EPSRC Engineering and Physical Sciences Research Council

EPSRC Delivery Plan 2008/09 to 2010/11

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

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1 Summary

EPSRC's mission is to invest in high-quality basic, strategic and applied research and related postgraduate training to maintain and develop a strong research base in engineering and the physical sciences and to promote future economic development and an improved quality of life in the UK. The UK research community is highly successful and ranks second only to the USA on many key output criteria. Much progress has also been made in translating the knowledge generated into tangible innovations for the benefit of the economy. However, given the pace of change, there is more that can be done.

The Science and Innovation Investment Framework challenges ESPRC to deliver two key components of the knowledge economy if the UK is to retain international prominence and economic stability:

- New knowledge from research, producing both scientific innovation and economic benefit.
- The supply of people with the skills to drive forward a modern economy.

In addition, we are tasked with demonstrating the economic impact of our investment, ensuring that its outcomes are efficiently transferred to users for potential exploitation.

Responding to the Challenges Facing Society and the Economy

The government has set out its vision for the key challenges that face UK society and the economy: climate change and the decline of fossil fuels, the rapidity of technological change, global uncertainty and terrorism, demographic change, including an ageing population, and the globalisation of markets. Mindful of these challenges, our plans include a number of specific research themes:

- Responding to the challenges of the 2007 Energy White Paper and the Stern Review on Climate Change, and building on the successes of the investment during the previous Spending Review period, an **Energy** programme will support a full range of basic research including power-generation and supply, demand-reduction, transport, and alternative fuels, and will work closely with the Energy Technologies Institute towards a step-change in energy research, development & demonstration.
- Early adoption of information & communication technologies enhances the performance of modern economies. A research theme in the **Digital Economy** will draw together ICT research outputs and industry across a number of sectors including healthcare, transport, and the creative industries, aiming for rapid take-up of key technologies to support both the economy and to enhance the quality of life of individual citizens.
- Disruptive, step-changes in technology are within reach via the application of nanotechnologies. A strategic research theme in **Nanoscience through Engineering to Application** will build a coherent programme that will pull basic research through to application.
- EPSRC recognises the need for lifetime improvement to the health of UK citizens, and for a healthcare model based on the increased use of preventative and diagnostic tools. We will invest in a research theme of **Next-Generation Healthcare** which will link appropriate engineering and physical science research to the work of healthcare partners for the improved translation of research outputs into clinical products and services.

Shifting Researcher Horizons

Our plans include a number of consciously chosen methodologies intended to help galvanise the research community around the vision for meeting the government's challenges. In particular, we will use the concept of research '**Grand Challenges**' to accrete a critical mass of research effort around particular goals. Some Grand Challenges will be researcher-led, generated by specific communities; others will be set by us, in the context of the public challenges described above.

We will also encourage the uptake of **transformative research**[1] as a vehicle for pursuing mould-breaking research activities. Furthermore, we will encourage researchers to shift their horizons away from a research-funding model built around sequential, incremental research projects, to one based on larger, longer and more ambitious programmes of research which may blend multidisciplinary and multi-centre inputs. The Interdisciplinary Research Collaboration is a successful model which we will continue to use.

Ensuring the Future Supply of People

People are at the heart of knowledge and skills; a secure future supply of researchers is essential for the research base and industry to be able to respond to as yet unforeseen challenges, to identify future opportunities, and to transfer knowledge - in person – when moving between the research base and industry. We will continue to make a major investment in doctoral training provision, and will align that investment with the focused themes described above through increased use of Doctoral Training Centres.

Generating a Vibrant and Sustainable Research Environment

Engineering and physical sciences research is intrinsically valuable in generating the knowledge capital from which new technology is derived. This can be via the incremental development of ideas over a medium to long-term period, or through unforeseen and dramatic breakthroughs. Either way, this bedrock of research activity has economic and social impact, and is essential to support progress in many other scientific disciplines including the environmental sciences, medical instrumentation, healthcare, aspects of biological sciences, and the modelling of economies and markets.

Our aim is to generate a vibrant and sustainable research environment that both encourages and rewards creativity. We will achieve this by supporting a core base of researcher-led activity, and, as described elsewhere in this document, by emphasising our willingness to support more ambitious programmes of work. We will use signposting, where appropriate, to increase the research community's engagement with specific research areas, many of which will have been identified by the community itself.

Stepping Up to Better Exploitation

Our plans consciously embrace the task of enhancing the pace and effectiveness of transferring research outputs into application by users in industry, business, government and elsewhere. This is not, however, an ambition we can realise alone: partnership with key players is crucial. Notable amongst these are the Energy Technologies Institute (ETI), the Technology Strategy Board (TSB), National Institute for Health Research (NIHR) and companies working in the EPS sectors (see box 1).

[1] Transformative research is "driven by ideas that stand a reasonable chance of radically changing our understanding of an important existing scientific or engineering concept or leading to the creation of a new paradigm or field of science or engineering. Such research is also characterised by its challenge to current understanding or its pathway to new frontiers." As defined in 'Enhancing Support of Transformative Research at the National Science Foundation', National Science Board, 2007.

Box 1 – Key Partners in Achieving Better Exploitation

Our ambitions to accelerate the exploitation of research outputs will be realised in partnership with a range of other organisations including:

- Energy Technologies Institute – we will invest £21M to realise a step-change in UK energy research, development & demonstration.
- Technology Strategy Board – we will provide at least £45M commitment in collaboration with the TSB to ensure the rapid exploitation of research in key technologies.
- National Institute for Health Research – we will work closely with the NIHR and with the MRC to align engineering and physical science research with clinical need.
- Industry – we will continue to invest in strategic partnerships with key industrial companies, building bridges between the research base and users.

Recognising that the movement of people is a highly effective route for knowledge transfer, we will increase the degree of targeted, demand-led doctoral training we support. Expanding, for example, the Engineering Doctorate concept, we will seek to align the skills base more closely to the needs of business innovation. Knowledge Transfer Accounts (a development of Collaborative Training Accounts) will offer increased flexibility for universities to develop demand-led training and other knowledge transfer opportunities.

We will also invest in research-industry collaboration through a number of targeted vehicles including Integrated Knowledge Centres (knowledge transfer centres of excellence) and Doctoral follow-on opportunities based in industry.

2 Introduction

This Delivery Plan provides a strategic overview of the Engineering and Physical Sciences Research Council's (EPSRC's) plans for the period 2008/09 to 2010/11. The plan sets out to describe our high level priorities and the approaches and principles we will use for achieving these priorities. It also outlines what EPSRC intends to do during the period to meet the Government's Science and Innovation Framework. The overall plan has been agreed by EPSRC Council with the activities described having been developed as part of our business planning processes.

The EPSRC scorecard of targets and milestones for the year 2008/09 will be published by March 2008 and will include details of the specific actions that we will take to implement the Delivery Plan and the measures we will use to gauge our success.

Progress against milestones is reported to the Department for Innovation, Universities and Skills (DIUS) on a quarterly basis and published annually. The EPSRC Delivery Plan and scorecard complement the Research Councils UK (RCUK) Delivery Plan and scorecard, where common plans for priorities for all Research Councils are described.

The Government published its **10-Year Science and Innovation Investment Framework**[2] in July 2004. This presented the Government's commitment to science and research over the next decade, with the long-term objective of increasing the overall levels of investment in research and development to 2.5% of gross domestic product by 2014. This Delivery Plan sets out how EPSRC is continuing to contribute to the achievement of the overall ambitions of the framework, which are to:

- Make the UK world-class in all areas of science, engineering and technology
- Translate the new knowledge generated more effectively into innovation
- Improve the prosperity and quality of life of the UK
- Make the UK the location of choice for R&D and high value-added business.

These challenging goals have been summarised by DIUS in two main outputs:

1. A healthy UK science and engineering base
2. Better exploitation.

In April 2006, Government reinforced these ambitions with the **Science and Innovation Investment Framework 2004-2014: Next Steps**[3] where it identified a number of enhancements to the research landscape, including the need for a step-change in the economic impact of Research Councils' research investments, the encouragement of transformative, multidisciplinary research, and the formation of the Science & Technology Facilities Council (STFC).

In November 2006, the Government set out its **Long-term Opportunities and Challenges for the UK**[4], which reiterated the major challenges facing the UK (see box 2), and also highlighted eight broad emerging technologies likely to have significant impact on society over the next decade: sensors and tracking, network interactions, security technologies, advanced materials and robotics, nanotechnologies, body and mind sciences, and energy technologies.

[2] http://www.hm-treasury.gov.uk/spending_review/spend_sr04/associated_documents/spending_sr04_science.cfm
[3] http://www.dti.gov.uk/science/science-funding/framework/next_steps/page28988.html
[4] http://www.hm-treasury.gov.uk/spending_review/spend_csr07/spend_csr07_longterm.cfm

Box 2 – Drivers and Influencing Factors

Drivers and influencing factors in developing our plans are:

- The government's long-term public policy challenges facing the UK:
  - Pressure on natural resources
  - Demographic change, including an ageing population
  - Shifting economic activity and the growth of emerging markets
  - Acceleration of innovation and technology requirements
  - Global uncertainty and the threat of terrorism
- The need to encourage innovation through transformative research.
- Increased emphasis on the economic impact of supported research, and the need for EPSRC to work effectively with key partners such as the Technology Strategy Board and the Energy Technologies Institute.
- The increased need for an interdisciplinary approach across traditional boundaries.
- New arrangements for publicly-funded health research, including the formation of the Office for Strategic Coordination of Health Research (OSCHR).
- The dynamics of research globally, including the rapidly maturing economies of India and China, and the importance of the UK exerting influence on the direction of EPS research.

This Delivery Plan builds on our current Strategic Plan[5], deploying approaches described in that document, including:

- Enhancing partnerships with academia and business
- The identification and use of incentives to help effect greater flow of knowledge between academia and industry
- A focus on the enhancement of research careers
- The pursuit of grand challenges to galvanise the research community to set stretching research objectives for itself
- Enhanced international activity to work with emerging economies.

These will be further supported by establishing and actively managing new and existing relationships with partner organisations, such as the Technology Strategy Board, the Energy Technologies Institute, key companies, and Regional Development Agencies/Devolved Administrations, to ensure joined-up approaches to the pursuit of research and the take-up of the knowledge generated.

[5] http://www.epsrc.ac.uk/publications/corporate/strategicplan2006.htm

3 Priority Themes

Energy

The Research Councils' Energy Programme, led by EPSRC and in partnership with BBSRC, ESRC, NERC, STFC, brings together all facets of energy research and training across the Research Councils in a comprehensive, multi-disciplinary programme. We will:

- Work to realise the potential of Energy Technologies Institute (ETI) for a step-change in energy research, development & demonstration (R, D&D) in the UK and internationally. ESPRC will provide the public funding in partnership with others, including TSB. We will seek to ensure that ETI work is highly focused in appropriate technology areas and pulls through the most promising work from the research base. ETI also presents a major opportunity to grow internationally competitive energy research capacity in the UK. EPSRC will work with ETI to ensure that our joint capacity building activities have maximum impact across the spectrum from postgraduate to leadership level.
- Lead the Research Councils' Energy Programme, ensuring it plays a key part of the UK energy innovation landscape. The aims are to support a full spectrum of energy research meeting the government's long term policy goals, to work in partnership to meet the research and postgraduate training needs of business, to develop research capacity, and to increase the level and impact of international collaboration.
- Increase support for research in demand-reduction and transport, whilst maintaining research in power generation and supply (see box 3), addressing UK government priorities in, for example, reducing greenhouse gas emissions. With ETI providing a major vehicle for R, D&D, EPSRC will give greater emphasis to developing a portfolio of highly speculative energy research to meet long-term needs.
- Support the fusion programme at Culham, using the internationally leading facility, Joint European Torus (JET). The major challenge facing the international programme over the next 10 years is the construction of the International Tokamak Experimental Reactor (ITER).

Box 3 – Supporting UK Emission Targets: Sustainable Power Generation and Supply (SUPERGEN)

SUPERGEN is a multidisciplinary initiative managed and led by ESPRC in partnership with BBSRC, ESRC, NERC and the Carbon Trust. The programme has invested over £32M since 2003 to help the UK meet its environmental emissions targets by improving the sustainability of power generation and supply. Establishing multi-disciplinary partnerships between industry and universities, the programme has been highly successful in generating new ideas and the transfer of research results in, for example, bio-fuels, photovoltaics, offshore wind, and energy storage.

Digital Economy

Early adoption of Information & Communication Technology (ICT) tools supported by research capacity and skilled people brings economic and social benefits[6]. ICT has already transformed the way business operates, the way government delivers, and the

[6] "Increased production of ICT contributes to output, employment and export earnings, while ICT use increases productivity, competitiveness and growth", World Bank Working Paper no 24.

way science is undertaken to improve the quality of life, but being able to respond rapidly to new opportunities and challenges is crucial to the future economic and social prosperity of the UK.

In supporting the Digital Economy we are building on a strong existing research base:

- EPSRC has developed a strong portfolio of research in multidisciplinary ICT focused research through £43M supporting five IT-Centric IRCs from 2000 to 2006, and the Wired and Wireless Intelligent Networked Systems programme, both of which have a strong user focus.
- EPSRC and ESRC have jointly supported a £9M research programme around People at the Centre of Communications and Information Technologies, aimed at gaining a greater understanding of the psychological, social and organisational aspects of people interacting with IT.
- ESRC have additionally supported a £6.5M research programme called the E-Society which explored the impact of digital technologies on society through 6 focused cluster areas.
- MRC has partnered other Research Councils in supporting methodological and behavioural research to underpin new opportunities in health data transfer and integration for a step change in information driven healthcare.
- AHRC has developed a £5.5 million multidisciplinary, user focused research programme exploring the increasingly rapid and transitory nature of digital culture, and a co-funded Collaborative R&D programme with BBC Future Media & Technology tackling issues such as the inhibited engagement with ICT based services in an aging population.

These activities have been underpinned by research funded through responsive mode in each of the Councils, providing a strong foundation in the core enabling technologies and understanding, linking to a rich research foundation in potential areas of application where user engagement will be vital.

Our focused research theme in the Digital Economy in partnership with AHRC, ESRC, MRC, and STFC will contribute to output, employment and export earnings for the UK, and new tools will increase productivity, competitiveness and growth.

We will:

- Make a step-change in the level of industrial engagement to pursue key research challenges, so that the transformational possibilities of ICT are brought to fruition quickly and efficiently.
- Concentrate on areas of maximum transformational impact: Healthcare, Transport and the Creative Industries for example, achieving alignment with public policy goals and concerns, including more efficient and accessible delivery of government.
- In partnership with the Technology Strategy Board, develop consortia of researchers around user-identified challenges and funding large research programmes or centres, focused around clearly defined grand challenges in the targeted sectors.
- Fund a programme in Information-Driven Healthcare, developed with key partners (e.g. MRC, GE Healthcare), feeding the early stages of healthcare research and development. The programme aims to use ICT to transform healthcare provision from 'get ill, get cured' to prevention and early identification via dynamic information provision which empowers the patient and the clinician. We will add value to the early stages of the healthcare pipeline, and seek to ensure a seamless

transition from basic research through proof of concept to clinical trials. We will work in partnership with industry and other health funders to support research encompassing the whole healthcare sector, from the health service to medical equipment suppliers.

- Support a training programme aimed at providing a cohort of students with a strong research capability in ICT research, but with an understanding of business and the other research areas needed to deliver the benefits of ICT (to include the social sciences). We will invest in at least four doctoral training centres supporting a cohort of 10 students per year for five years.
- Establish a management structure across the user-focused areas to ensure that lessons and common research challenges are shared, and engage industrial mentors to provide appropriate guidance to projects and engender a spirit of entrepreneurship in the research community.

Box 4 - IT-Centric Interdisciplinary Research Collaborations

ESPRC has supported five IRCs to build on the potential of information & communication technologies to facilitate inter-institutional working and its increased importance in a wide range of interdisciplinary activities. These collaborations were reviewed in 2007 and found to be internationally-leading examples of multi-disciplinary, multi-centre collaborations with strong industrial engagement. The mechanism allows for more speculative research and for the incorporation of new lines of enquiry. Our plans include the wider deployment of the IRC mechanism across other areas of our portfolio.

Nanoscience through Engineering to Application

Nanotechnologies can revolutionise society; they offer the potential of disruptive step-changes in electronic materials, optics, computing and in the application of physical and chemical understanding (in combination with biology) to generate novel and innovative self-assembled systems. The field is maturing rapidly, with a trend towards ever more complex, integrated nanosystems and structures. It is estimated that by 2015 products incorporating nanotechnology will contribute US$1 trillion to the global economy, and that the UK has a 10 percent share of the current market.

We propose to build on the previous investment of £92M nanotechnology research (at 2004, and representing 1.3% of UK R&D expenditure). Of this, the EPSRC has contributed a responsive mode investment of around £30-40M per annum and 40 new PhD starts, in addition to the MNT investment of £90M over 6 years. These investments complement a sum of €3.6B for nanotechnology research in the 7th EU Framework Programme.

With support from all Research Councils and a wide range of stakeholders, EPSRC will lead a co-ordinated, focused programme designed to:

- Consolidate earlier investments by bringing together the various elements into a coherent, directed programme taking basic research through to application to realise the potential benefits through a series of Grand Challenges addressing areas of societal importance.
- Support goal-driven research programmes, staged over a timeframe of the CSR period and beyond, with increasing sophistication and complexity of structures moving, for example, from polymer liposomes (nanosomes) for molecular delivery in the healthcare, personal products and food sectors within three years, to self-assembling nanostructures within ten years.

- Deliver Grand Challenges in applying nanotechnology to energy (e.g. harvesting solar energy), environmental remediation, healthcare & digital economy, using a stage-gate approach from basic research through to application.
- Build doctoral training centres to generate critical mass in required skills in this interdisciplinary subject.
- Ensure the wide availability of cross-cutting infrastructure via equipment-sharing.
- Building on the past investment of public funds, support a broad base of research with signposting of strategic areas.

Box 5 – Nanotechnology Grand Challenges

EPSRC is using Grand Challenges which address societal and/or economic issues where nanotechnology can make a unique and significant contribution. We have issued a call for proposals of large-scale, integrated projects exploiting nanotechnology to enable cheap, efficient and scalable ways to harvest solar energy. A future Grand Challenge will focus on medicine and healthcare.

Towards Next-Generation Healthcare

This element of our Delivery Plan recognises the challenges of an ageing population and aims to improve the health of UK citizens at all stages of their lives, through earlier disease diagnosis and better treatment, reducing the associated costs. EPSRC already supports a strong portfolio of medical engineering, including collaborative work with key companies (e.g. GE Healthcare), the NHS and the MRC. Healthcare-related investment will enhance both the excellence of the research base and translation to products and services.

We will:

- Work with key partners to ensure a seamless transition from basic research through proof of concept to clinical trials;
- Obtain co-funding from partners in industry, charities and NIHR over the period, with the emphasis on:
    - Excellent research to support the development of novel medical technologies, sensors and information systems.
    - Partnerships with business and charities to maximise pull-through of underpinning research into products and clinical practice.
    - The delivery of better health and well-being through dynamic information and intervention.
- Increase the volume of high-quality collaborative research and pull-through to clinical products and practice, in the areas of Systems approaches to healthcare, Medical information systems, Medical sensing, and Targeted therapies. We will establish further strategic partnerships with public and private funders such as those already in place with Cancer Research UK (see box 6), the TSB, GSK, Pfizer and AstraZeneca.

Box 6 – Partnership with Cancer Research UK

EPSRC and Cancer Research UK have established a strategic partnership to promote the application of imaging science to cancer research. UK engineering and physical sciences researchers have a strong history of delivering fundamental insights and technologies that have revolutionised imaging science. Cancer Research UK's knowledge of cancer biology, clinical need and imaging development is similarly internationally leading. This partnership will draw upon these strengths to stimulate the research base with challenges associated with clinical need and to ensure technology pull-through to clinical practice.

Contribution to other Research Councils UK Research Themes

Living with Environmental Change

Living with Environmental Change (NERC, AHRC, BBSRC, EPSRC, ESRC, MRC, and working with partners in at least nine Government departments/agencies) is focused on increasing resilience to - and reducing costs of - environmental change, addressing the associated pressures on natural resources, ecosystem services, economic growth and social progress. EPSRC will contribute the engineering research to tackle the implications of climate change for buildings, infrastructure and utilities. ESPRC has established consortia in its Building Knowledge for a Changing Climate programme, working with key stakeholders (e.g. DEFRA) to pull through outputs, and has supported the Dongtan Ecocity project in China providing technology and people via Network grants, in partnership with Arup.

Global Threats to Security

The Global Threats to Security programme (AHRC, BBSRC, ESRC, EPSRC and NERC) will integrate research in crime, terrorism, environmental stress and global poverty, to address causes of security threats, their detection and possible interventions to prevent harm. EPSRC will focus on research and innovation to support the development of technology, systems and services for the prevention and detection of crime and terrorism or manage/minimise its impacts.

Ageing: Life-Long Health and Wellbeing

This initiative will establish new interdisciplinary research centres targeting the major determinants of health and wellbeing over the whole life-course and reducing dependency in later life. EPSRC's contribution to this Cross-Council investment (MRC, AHRC, BBSRC, EPSRC, ESRC and NERC) will provide underpinning medical engineering, building on our established portfolio of investment in the area.

4 Sustainability

Support for the core of engineering and physical sciences research activity ensures a vibrant and healthy research capacity, delivering outputs for all of science and the knowledge-driven economy. The UK has a clear dependence on a healthy engineering and physical science (EPS) base, both as an underpinning factor in a successful economy and in contributing across the whole research sector (see box 7).

Box 7. The Value of the Engineering and Physical Sciences Sector[7] [8] [9]

- Surveys of R&D managers in the EU and the US have shown that EPS-related scientific fields are more pervasive in their impact than other disciplines particularly in Engineering, Materials Science and Computer Science.
- Global companies use quality of R&D personnel as a major determinant for their location indicating the need for a strong research base to ensure inward investment.
- Sectors with the fastest growth of value-added per employee are those with the highest dependence on the EPS sector.
- Engineering and physical sciences are most frequently cited as critically important for advances in all other areas of science.
- The growth in productivity of different industrial sectors is highest in those with EPS relevance.
- The UK has a lead in areas such as plastic electronics, pharmaceuticals and aerospace.
- EPS postgraduates contribute more to the economy in terms of average salaries than non-EPS.

Nonetheless, it is clear that capacity needs to be enhanced in strategic and emergent areas of the research base. In addition, more can be done to align research activity with broader challenges.

Our aspirations for a sustainable research base are to:

- Deliver a vibrant, creative and healthy science and engineering base
- Ensure the long-term health of disciplines
- Encourage a move to more transformative and multidisciplinary research
- Supply trained people for the economy and provide the next generation of world-leading researchers
- Enhance capacity in areas of national importance.

[7] Engineering & Physical Sciences in the UK, SPRU, 2003
[8] Thursby & Thursby, Where is the New Science in Corporate R&D, Science, volume 314; Rising Above the Gathering Storm: Energizing & Employing America for a Brighter Economic Future, National Academy of Sciences, 2007
[9] O'Leary & Sloane, The Return to a University Education, Dept of Economics, Swansea University: lifetime premiums on higher degrees over 2 A levels

A Healthy Science and Engineering Base

Support for the core of engineering and physical sciences research activity ensures a vibrant and healthy research capacity, delivering outputs for all of science and the knowledge-driven economy. Enabling the flexibility for researchers to take the lead on the areas we support assists the academic base to fit to a changing research landscape where traditional boundaries have broken down and where new areas of research (e.g. plastic electronics, spintronics, quantum coherence, complexity) need to be swiftly pursued.

We will:

- Access the potential creativity in the research base via researcher-led activity. This base is crucial both for the health of disciplines and to ensure that the skills and knowledge are available to meet as yet unknown problems.
- Use signposting of specific research areas to help galvanise researcher effort around topics of strategic importance.
- Emphasise output-focused, multidisciplinary research, using vehicles such as IDEAS factories and Grand Challenges, and 'bridging the gap' awards, encouraging researchers to identify and pursue opportunities for transformative research in areas such as low-carbon manufacturing, molecular electronics, and DNA-based devices.
- Invest in the necessary research infrastructure (see Facilities and Infrastructure below).

Box 8 – Boosting Capacity – Science & Innovation Awards

Science & Innovation Awards, co-supported by the Funding Councils, are large, long-term grants supporting new research groups in areas where research capacity needs to increase in order to ensure the future international standing of the research base. Areas where ESPRC has recently invested include analytical science, energy, operational research, structural ceramics, and tribology. We will invest in a further tranche of these awards.

Securing the Future Supply of People

Discovery and innovation in science and engineering happen through creative people working in a high quality research environment. Whilst the demand for EPS graduates in the workplace, especially in the knowledge economy sectors, appears to be increasing[10], falling numbers of UK-based degree entrants in those subjects is a major concern.

We will:

- Support the next generation of world class researchers and research leaders so that the UK can increase its global research impact and economic competitiveness.
- Strengthen strategic research areas by using targeted funding to create new research teams.
- Attract the most talented people to research by enhancing the Doctoral experience, working with the Funding Councils.
- Help the flow of people through their research career pathways, either in industry or academia, and enhance skills to meet user needs.

[10] ESPRC analysis of employment data from Labour Force Surveys between 1998 & 2002

- Continue to support and monitor the success of the academic fellowship scheme on behalf of all Research Councils.
- Enhance the attractiveness of research careers and share best practice to address diversity issues, working with the RCUK Research Careers and Diversity Unit.
- Inspire the young to pursue research careers in science, mathematics and engineering, in collaboration with the RCUK Science in Society Unit, through our Public Engagement programme.

Box 9 – Doctoral Training Centres

Future research needs require appropriately trained multidisciplinary manpower. The Doctoral Training Centre mechanism offers a new and exciting approach to post-graduate training. Each centre supports up to five annual cohorts of up to ten students, with taught training fully integrated into research projects. Each centre, focused around a small number of research themes, has strong industrial engagement, both in the management and support for research. This approach has been used so far in the Life Sciences Interface, Systems Biology and Complexity. Our plans include an increase in the use of such centres in order to bring greater alignment of training with strategic research areas.

5 Greater Economic Impact

Knowledge transfer is integral to all of EPSRC's research and training activities, being significant in the core, researcher-led portfolio via collaboration on research grants, and providing a supply of trained people into industry and the wider economy. We already support a research portfolio which is around 40% collaborative with industry, and circa 40% of EPSRC-supported research studentship training involves the participation of industry. There is more to do, however, to reduce the time to exploitation of break-through research.

We will:

- Accelerate the exploitation of research outputs for economic benefit through major strategic partnerships with the Energy Technologies Institute and the Technology Strategy Board.
- Within our priority research themes, Energy, Digital Economy, Nanoscience, and Towards Next Generation Healthcare, work with key stakeholders to form bridges that pull research through to exploitation more rapidly and efficiently.
- Align the skills base more closely to the needs of business innovation through more targeted, demand-led doctoral training.
- Enhance the flow of knowledge and people between academia and industry by facilitating partnerships and through targeted vehicles for collaboration, including knowledge transfer centres of excellence, and via post-doctoral follow-on opportunities based in industry.
- Publicise the opportunities for, and successes of, knowledge transfer so that it becomes normal business for the research community.

We have specified a baseline for our economic impact (see Annex 1).

Box 10 – Demand-Led Training: the Engineering Doctorate

The Engineering Doctorate was established in 1992 to provide a high-quality, broad-based doctoral research experience with a taught component relevant to the needs of users. A 2006 review of the scheme was "convinced of the value and performance of the EngD scheme, the quality of the intake and outputs, and the contribution it makes to EPSRC strategic objectives by providing high quality knowledge transfer through people." We will build on this endorsement by raising the profile of the EngD brand, and by extending the use of the concept to other areas of doctoral training.

Impact on Public Policy and Government Service Delivery

EPSRC has a unique position in helping to maximise investments across a wide range of Government policy and delivery, and in supporting, for example, better healthcare, improved transport, flood control, crime-prevention, anti-terrorism, and reduction of carbon emissions.

Many Departments and agencies will continue to be key stakeholders in these endeavours, co-sponsoring our research programmes, and will be major users of our research outputs, both knowledge and trained people.

Box 11 – EPSRC Partnership across the Public Sector: Department for Transport

Our extensive partnership with the Department for Transport covers (a) transport technology research, e.g. Future Intelligent Transport Systems - co-funded with TSB and Rail Research UK; and (b) transport and land use planning, e.g. the Solutions and Revisions Research Consortia which has co-funding from the East of England Regional Development Agency.

Our Delivery Plan will have major impact on all five of the Government's Public Policy Challenges, as described below.

Natural Resources and Climate Change

EPSRC's leadership of the Research Councils' Energy programme builds on our established partnership with the BERR Energy Programme. Key areas of research that will inform future energy policy include:

- Keeping the Nuclear Option Open and Future Network Technologies.
- Partnerships with DEFRA, CLG and the Carbon Trust on low-carbon buildings and on the mitigation of, and adaptation to, climate change.
- Informing key Government policy instruments e.g. Building Regulations & Planning Policy.
- Targeted knowledge transfer activities (e.g. Knowledge Transfer for Sustainable Urban Environments) to synthesise raw research outputs to better inform policy and practice, and with DEFRA, focused on the quantification of environmental risks in policy formulation.
- Partnership with DEFRA on (i) Flood Risk Management, generating output that is directly benefiting both policy development, and the Environment Agency's service delivery; and (ii) waste management, with joint benefit on policy and service delivery in the local Government domain.

Technological change

Engineering and the physical sciences are critical to the development of technological innovation across the spectrum of business. EPSRC is the largest Research Council partner with the TSB, and we have our own extensive range of direct collaboration with industry, from major strategic partnerships to our extensive support to all aspects of industry, including SMEs, through collaborative training and knowledge transfer activities. Our key Delivery Plan priorities will broaden our engagement with business and the service sector, working in partnership with TSB and BERR.

Examples are:

- Engaging with financial service and retail sectors on innovation in services e.g. advanced techniques to combat credit card fraud, through the Digital Economy theme.
- Supporting Government as a major user of ICT, e.g. in partnership with the Home Office Passport and Identity Agency through the Network & Security Innovation Platform.
- Contributing to energy transformation (e.g. efficient photovoltaics) via the Nanoscience theme, supporting new technologies e.g. plastic electronics, quantum information processing, advanced composites, and beyond silicon electronics (e.g. DNA-based devices).

Globalisation and Shifting Economic Patterns

The challenges globalisation raises for business in the UK are constantly evolving. Features of EPSRC'S contribution include:

- Our portfolio of Innovative Manufacturing Research Centres (IMRCs) fund a wide range of research in manufacturing technology, supply chains, business process engineering and manufacturing management. This work, which has contributed to the forthcoming Sainsbury Review, will continue to provide an important evidence base for BERR, DIUS and the Treasury in the development of innovation policy and strategy.
- Our deployment of user-driven Grand Challenges will ensure that we remain aligned with the strategic needs of the economy and society.
- Realigning our PhD training to be competitive internationally, and will gain leverage from international expertise by partnerships with peer funding agencies.

Global Uncertainty and Terrorism

In tackling the challenges of the prevention, detection and response to crime and terrorism, EPSRC has funding partnerships with a number of key stakeholders. Our crime portfolio features extensive end-user collaboration including Home Office Agencies, Police services, Local Authorities and industry. Activities will include:

- Ideas Factories in crime and terrorism in collaboration with the Home Office, initially on container screening at ports, building on the success of earlier events on gun crime and combating terrorism in public places.
- Establishing partnership with the Centre for Protection of the National Infrastructure (CPNI), aiming to expand this to include other key stakeholders such as the MoD and the Cabinet Office.
- Further collaboration with the Home Office and the Communities & Local Government in areas such as designing out crime and crime-free communities.
- EPSRC is the dominant Research Council partner in the MoD Joint Grant Scheme, with discussions underway to expand our interaction with MoD initially focused through the Nanoscience theme.
- Defence interests also feature strongly in our portfolio of strategic partnerships with industry, in particular with BAE Systems and QinetiQ.
- Emerging partnership with DFID, building on international development activity focused on Energy.

Demographic Change

EPSRC's key interests in demographic change are concerned with ensuring that society is able to rise to the challenges that the new demographic profile will present, the ageing population in particular. Key areas will be:

- The Next Generation Healthcare theme, encompassing our collaboration with the Department of Health in areas such as Information-Driven Healthcare and Assisted Living, both of which support the cross-Council Life-Long Health and Wellbeing agenda.
- Our Extended Quality of Life portfolio, addressing issues such as rehabilitation technology and the inclusive design of products and environments, with strong engagement with social care agencies both in the charity sector, local Government and the NHS.
- The IMRCs' support for healthcare service delivery, with dedicated centres focused on the provision of infrastructure and on technology assessment and procurement, working closely in partnership with NHS stakeholders.

6 Facilities and Infrastructure

High-End Computing

We will ensure the provision of high-end computing infrastructure through the following activities:

- The High-End Computing Terascale (HECToR) service commenced in October 2007. Work is in hand with the sponsoring Research Councils, industry and academia to ensure good exploitation of the facility;
- The scale and cost of provision required beyond HECToR has led to negotiation at European-level, with the scientific case already agreed. EPSRC will invest in the initial 2-year phase of technology development activities (due to be matched by funds from the Commission).

Other Facilities

We will support a number of facilities where critical mass and centralisation offer more appropriate provision than dispersed, multiple provision. Continued investment in the following will ensure that researchers have access to essential infrastructure in a cost-effective manner:

- Isaac Newton Institute & International Centre for Mathematical Sciences
- Engineering Loan Pool
- Materials science equipment sharing
- Meso-scale facilities
- Capital equipment to support leading-edge research.

We will also follow up the International Review of ICT recommendation to maintain the software necessary to support UK researchers' competitive advantage in the Digital Economy.

Next-Generation Facility Users

In collaboration with STFC, EPSRC is investing to ensure that maximum value is obtained from the UK's centrally-provided research facilities, including Diamond Light Source and ISIS Target Station 2. We are providing funds to support a balanced portfolio of research with an element of doctoral training in order to develop the next generation of researchers skilled in using these and other facilities.

7 Science in Society

The key aims of EPSRC's Science in Society programme are to secure the future supply of people into research, and to engage citizens about the outcomes and processes of science and engineering. We will work with the RCUK Science in Society Unit on those activities which are more effective when delivered collectively, and will collaborate, where appropriate, with key partners such as the learned societies. Council is advised in this by its Societal Issues Panel which helps identify the challenges and opportunities for researchers in early engagement with public views. The Public Engagement programme manages the activities which contribute to this and to attracting young people into research.

Specifically, we will:

- Deploy the Societal Issues Panel to evolve EPSRC's thinking to take fuller account of the societal, political and legislative environment.
- Encourage and incentivise the EPSRC research community to engage with the public, for example by continuing to tailor public engagement support, training and advice and by supporting the HEFCE/RCUK Beacons pilot.
- Provide training and support for the EPSRC research community in:
    - Science communication and working with the media to reach the public.
    - Raising awareness of the societal and ethical implications of research.
- Foster public engagement, dialogue and debate around emergent research, technology and grand challenges.
- Enthuse young people to encourage them to pursue a scientific career, for example by continuing to support RCUK activities and further developing the NOISE campaign.
- Highlight areas where supply shortages have been identified, for example:
    - Computer science (as identified in the International Review of ICT 2006)
    - Engineering, where we will complete the 'Engineering a Better World' project
    - The number of women in engineering and physics, over and above the general shortages in maths, physics and chemistry
- Highlight to the public our priority research themes.

Box 12 – Science in Society: Key Objectives

- Ensure that EPSRC's thinking is informed by public views and by consideration of societal implications;
- Enable researchers to participate in high quality engagement with the public, and to consider societal implications and public attitudes in the conduct and use of research;
- Contribute to sustaining future people flow into engineering and the physical sciences by enthusing young people about the creative process, issues, aspirations and outcomes of research;
- Ensure the public are informed about developments, achievements and impacts of EPSRC-funded engineering and physical sciences research, in order to account for our investment and build public awareness of research.

8 International

World-class research is characterised by a high level of collaboration between leading research groups internationally. International collaboration will be embedded within programmes to ensure strong connectivity with specific research areas where the UK can benefit or offer global leadership. One high-profile example is the Dongtan Eco-city project, where EPSRC is working with Arup to develop a collaborative research programme involving Chinese and UK universities.

Specifically, we will:

- Further develop strategic and focused activities within target countries of China, India, Japan, USA and Europe, linking these to priority themes of Energy, the Digital Economy, and Nanoscience via targeted funding. This will include the continued activities of ring-fenced programmes such as 'INTERACT'.
- Work through RCUK offices in China, USA, and India to forge relationships with counterpart organisations.
- Take forward the Science Bridges programme as host of the RCUK Washington office.
- Lower barriers to international collaboration by working with funding agencies in target countries. Discussions with the NSF in the USA have already identified sustainable energy, nanoscience and the digital economy as collaboration topics, and ideas-exchange on transformative research.
- Engage in strategic international dialogue to ensure that the agenda for UK science and engineering is represented at appropriate levels (e.g., through the Global Science & Innovation Forum, DIUS' Science & Innovation Group and Brussels).
- Work with UK Trade & Investment (UKTI) to help secure inward investment.

Box 13 - Enhancing International Engagement: Key Objectives

- Facilitate 'best with best' research collaboration
- Enhance relationships with target countries: USA, China and India
- Promote the UK and seek global influence.

9 Improving Efficiency and Effectiveness

EPSRC has a strong commitment to ensuring that the public investment in the research base is used wisely. EPSRC will contribute its share of the RCUK efficiency requirements in the CSR period, as described in the RCUK Delivery Plan, including committing to a new cross-Council efficiency delivery programme to collectively deliver at least 3.65% per annum net cashable value for money gains.

We will achieve savings and increased effectiveness via:

- More efficient methods of peer review, e.g. greater use of outline proposals and a revised approach to project reporting, achieving £6M savings over the period
- Increased leverage on public investment by securing additional contributions from industry through, for example, additional strategic partnerships with companies
- Reducing the proportion of budget spent on administration to below 2.7% by 2010-11
- Working with other Research Councils e.g. on pay harmonisation and the Shared Service Centre (SSC), restructuring to be fit for purpose post-SSC
- Increasing the co-funding of research and training across our programme
- Adding value to research management by deploying staff in creative and flexible ways (e.g. sector-focused teams, IDEAS factories).

10 Financial Summary

Table 1– Research Grant and Training Commitment by Delivery Plan Theme

	£ million			
	2008/09	**2009/10**	**2010/11**	**CSR Total**
Energy	75.2	70.0	75.0	220.2
Of which Energy Technologies Institute	*15.0*	*20.0*	*25.0*	*60.0*
Digital economy	53.1	25.0	25.0	103.1
Nanoscience through engineering to application	22.9	10.0	6.0	38.9
Towards next generation healthcare	16.0	10.0	10.0	36.0
Living with environmental change	9.0	0.0	0.0	9.0
Global threats to security	6.0	0.0	0.0	6.0
Ageing: life-long health & wellbeing	10.5	0.0	0.0	10.5
Healthy science & engineering base	301.9	282.3	282.3	866.5
Securing the future supply of people	205.5	189.5	196.8	591.9
Towards better exploitation	251.5	113.2	117.3	482.1
Total	951.6	700.0	712.5	2364.1

CSR = comprehensive spending review. Some activities, such as fusion and high-end computing, are not funded as commitment and are excluded from this table. Numbers may not total due to rounding errors.

Table 2– Expenditure by Delivery Plan Theme

	£ million			
	2008/09	**2009/10**	**2010/11**	**Total**
Energy	74	79	86	240
Of which Energy Technologies Institute	*3*	*6*	*12*	*21*
Digital economy	1	15	22	39
Nanoscience through engineering to application	0	7	9	16
Towards next generation healthcare	0	5	7	12
Living with environmental change	11	10	5	26
Global threats to security	7	7	3	17
Ageing: life-long health & wellbeing	13	12	6	31
Healthy science & engineering base	368	354	343	1064
Securing the future supply of people	214	215	216	645
Towards better exploitation	81	99	118	298
Other	25	27	28	80
Total	795	830	843	2468

Table 3 – Net Income & Expenditure by Mechanism

		£ million		
		2008-09	**2009-10**	**2010-11**
Income				
Near cash		738.699	752.631	788.305
	Of which own EYF	*10.757*	*7.473*	*0.000*
	Of which other EYF	*5.497*	*9.030*	*0.000*
Non cash		9.653	13.931	5.899
Direct capital		13.268	13.626	13.994
Capital grants		33.437	34.340	35.267
HECToR large facilities capital fund		0.000	15.000	0.000
Income total		**795.057**	**829.528**	**843.465**
Near cash				
Administration costs	Administration	19.813	20.605	21.223
	Administrative programme costs	1.723	1.792	1.846
	Restructuring	0.250	0.250	0.250
International subscriptions	European Science Foundation	0.195	0.210	0.226
	Contribution to fusion for Europe	0.117	0.142	0.177
Postgraduate training	Studentships	171.018	179.116	188.099
Fellowships	EPSRC fellowships	35.366	36.720	39.925
	Academic fellowships	17.795	17.793	15.536
Grants	Research grants	474.829	484.483	497.118
Knowledge transfer, science & society, other	Energy Technologies Institute	3.000	6.000	12.000
	Programmes	4.789	5.422	4.892
Near cash total		**728.895**	**752.533**	**781.292**
Non cash				
	Depreciation	11.035	13.628	11.495
	Other	1.589	1.139	1.347
Non cash total		**12.624**	**14.767**	**12.842**
Capital				
	Capital	1.261	15.135	1.270
	SSC capital grants	3.000	0.930	0.570
	Capital grants	49.277	46.163	47.491
Capital total		**53.538**	**62.228**	**49.331**
Total expenditure		**795.057**	**829.528**	**843.465**
Income		**795.057**	**829.528**	**843.465**
In year EYF		**0.000**	**0.000**	**0.000**
Cumulative EYF		**7.473**	**0.000**	**0.000**

EYF = end of year flexibility, SSC = shared service centre

Annex 1 - Economic Impact Baseline

Delivering Impact from Excellence

Achieving the government's goal for a step change in economic impact arising from EPSRC's investments is only possible with a cutting-edge, highly-creative, internationally-leading portfolio.

Delivering Highly-Skilled People into the Wider Economy

EPSRC delivers a significant impact through the **provision of trained people into industry and the wider economy**:

- We spent nearly £150M in 2006/07 supporting ~7,700 PhDs.
- One third of our PhD graduates take up initial employment in business and public services.
- On average, the lifetime premium (relative to 2+ A-levels) for PhD graduates in engineering and physical sciences is estimated at £198k[11]. For the current cohort of EPSRC-supported students this will amount to collective additional lifetime earnings of ~£1.5 billion at current levels.

User-orientated training helps to satisfy the requirements of employers. EPSRC invests in a significant level of training with user involvement:

- Around 40% of EPSRC research student training involves the participation of industry.
- We support over 1,700 PhD students in collaborative training partnerships with industry.
- Currently 230 user organisations are engaged in collaborative PhD training.
- Industry currently contributes £56M to EPSRC postgraduate training.

The **Engineering Doctorate** (EngD) is a good example of highly successful vocational training well-suited to the needs of industry. Currently EPSRC supports 620 EngD students. Benefits identified in a recent case study[12] include:

- A positive impact on business performance worth possibly £10's millions annually through the creation of new products, processes or services
- Lifetime salary benefits of £100-300k (which also has a wider impact on the economy) compared to standard Physical Science PhD graduates.

A significant proportion (over 20%) of EPSRC-funded research assistants take up employment in business and public services: currently we support over 4,300 RAs.

[11] Estimate derived from HESA data on PhD student gender balance in EPS subjects (2004/05) combined with lifetime earnings differential data (2002 prices, net of taxes, excl. Scotland) published by O'Leary and Sloane 2005: The Return to a University Education in Great Britain Nat. Inst. Ec. Rev. v.193 pp 75-89 (July 2005)

[12] RCUK: Study on the Economic Impact of the Research councils 2007

Delivering Benefits to Business through the Exploitation of Excellent Research

EPSRC delivers **economic impact through support of basic research**. Broadly, the rate of return from academic research has been estimated to be 28%.

- EPSRC spent £420M on research grants in 2006/07, which is expected to yield returns to the economy of approximately £540M.
- EPSRC-supported research reported 159 licences and patents and 104 spinout companies[13].
- A recent review of EPSRC investment in polymer research concluded that, from an initial investment of ~£16M, impacts of the order of £200M have been identified, arising primarily from new businesses or products.

Working in Partnership with Users

The involvement of users in research, either directly on collaborative research projects or through strategic partnerships with EPSRC, facilitates and accelerates transfer and exploitation of the knowledge generated. The EPSRC portfolio has significant engagement of users in research:

- Approximately 40% of the research portfolio is collaborative with over 2,000 private and public organisations and charities.
- Over £90M was contributed by user organisations to research projects supported by EPSRC grants completed in 06/07.
- In a recent EPSRC survey of research collaborators 77% of users were satisfied with the EPSRC-financed research project in which they had been involved.
- EPSRC investment in research in collaboration with the Technology Strategy Board totals £24M.

EPSRC has developed **strategic partnerships** (i.e., formal arrangements for mutual financial support of targeted research programmes or research chairs) with key R&D intensive companies:

- Currently 28 organisations engage with EPSRC through Strategic Partnership agreements.
- A previous EPSRC strategic partnership in the area of combinatorial chemistry led to new chemistry which underpins ongoing research activity in major pharmaceutical companies, enhanced the competitiveness of a UK SME, and contributed to the position of pharmaceuticals as one of the UK's most dynamic industries.

Commercialisation

Another key element is the **promotion of commercialisation and enterprise** through focused programmes such as the Follow-on fund, Business Plan Competition etc.

- EPSRC invested about £1.3M on commercialisation programmes in 2006/07.

Delivering Benefits to Government and Public Services

EPSRC also provides inputs across a wide range of Government policy and delivery, and supports better healthcare, improved transport, flood control, crime prevention,

[13] Numbers reported on completed EPSRC research projects assessed in 05/06 and 06/07

anti-terrorism, and combating climate change, for example, through reduction in carbon emissions. EPSRC works effectively with partners across the public sector:

- Our partnership with the Department for Transport covers transport technology research and transport and land use planning, both of which have attracted co-funding from other key stakeholders such as the TSB, Rail Research UK, and the East of England Regional Development Agency.
- Our crime portfolio also features extensive end-user collaboration including Home Office Agencies, Police Services, Local Authorities as well as industry.

Table 4 - Summary of Economic Impact Baseline	
Delivering highly skilled people into the wider economy	34% EPSRC-supported PhD students take up initial employment in business and public services i.e. over 2,500 of our current students
	1,700 PhD students are supported in collaborative training partnerships involving 230 user organisations
Delivering benefits to business through the exploitation of excellent research	159 licences and patents and 104 spinout companies have arisen from EPSRC research assessed over the last 2 years
	Over 2,000 user organisations are currently collaborating on EPSRC research grants
	77% of users were satisfied with the research grant partnership in which they had been involved
	28 organisations engage with EPSRC through Strategic Partnership agreements
Delivering benefits to government and public services	Benefits include: better healthcare, improved transport, flood control, crime prevention, anti-terrorism, and combating climate change