



Innovate UK

Technology Strategy Board

Emerging technologies & industries strategy

2014-2018

Executive summary

“Our vision:
new £1bn growth
sectors from emerging
technology areas.”



The UK has one of the best research bases in the world. It is a fertile source of new knowledge, discovery and invention, helping to create totally new technologies that will change our world in the future.

Our emerging technologies and industries programme scans the research base to identify new technologies just as they are emerging and accelerates their adoption and use, helping to shape our future world and put the UK at the centre of global cutting-edge technology innovation.

An emerging technology is one that is still emerging from, or has only recently emerged from, the research base. It allows you to do something that was not possible before, or was only possible in theory; and, because of this, it disrupts existing markets, and leads to new ways of improving our lives and new sources of wealth generation.

We have an ambitious vision. Within a decade we want to see the UK poised to lead the world in one or more major new growth sectors of around £1bn turnover from an emerging technology area.

We will be increasing investment in our emerging technologies and industries programme and expect to commit more than £50m during the lifetime of this strategy. In doing so we will work with our partners in industry and the research sector to identify emerging technologies, to create truly national programmes in emerging fields, and to establish the critical mass of skills and capability that will help the UK to be fastest to global markets. At the appropriate point of technology emergence, the work will be integrated into core Innovate UK programmes.

Our strategy

Our emerging technologies and industries programme seeks to identify the early-stage technologies that will lead to the new products, processes and services of tomorrow – those with the potential to lead to the creation of completely new billion-pound industries. We will act to help develop the most promising.

No-one can accurately foresee the future, so it is hard to predict which technologies will have the most impact. For this reason, we will invest in a pipeline of emerging technology areas, exploring the potential of many different technologies, and escalating investment in the most promising.

The pipeline is constantly being refreshed, but so far we have identified and invested in seven high-potential technologies of strategic national importance – synthetic biology, energy efficient computing, energy harvesting, non-animal technologies, emerging imaging technologies, graphene and quantum technologies. Investments in other areas are planned.

Strategic themes

Our strategy is based around four strategic themes: to identify and evaluate emerging technologies with disruptive potential; to create a coordinated programme; to accelerate the journey to market; and to build critical mass and nurture capability.

We will:

- identify exciting early-stage technologies and evaluate their global market potential
- invest in a pipeline of emerging technologies with high commercial potential and help to accelerate their journey to market
- invest in the creation of demonstrators (of varying kinds), roadmaps and standards, taking an international perspective
- help to build connected ecosystems that support growth.

We have a robust process for identifying new areas to add to the programme and for prioritising investment in the most promising.

Challenges and opportunities

Businesses face particular challenges in turning emerging technologies into new products, processes and services. What the commercially viable offerings will be may not be apparent at the outset, and investment for the early-stage activities that are required can be hard to find. Supply chains are likely to be immature and there may not be the critical mass needed to move fast enough, or enough people with the necessary skills.

On the other side, the opportunities can be enormous. There is the potential for billion-pound industries to be created through emerging technologies. This is recognised by the UK Government, which, for example, has announced multi-million pound investments in both graphene and quantum technologies during the life of this strategy.

We will use the tools we have available to us, such as feasibility studies, demonstrators and innovation and knowledge centres, to support the emerging technologies we have prioritised. We will also help to co-ordinate innovation support nationally through involvement in leadership groups, technology roadmapping, supporting the development of standards, and by building an active community of innovators through our Knowledge Transfer Network.

In developing this strategy we have consulted widely with key players



Why are emerging technologies & industries a **priority** for us?

“Emerging technologies will be growth sectors of tomorrow and will transform markets”



Innovate UK is charged with helping UK businesses to grow. Much of our investment goes to support business innovation in thematic areas where the opportunities for industry are well understood and the technology development challenges known. But huge potential also exists in earlier stage technologies, although these are further from market.

These newly emerging technologies will be the growth sectors of tomorrow. They will transform the markets in which they are deployed, and they can be adopted by existing companies or by new entrants. The first to market generally gain a disproportionate share of the value, so identifying the opportunities and investing early will help to ensure that UK business captures the maximum possible value.

Emerging technologies have the potential to disrupt existing markets and to create billions of pounds of economic value for the UK. Photonics is a good example of how UK business profited from an emerging technology (see panel).

Strong research base

The UK has a flourishing, inventive and strong research base, with an excellent position globally. We have only 0.9% of global population but are responsible for 3.2% of global R&D expenditure. We have overtaken the US as number one among our comparators for citations in high-quality research and are responsible for 15.9% of the world's most highly-cited articles [1].

UK universities form twice as many spin-out companies – which often spearhead the development of early-stage technologies – per £m of research funding as US universities. There are more than 1,200 UK university spin-out companies, which together bring £3.3bn to the UK economy annually [2]. Four UK institutions were ranked in the top six of the QS World University Rankings 2014/15 [3].

As an example, the UK is a global leader in research into quantum physics. With our world-class industrial and academic capabilities in supporting technologies, such as nanofabrication, optics and vacuum systems, and strong skills in multi-disciplinary working, quantum technologies could deliver huge benefits to the UK.

Commercialisation of early-stage technologies, where there are so many unknowns, is always challenging, so our programme is key to UK success in exploiting and capitalising on the UK's excellent academic research. If we wait until the markets and opportunities are precisely defined, much of the value will already have been captured.

Case study

Photonics: a UK success story

The photonics industry did not exist 30 years ago. Today, it is worth £10.5bn to the UK economy, supporting more than 1,500 small and medium-sized companies (SMEs) and employing more than 70,000 people. It is growing at 8-10% annually.

Photonics began with the invention of the laser in 1960, followed by the laser diode in the 1970s and optical fibres for transmitting information, leading to the game-changing and dramatic growth of telecommunications.

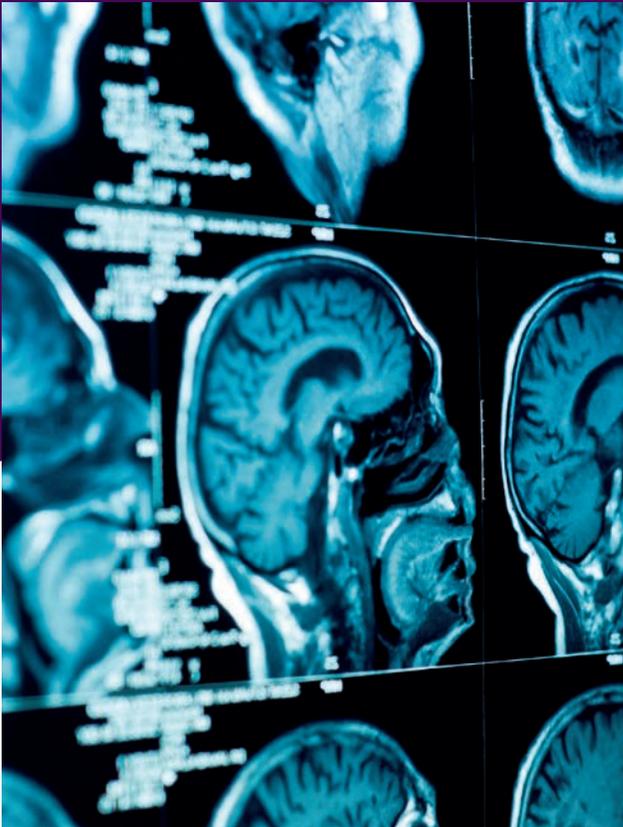
Clusters emerged around universities such as Strathclyde, Cambridge and Southampton, providing the expertise for SMEs to develop and grow an emerging industry.

UK academics were right at the forefront of this disruptive technology development and have helped companies to retain value from it for the UK.

The UK photonics industry now produces lasers for manufacturing, entertainment, computer chips, transmitting information, 3D printing, measurement, sensors and healthcare. Photonics is also the basis for LEDs in high-efficiency lighting and flat-screen displays for phones and televisions.

What are the challenges for emerging technologies?

“People do not buy technology, they buy what it does for them”



Turning emerging technologies into commercial products can be a lengthy, high-risk and complex process. Matching technological capability to market demand is notoriously difficult, and often the process fails, but failure to take potential markets into account is a recipe for disaster.

Since any given technology has to be combined with other technologies to make commercially viable systems work (for instance, a smart phone includes communications, data storage, liquid crystal display, digital camera and touch screen technologies) each new market evaluation comes with a new set of technology challenges.

Notwithstanding the complications, our action is guided by the principle that people do not buy technology, they buy what technology does for them, so demonstrating this is a key step in accelerating the journey to market.

Some of the challenges in commercialising emerging technologies include:

- the potential applications are not always apparent at the outset
- finding the best route to market for disruptive ideas is inherently difficult
- companies are not always aware of the opportunities presented by emerging technologies, or how to manage threats they might present to their existing business models
- support for early-stage, pre-investment, proof-of-concept work can be difficult to raise
- it is often not clear initially how costs will compare with existing solutions, which are likely to benefit from the economies of scale and experience
- establishing a unique selling point in the case of potential global competition is not straightforward
- the time taken to get products to market is incompatible with many sources of equity or investment
- people with the requisite skills can be in short supply and the capabilities needed change during the commercialisation process
- public sector support is not always aligned across the various bodies that can help.

Access to finance

Access to early-stage seed, angel or venture capital is particularly important to businesses working with emerging technologies, allowing them to demonstrate possible applications to potential customers and establish a route to market. Immediately post crash, venture capital investment in technology companies dramatically reduced. For example, in 2010, British Venture Capital Association members invested 30% less in UK venture capital stage companies than in the previous year [4], and venture capital fund managers focused on managing the performance of their existing portfolio companies, which were taking longer to exit, rather than making new investments [5].

Since then, however, access to venture capital has started to recover, and in 2012 the BVCA members' investment in the UK increased to £343m in 431 early-stage companies, particularly in software, internet, medical equipment, biotechnology, pharmaceutical and electronics applications [6]. The funding available to companies through the emerging technologies and industries programme complements the private equity available, slowing burn rate and increasing the likelihood of commercial success.

Case study

Synthetic biology programme

One of our strategic themes is to create coordinated national programmes in emerging technology areas.

An excellent example is in synthetic biology, which we have been supporting since 2011. Our investment built on earlier investments of over £80m by the research councils in research, networks, centres and training.

Since 2011, Innovate UK, the Engineering and Physical Sciences Research Council (EPSRC), the Biotechnology and Biological Sciences Research Council (BBSRC) and others have worked together to build a national innovation programme, providing collectively more than £50m of public funding to synthetic biology projects. A further £18m has been committed by industry.

The innovation programme includes support for business-led feasibility and demonstrator projects, an innovation and knowledge centre (SynbiCITE) based at Imperial College, European ERANET funding, doctoral training centres and several large multi-disciplinary academic research centres.

Other work includes:

- establishing a special interest group to support open innovation and networking
- forming a national leadership council
- publishing a UK roadmap for synthetic biology [7]
- consultative work on standards development
- synthetic biology companies working together as a group within the Bio-Industry Association.

What are the **opportunities** for emerging technologies & industries?

New technologies are emerging all the time from the UK research base. There is always the potential for tomorrow's multi-billion pound industry to be created from something we have yet to identify. Early identification of tomorrow's technologies will allow UK businesses to take full advantage of them and drive future growth to the benefit of all.

We provide a mechanism at the national level to identify high-potential early-stage technologies, prioritise them, design and run a coordinated programme of investment, and track their progress as they develop into tomorrow's emerging industries.

Our emerging technologies and industries programme has identified a number of areas where we believe successful UK research work could be translated into successful commercial products. These areas are synthetic biology, energy-efficient computing, energy harvesting, non-animal technologies, emerging imaging technologies, graphene, and quantum technologies (see panel opposite).

Each of these areas has the potential to be a new billion-pound industry for the UK. Although most, or all of them, will play some part in future economic growth, we do not yet know which ones will have the greatest impact at a national level. During the lifetime of this strategy, we fully expect to identify further emerging technologies that have the potential to be billion-pound industries for the UK.

Emerging technologies

Our programme has identified a number of emerging technology areas that we support. Those identified below represent the picture at publication of our strategy in October 2014. The list will change during the lifetime of this strategy as the most promising areas move on to be supported under the relevant Innovate UK programme and as new high-potential emerging technologies are identified.

Energy-efficient computing

This is the design of hardware and software to reduce the energy needed to execute computing processes. The applications lie anywhere that computing is done – from mobile devices to high-performance computing, from the ‘internet of things’ to data centres, and many others.

Energy harvesting

This is the scavenging of low levels of energy (milliwatts to watts) from, for example, environmental temperature gradients, vibration or pressure. It can be used to enable miniature electronic devices to power themselves independently, reducing or eliminating battery use, in markets such as wireless sensor networks, automotive power management, building controls and consumer devices.

Non-animal technologies

This is the development and use of in-vitro or in-silico technologies that give better answers to new substance-related questions such as “does it work?” and “is it safe?”. It has applications in numerous areas, including drug discovery and the evaluation of new medicines, improved crop protection chemicals and new personal care products. The opportunity is not solely to replace current animal models with their non-animal equivalents, but to develop better tests that are fundamentally more predictive.

Recent advances in relevant fields in the biosciences (including induced pluripotent stem cells, tissue engineering technologies, high-throughput platforms, computational methods and modelling) offer

many more opportunities for these systems to transform drug and chemical development. The UK leads the science in these technologies.

Emerging imaging technologies

These are new techniques to create or process images, allowing better extraction of data from imaged areas and/or enhanced data processing techniques to create a richer understanding of the observed area. There are applications in medical diagnostics, industrial process and quality control, enhanced security and traffic management.

The UK is a world leader in scientific research into technologies that could transform the imaging sector. For example, we have significant capability in photonics, computing, optics, terahertz sources and detectors, visualisation, photonic crystals and fibres, meta-materials and plasmonics, graphene and optical signal processing.

Graphene

This is a form of carbon having a two-dimensional, single layer structure and extraordinary mechanical, electrical, optical, gas-barrier and other properties. It could find applications in enhanced composite materials, electronic devices such as capacitors and display screens, conductive inks and many other areas.

The Government is investing more than £90m in graphene research and infrastructure, building on the Nobel Prize awarded to University of Manchester researchers Andre Geim and Konstantin Novoselov, and other UK research strengths in universities and business. More than 35 UK university groups are active in fundamental and applied graphene research, having attracted significant funding from Europe, global corporations and learned societies such as the Royal Society and the Royal Academy of Engineering.

Quantum technologies

These have the potential, amongst other things, to allow ultra-secure communications, highly sensitive sensing, measuring and imaging techniques, and massively faster computing and simulation. Potential applications include mineral extraction, navigation without use of satellites, medical imaging and secure communications.

The government is investing £270m over five years in the development of quantum technologies. The investment will support the development of a national network of research hubs, as well as postgraduate skills, research and infrastructure, and a £50m innovation programme.

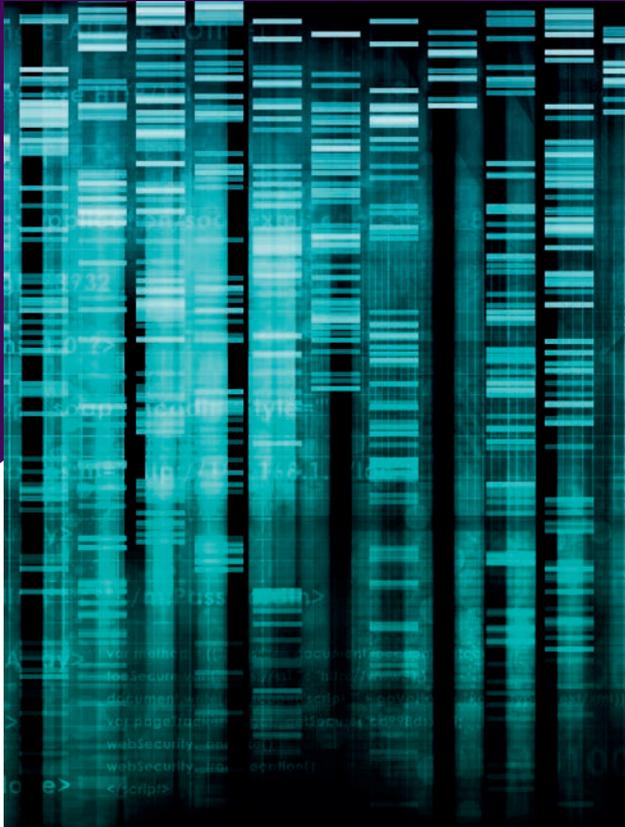
Synthetic biology

This is the design and engineering of novel biologically-based parts, devices and systems, or the redesign of existing biological systems for useful purposes. There are numerous potential applications, including the creation of new medicines and vaccines, new routes to bio-fuels and highly selective sensors.



Our emerging technologies & industries **strategy**

“We identify & prioritise emerging technologies”



The UK is host to one of the best research bases in the world. It is a fertile source of new knowledge, discovery and invention, helping to create totally new technologies that will change our world in the future.

Our emerging technologies and industries programme scans the research base to identify new technologies just as they are emerging and accelerates their adoption and use, helping to shape our future world and put the UK at the centre of global cutting-edge technology innovation.

An emerging technology is one that is still emerging from, or has only recently emerged from, the research base. It allows you to do something that was not possible before, or was only possible in theory; and, because of this, it creates a totally new value proposition. It disrupts existing markets, and leads to new ways of improving our lives and new sources of wealth generation.

Within a decade, we want to see the UK poised to lead the world in one or more major new growth sectors of around £1bn turnover from emerging technology areas where the UK has great strength and capability.

A key focus of our programme is to identify those areas with greatest promise and accelerate them to market. Our thinking and our activities are guided by the view that people do not buy technology; people buy what technology does for them.

We provide a mechanism at the national level to identify high-potential early-stage technologies, prioritise them, design and run a coordinated programme of investment, and track their progress as they develop into tomorrow's emerging industries. The process of identifying and prioritising emerging technologies is overseen by the Emerging Technologies and Industries Steering Group, a body consisting of successful technology entrepreneurs, investors, research funders, government departments and academics, with profound knowledge of developing and commercialising early-stage technologies.

A robust process

We have developed a robust process for prioritising the emerging technologies on our list, based on the Innovate UK investment criteria. The prioritisation process enables us to use data alongside more qualitative information to rate each technology with respect to the following questions:

- is there a large global market opportunity?
- does the UK have the capability to exploit it?
- can Innovate UK add value?

This process was developed and refined in consultation with stakeholders from industry, the investment community, the research base and government, and has been validated for its utility.

A sound base of previous and ongoing high-quality research is crucial in building and supporting a strong UK industry, so we will continue to work closely with EPSRC, BBSRC, MRC and other research funders to identify areas where companies might benefit most.

Case study

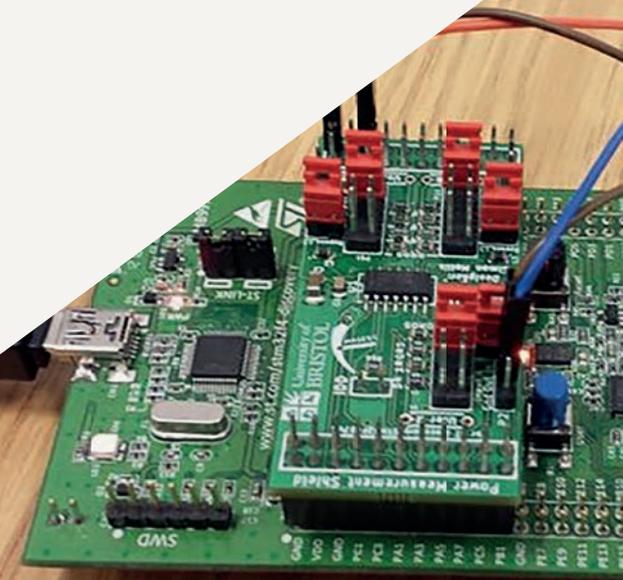
Embecosm

UK small business Embecosm and the wider computer engineering community have cemented their place as leaders in energy-efficient computing with funding from Innovate UK.

Embecosm is an expert in compilers – essential parts that convert software programs into a binary format that computer hardware can execute.

To date, compilers have always emphasised speed or code size. Embecosm, working with Bristol University, has, for the first time, optimised mainstream compiler infrastructures for energy efficiency. It has also developed a low-cost hardware circuit board to measure the actual energy used by software code, and where in the sequence of code the highest energy burden accrues.

Funding from Innovate UK's 'energy-efficient computing' feasibility studies competition allowed Embecosm to create and distribute 50 prototype boards for the broader industry to evaluate as a development tool. This has benefited the whole industry by allowing others to get better information about energy usage and to design for energy efficiency.



Our emerging technologies & industries **strategy**

continued...



Strategic themes

This strategy builds on our emerging technologies and industries strategy 2010-2013. We have set out four strategic themes to help the UK to identify and to benefit from new, disruptive, technologies just emerging from the science base. These are: to identify and evaluate emerging technologies with disruptive potential; to create a co-ordinated programme; to accelerate the journey to market; and to build critical mass and nurture capability.

Identify and evaluate emerging technologies with disruptive potential

We will:

- develop and deploy processes, with partners, to identify newly emerging technologies in the research base
- use a robust process to evaluate the innovation potential of identified technologies, anticipating current and potential future market pull
- ensure that UK capability is seen in an international context.

Create a co-ordinated programme

We will:

- develop and support, with partners, a pipeline of emerging technologies investments
- escalate the scale of investments in the most promising areas
- raise awareness of the opportunities within selected emerging technologies
- build a co-ordinated programme of investments within any given technology area, working with partners and other funding agencies to invest in demonstrators, nurture capacity and build critical mass
- obtain advice and guidance from our Emerging Technologies and Industries Steering Group
- integrate the most promising emerging technologies into core Innovate UK programmes at a suitable point of technology evolution.

Accelerate the journey to market

We will:

- invest in different kinds of demonstrators to speed up the transition between the different phases of technology emergence, for example:
 - technology demonstrators
 - application demonstrators
 - commercial application demonstrators
- help companies to find, and work with, the best partners to maximise impact
- enable standards that promote the penetration of new disruptive technologies
- take an international perspective on the development and commercialisation of these early-stage technologies
 - raise awareness of opportunities overseas, particularly funding within the EU's Horizon 2020 programme.

Build critical mass and nurture capability

We will:

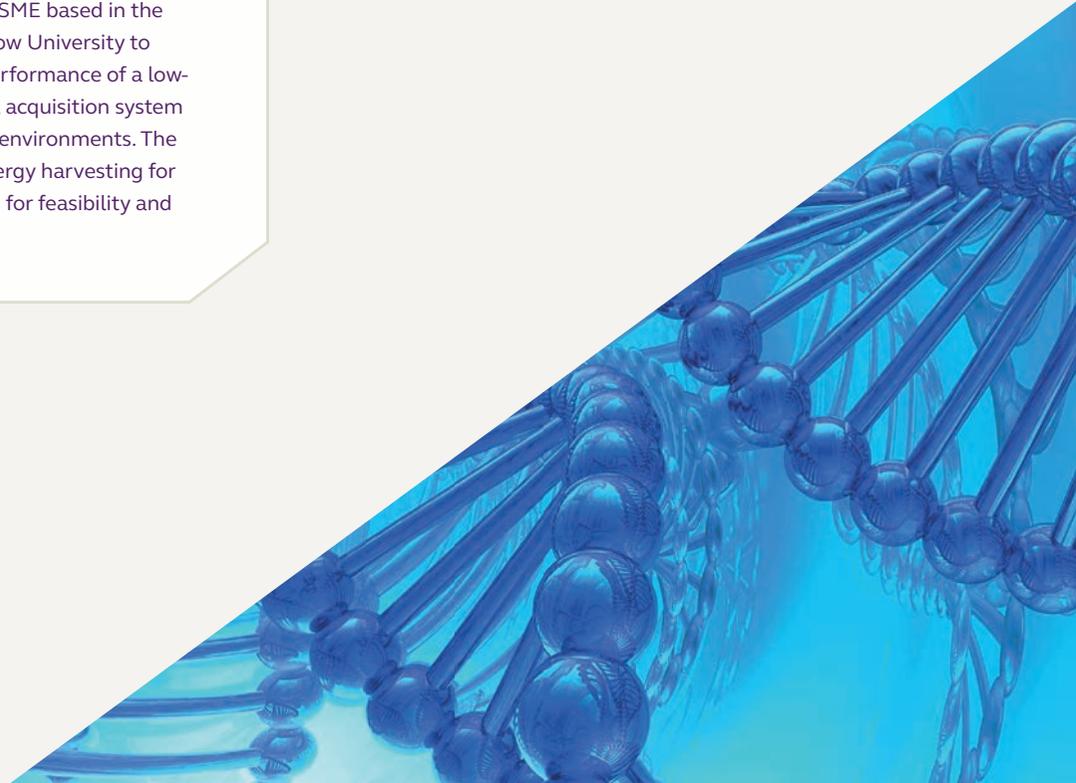
- build communities of interest in high-potential emerging technologies
- support companies and, where possible, individuals to develop their capacity to advance their early-stage technologies
- create cohorts in suitable areas to build critical mass and increase sector capability
- continue, with the research councils, to fund innovation and knowledge centres as early-stage nucleating points for an emerging industry.

Funding demonstrators

Demonstration is a critical step that determines whether a technology will move from the scientifically possible to the technologically real, and from the technologically real to the commercially viable, and how quickly it does so. It is demonstration that speeds the whole process up.

We accelerate the journey to market for fledgling industries through support for technology, application and commercial application demonstrators that are known to translate science and technology into applications, markets and growth. Our strategy is built on the industrial emergence framework developed at the Institute for Manufacturing, University of Cambridge [8].

One example of many demonstrators we have funded is European Thermodynamics, an SME based in the Midlands. It is working with Glasgow University to demonstrate the reliability and performance of a low-power microprocessor-based data acquisition system in harsh and hazardous industrial environments. The project won support from our 'Energy harvesting for autonomous sensing' competition for feasibility and demonstration funding.



Our emerging technologies & industries **strategy**

continued...

“We will invest to help business to develop and deploy emerging technologies”

Identifying and supporting technologies

Through this programme we will identify, and make business aware of, a pipeline of high-potential emerging technology areas. The pipeline will be continually updated, and investments escalated in those areas with the highest potential, using the full range of Innovate UK tools.

Our programme has already identified a number of emerging technologies and industries – synthetic biology, energy-efficient computing, energy harvesting, non-animal technologies, emerging imaging technologies, graphene, and quantum technologies. We will invest to help UK businesses overcome the barriers to developing and deploying these technologies, using our existing tools (such as feasibility and collaborative R&D funding, SBRI, launchpads, demonstrators, and innovation and knowledge centres) or creating new tools if gaps exist.

We will also help to co-ordinate innovation support nationally, including through joint funding of programmes, involvement in leadership groups, publishing technology and industry roadmaps, and supporting the development of standards where needed. We will continue to build an active community of innovators through the Knowledge Transfer Network.

When these early-stage technologies reach a suitable stage of emergence, and it makes sense to do so, we will transfer them to the relevant existing Innovate UK programmes. This frees the emerging technology and industries programme to support the next high-potential early-stage field.

For specific details of our work and opportunities to participate in our programmes, see our delivery plan, published annually on our website, and sign up for alerts, newsletters and information at www.innovateuk.org

Innovation and knowledge centres

Innovation and knowledge centres are an important part of our strategy. They were first created by EPSRC and are funded by them, Innovate UK, and other research councils, such as BBSRC, as appropriate. IKCs are based in a university to allow access to a broad range of scientific and technical expertise, and associated laboratory and scale-up facilities.

We regard them as early stage nucleating points for an emerging industry – that is they act as a magnet for those working in an emerging technology area, helping to advance the science, helping companies to explore the potential of that technology in a range of markets to see which are the most promising, and helping to build the skills that will accelerate commercialisation of new products and services.

Starting with the pioneering work of EPSRC, seven IKCs have been set up since 2007:

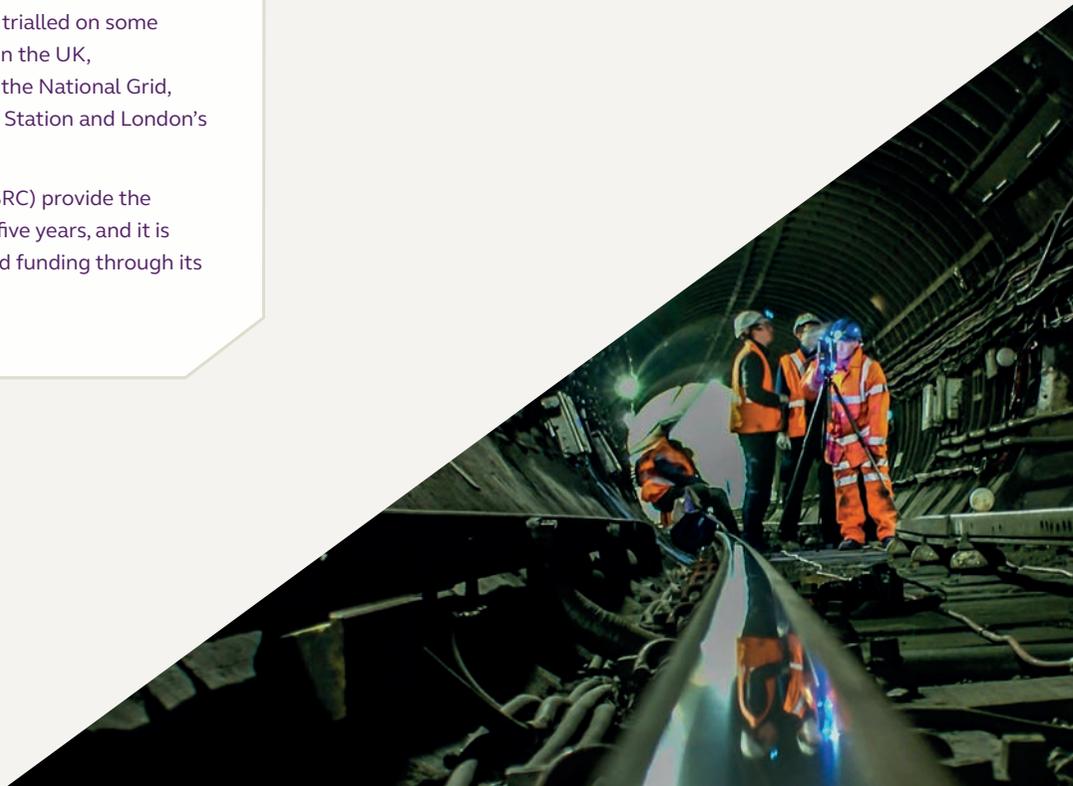
- advanced manufacturing technologies for photonics and electronics (Cambridge University)
- ultra-precision and structured surfaces (Cranfield University)
- secure information technologies (Queen's University, Belfast)
- medical technologies (University of Leeds)

- innovative functional industrial coatings (Swansea University)
- smart infrastructure and construction (University of Cambridge)
- synthetic biology (Imperial College London).

The Cambridge Centre for Smart Infrastructure and Construction is helping companies to improve the condition monitoring and future design of expensive civil engineering assets by introducing sensor and data management technologies to the traditionally conservative, risk-averse infrastructure industry. It is collaborating on 30 field demonstrators, incorporating fibre-optic sensing in tunnels, bridges, roads, railways, buildings and utilities.

Breakthrough technologies are being trialled on some of the largest infrastructure projects in the UK, including by Crossrail, Thames Water, the National Grid, London Underground, London Bridge Station and London's Shell Centre.

The co-funders (Innovate UK and EPSRC) provide the IKC with a core budget of £10m over five years, and it is drawing in significant industry-focused funding through its demonstration programmes.



References and sources

- [1] BIS 2013, International Comparative Performance of the UK Research Base - 2013, www.gov.uk/government/publications/performance-of-the-uk-research-base-international-comparison-2013
- [2] HEFCE 2012, Business and Community Interaction Survey: 2010-11, www.hefce.ac.uk/pubs/year/2012/201218/#d.en.74004
- [3] QS World University Rankings, www.topuniversities.com/qs-world-university-rankings
- [4] British Venture Capital Association (BVCA), 2010 activity survey, www.bvca.co.uk/researchpublications/industrystatistics.aspx
- [5] Nesta 2010, Venture Capital: Now and After the Dot Com Crash, www.nesta.org.uk/publications/venture-capital-now-and-after-dotcom-crash
- [6] British Venture Capital Association Private Equity and Venture Capital Report on Investment Activity 2012, May 2013, www.bvca.co.uk/Portals/0/Library/Files/News/2013/RIA_2012.pdf
- [7] Technology Strategy Board 2012, Synthetic Biology Roadmap, <http://connect.innovateuk.org/web/synthetic-biology-special-interest-group/roadmap-for-synthetic-biology>
- [8] Institute for Manufacturing, University of Cambridge, www.ifm.eng.cam.ac.uk/research/ctm/industrial-emergence/

Image credits

Front cover - courtesy of NPL

Page 11 - courtesy of Embecosc

Page 15 - courtesy of Cambridge Centre for Smart Infrastructure and Construction

Innovate UK

North Star House
North Star Avenue
Swindon
SN2 1UE

Telephone: 01793 442 700

www.innovateuk.org
support@innovateuk.gov.uk

Follow us on



Innovate UK is the new name for the Technology Strategy Board – the UK's innovation agency.

We know that taking a new idea to market is a challenge. We fund, support and connect innovative businesses through a unique mix of people and programmes to accelerate sustainable economic growth.

The Technology Strategy Board is an executive non-departmental public body sponsored by the Department for Business, Innovation and Skills, and is incorporated by Royal Charter in England and Wales with company number RC000818. Registered office: North Star House, North Star Avenue, Swindon SN2 1UE.

© Technology Strategy Board October 2014 T14/039
Printed on 100% recycled paper.