietary CriticalSorb™ technology as an alternative to injection. hGH, a leading biological drug for the treatment of growth disorders, had global sales of $2.8bn in 2007.

- **Owlstone Ltd** Spun-out of the University of Cambridge by EPSRC-funded entrepreneurial students in 2004, developed a rapid and accurate chemical detection system, one hundred times smaller and a thousand times cheaper that the existing technology at the time. The technologies developed have a wide range of applications including homeland security, industrial, automotive and personal care and have won Owlstone widespread commercial and academic recognition. Based in the Cambridge Science Park, the company now employs 35 people and has secured multi-million dollar contacts from the US Department of Defense and Selex Galileo.

Improving public policy and public services

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: currently partners include the Department for Transport, Ministry of Defence, DSTL, Cancer Research UK and the Wellcome Trust. 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.

Examples of research investment which has led to impact in key areas:

- **Energy**

  EPSRC's strategic partnership with EDF energy (one of the UK's largest energy suppliers) is encouraging the speedy take up of green heating technologies in UK homes and businesses. The four-year agreement will see UK academics collaborating with EDF's research and development specialists at the European Energy Efficiency Research Centre and will provide funding for research projects looking at the technical, sociological and economic factors involved in rolling out energy efficient technologies across the UK. The expertise that EDF can provide in this area, combined with the support of excellent research from leading UK academics will assist the UK in meeting its carbon reduction targets whilst delivering secure and affordable energy to UK homes and businesses.

  EPSRC and energy company E.ON have announced £6.9 million of research funding for four consortia investigating aspects of carbon capture and storage (CCS) technologies, such as large-scale transportation of CO_2 through pipelines and improving the economics of carbon capture and storage. This is the third stage of the partnership between E.ON and EPSRC. More than £6 million of research into low carbon and energy efficiency technologies is already taking place in other projects launched by the partnership during the last three years.

  EPSRC has played a leading role in the formation of the UK Energy Research Centre (UKERC) which provides a focus for sustainable energy research in the UK and for collaborative international energy research. The centre co-ordinates a network of environmental, engineering, economic, life and social scientists, linking other centres of excellence, research institutes and universities as well as bringing together key stakeholders. EPSRC-funded researchers at the UKERC played an important role in the Climate Change Congress which took place in Copenhagen in January 2009. UKERC researchers contributed five presentations and posters with Research Director Professor Jim Skea chairing a session on the potential of Renewable Energies.

- **Environment**

  Using the Birmingham Eastside re-development project as a case study, EPSRC-supported researchers at the University of Birmingham have explored issues relating to sustainable development. The findings from this research have been used to inform the decision making of local authorities across the country involved in redevelopment projects.

  EPSRC-funded researchers at Imperial College London have developed a polymer from sugars found in fast growing trees and grasses that will be used in the manufacture of plastic packaging. The process is much less energy intensive than current methods of producing plastic and the new material is also better for the environment because it degrades quickly, breaking down within a matter of months.

- **Transport**

EPSRC has invested in a £10 million project with the Technology Strategy Board, Department for Transport and the Highways Agency to support research and development leading to the introduction of innovative systems and services to help goods move around the country more effectively. This will help enable the UK to support more freight traffic as the economy grows, whilst decreasing the associated road congestion and environmental impact. The project seeks to promote industry collaboration and the use of systems engineering and integration to increase efficiencies in the whole logistics network.

- **Crime and Security**

EPSRC-funded researchers at the University of Sheffield have developed innovative software that enhances marks from footwear, gloves, tyres and fingers and transmits these to the police, allowing officers to search police databases for possible matches. The Latent Image Markup and Analysis (LIMA) software combines the visual abilities of forensic experts with a visually intuitive toolbox to allow fast and accurate searching to identify timely intelligence that can help identify and apprehend criminals. LIMA enables officers to identify a fingerprint in less than 20 minutes compared with 24 hours using the traditional approach.

With EPSRC funding, scientists at Manchester Metropolitan University, Newcastle University, Queen Mary, University of London and the University of Manchester have developed a prototype scanner designed to help police identify criminals carrying guns and knives without putting themselves in the line of attack. The new technology uses electromagnetic waves in order to pick up “reflections” from concealed guns, gun barrels or knives without the need to be close to the subject. The research is being sponsored and supported by the Metropolitan Police (who are currently testing the scanner) and the Home Office Scientific Development Branch.

- **Health**

An innovative breast-imaging device developed by EPSRC researchers at the University of Bristol which uses radio waves and therefore has no radiation risks is being trialled by the Bristol NHS Trust.

Software developed from research at the University of Oxford and commercialised by t+Medical is being used to improve lives of people with chronic diseases such as diabetes and asthma.

Progress since last baseline

- EPSRC was supporting grants involving government/public sector organisations with a totalling £431 million in 08/09 including contributions of £37 million from the collaborating organisations.
- EPSRC currently has strategic partnerships with ten government/public sector/ charitable organisations including the Department of Transport, the Wellcome Trust and the Ministry of Defence; the number has increased from four in 06/07.
- The recently established EPSRC/ESRC/NERC/Defra Collaborative Centre of Excellence in Understanding and Managing Natural and Environmental Risks is delivering practical research, tools and advice to Defra, through world-leading research in risk science. Research undertaken is being used to inform policy relating to areas such as flooding, animal and plant diseases and climate change.
- The EPSRC-led RCUK Digital Economy Programme has funded a joint project with India into next generation telecommunication networks. The project, which has attracted over £4 million of private investment to date, will aid healthcare and early warning weather systems in rural areas in both countries.

Attracting R&D investment from global business

Companies site their advanced technology centres in areas rich in relevant skills[14] and the globalisation of such activities by multinational firms has accelerated[15]. EPSRC has a key role in maintaining and extending the excellence of the research base to ensure that the UK remains an attractive location for the R&D activities of leading hi-tech companies, such as those in the pharmaceutical, aerospace and electronics sectors. For example, a number of key companies such as Nokia, Hitachi and Microsoft have established research centres around Cambridge, building on centres of excellence such as the EPSRC-supported Interdisciplinary Research Collaboration in Nanotechnology[16]. Further examples are the IT giant Hewlett Packard and leading telecoms company Toshiba, both of whom have established research centres in the UK, near Bristol.

EPSRC also plays a key role in building and maintaining the excellent reputation of the Higher Education research base. This is a key factor in attracting overseas students to the UK, a significant source of income and impact on the UK economy. Of the 319,000 students in engineering and physical science subjects in 2007/08, nearly 25% were from overseas[17]. It is estimated that approximately one fifth of the 9,129 students funded by EPSRC during that year were from overseas.

EPSRC engages directly with R&D intensive companies through strategic partnerships: by offering flexibility and responsiveness in our approach to the support of research and training we provide attractive opportunities for them to invest in the UK research base.

- EPSRC works closely with the leading UK universities through Framework Agreements, to maximise the quality of research and training and ensure that the research base continues to attract investment from leading multinational companies.
- EPSRC also assists UKTI in its role to attract inward investment from overseas companies, providing information about leading research groups in the UK and making contacts for UKTI virtual teams (recently in Transport, Aerospace, Nuclear and Renewable Energy and Electronics). For example, the Electronics and Software, Media and Communications sector teams were part of the UKTI stand at the Mobile World Congress in Barcelona in February 2009.

The global impact of our research portfolio was demonstrated through the findings of the recent studies on the economic impact of physics and chemistry research which concluded that the investment made by EPSRC and other similar organisations in basic research in these areas had attracted significant R&D investment from global business and had generated significant wealth for the global economy. For example:

- A consortium comprising of the German company HB Systems and Surrey Satellite Technology Ltd (SSTL), a company spun out by EPSRC-funded researchers from the University of Surrey in 1985, has secured a contract worth £510 million to supply the first operational spacecraft for Europe's Galileo satellite-navigation system. One recent study found that between 2006 and 2025, Galileo is likely to bring cumulative economic benefits to the nation of over £18 billion, from such benefits as transport safety improvements and environmental benefits from shorter journey times.
- Since their development by pioneering UK physicists in the 1960s and 70s, Liquid Crystal Displays have generated over £275 million for the UK economy. In addition, the key global players in the LCD industry have contributed over £132 million directly to the UK GDP and have spent £70 million on R&D.

- The magnetic fields necessary for MRI are generated by superconducting magnets developed in the UK by the first physics-technology spin-out company from the University of Oxford, Oxford Instruments which today has a turnover of £177 million. As a result of the R&D being undertaken by global players in the medical instrumentation market such

as Siemens, there are now 20,000 MRI scanners worldwide and the global market is expected to reach £4 billion by 2010.

- Between 2000 and 2003, EPSRC funded work undertaken by the University of Sussex to improve the longevity and safety of the Advanced Gas-cooled Reactor (AGR) which currently provide about 75% of the UK's nuclear energy generating capability. It is estimated that if the 14 UK operating AGRs closed unnecessarily early, it could lead to losses running into billions of pounds, threaten the UK's carbon dioxide emission targets and widen the nation's energy deficit. This research has also informed the scale of the decommissioning process required for the first generation Magnox reactors.

- Ground-breaking work undertaken by Professor Ian Norton into the physical chemistry of polysaccharide transition (part-funded by EPSRC on the basis of a CASE award between Unilever and the University of York), led to the development of many new innovative products with a lower fat content while maintaining taste and texture performance. Such research is a necessary to help deliver a sustainable response to obesity in the UK, which according to study by the Department of Health cost the NHS £4.2 billion in 2007 and could rise to £6.3 billion by 2015.
- The manufacture of polymer-based packaging products in the UK supports 26,000 jobs and contributes £315 million to the UK economy and is entirely dependant on chemistry research. EPSRC funding of researchers at the universities of Bradford, Durham, Leeds and Sheffield through the Polymer IRC led to the development of the Curv™ polymer that has been used in the manufacturing of products as diverse as helicopter parts, sporting equipment, audio equipment and high-end luggage. It is acknowledged[18] that without EPSRC funding for the fundamental research and support for the commercialisation of the resulting products, Curv™ technology would never have been developed.

Progress since last baseline

Research Excellence - a new study[19] of over 7,000 journal articles has shown that EPSRC researchers achieve a higher than average citation rate of 1.6 compared to a UK average of 1.4 and world average of 1.0. This impressive rating reflects the impact that EPSRC researchers have and also highlights how competitive EPSRC funded research is internationally. The study also shows that EPSRC researchers publish their articles in the leading journals in their fields. Articles arising from larger grants of more than 36 months and £350 thousand have a bigger impact than other, smaller grants in terms of how often and where they are cited. The study also demonstrated that there is no real difference in citation performance between 'responsive' research articles or 'targeted' research articles.

"**EPSRC funded research, overall or by funding mode or grant type, has a higher citation impact than similar UK research in physical sciences and engineering.**" EPSRC Citations Study 2009

The UK maintained its high ranking in 08/09 in terms of Citation Impact[20] amongst the G8 nations in:

- Physical Sciences **3rd** (with differences between the top 3 countries marginal- Germany 1.67, USA 1.65 and the UK 1.63)
- Mathematics **2nd** and
- Engineering **3rd**

This performance is also delivered more efficiently, with UK productivity in terms of citation numbers second only to the USA (with the exception of Engineering where it lies 4th) and the UK has an impact of 1.2 to 1.5 times the world average. The work undertaken by researchers in other

highly-ranked research areas such as “environment” and “health and medically-related” are underpinned by work undertaken by researchers in the EPS disciplines.

In its recent report “A Vision for UK Research” (March 2010), The Council for Science and Technology highlighted the importance of maintaining funding for STEM research, recognising that innovative discoveries in areas such as life sciences are dependant upon high quality research from the engineering, mathematics and physical sciences research base.

Citation Impact of Physical Sciences Papers

	Recent Average (2003-2007)	Current Value	Current relative to Recent
UK citation impact	1.39	1.63	**+17%**
Group average citation impact	1.12	1.20	**+7%**
UK/Group Average	1.24	1.35	**+9%**
UK rank within Group	6	6	⇔
UK rank within G8	2	3	⇓

Citation Impact of Mathematics Papers

	Recent Average (2003-2007)	Current Value	Current relative to Recent
UK citation impact	1.30	1.43	**+10%**
Group average citation impact	1.07	1.09	**+1%**
UK/Group Average	1.22	1.31	**+15%**
UK rank within Group	5	4	⇑
UK rank within G8	2	2	⇔

Citation Impact of Engineering Papers

	Recent Average (2003-2007)	Current Value	Current relative to Recent
UK citation impact	1.05	1.22	**+16%**
Group average citation impact	1.03	1.04	**+1%**
UK/Group Average	1.02	1.17	**+15%**
UK rank within Group	12	7	⇑
UK rank within G8	4	3	⇑

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