Technology Strategy Board
Driving Innovation

Enabling technologies
Strategy

2012-2015

Advanced materials

Biosciences

Electronics, sensors and photonics

Information and communication technology

02

ENABLING TECHNOLOGIES

EXECUTIVE SUMMARY

The four enabling technologies of advanced materials; biosciences; electronics, sensors and photonics; and information and communication technology (ICT) have a key role to play in helping business to develop high-value products and services to meet market needs across all economic sectors, and to generate significant growth in the UK.

Innovation in each of these four areas can also help to address some of the high-level challenges facing this country in fields such as energy, food, healthcare, transport and the built environment.

Nanotechnologies will have a huge underpinning effect across most of these technology areas, particularly in the healthcare and life sciences sectors.

Opportunities

Business opportunities in enabling technologies are collectively worth hundreds of billions of pounds globally and are growing at double-digit rates. National statistics[1] indicate that UK businesses that produce, process, fabricate and recycle materials had an annual turnover of £197bn in 2010 and contributed £53bn to gross value added (GVA).

Businesses in biosciences had turnover of £134bn and GVA of £41bn, while ICT firms had turnover of £137bn with GVA of £66bn. The UK's electronics, sensors and photonics industry generated over £29bn, contributing £12bn to GVA.

Between them, these industries consist of more than 196,000 companies. These figures significantly underestimate the impact of enabling technologies on the broader economy.

Important link

Each of the four enabling technology areas can underpin innovation across many different markets.

Developments in advanced materials can address concerns about the sustainability of natural resources and energy supply, and have the capability to sustain high value manufacturing and construction in the UK. Biosciences play an important role in development of a wide variety of items for everyday needs, from food to medical care, while ICT and electronics, sensors and photonics are now fundamental to almost every aspect of modern life and business, providing the computing and communications backbone to the economy.

All four enabling technologies provide an important link between businesses and the research base, where many technologies are first developed, sometimes without a specific end use in mind.

'Business opportunities are worth hundreds of billions of pounds and growing at double-digit rates.'

OUR STRATEGY

We aim to stimulate the development of enabling technologies, tools and approaches and the exploitation of new high-value products, services and systems based on them.

We will:

- invest around £20m a year in higher-risk, early-stage innovation across advanced materials; biosciences; electronics, sensors and photonics; and ICT
- invest half of our funds in activities to stimulate innovation that tackles technological challenges, resulting in capabilities that can be exploited across many sectors (or 'technology-inspired')
- invest the other half in driving early-stage technology development towards specific sector challenges (constituting markets of first use) as identified by colleagues working in these areas
- continue to run Collaboration Nation events to showcase technological innovation and to create new links between innovators and potential investors and partners
- make strategic use of a wider range of Technology Strategy Board tools, such as Launchpad, Smart grants and Knowledge Transfer Partnerships, in our programmes to encourage small and micro businesses to innovate
- promote cross-disciplinary links between relevant technology communities and the Catapults network of technology and innovation centres by harnessing the power of the Knowledge Transfer Networks and **_connect**
- continue to work with the research councils, the European Commission and other partners to ensure strategic alignment of science and innovation strategies for best effect for UK businesses.

For more detail on where we expect to invest our funds, please refer to the individual technology areas which follow.

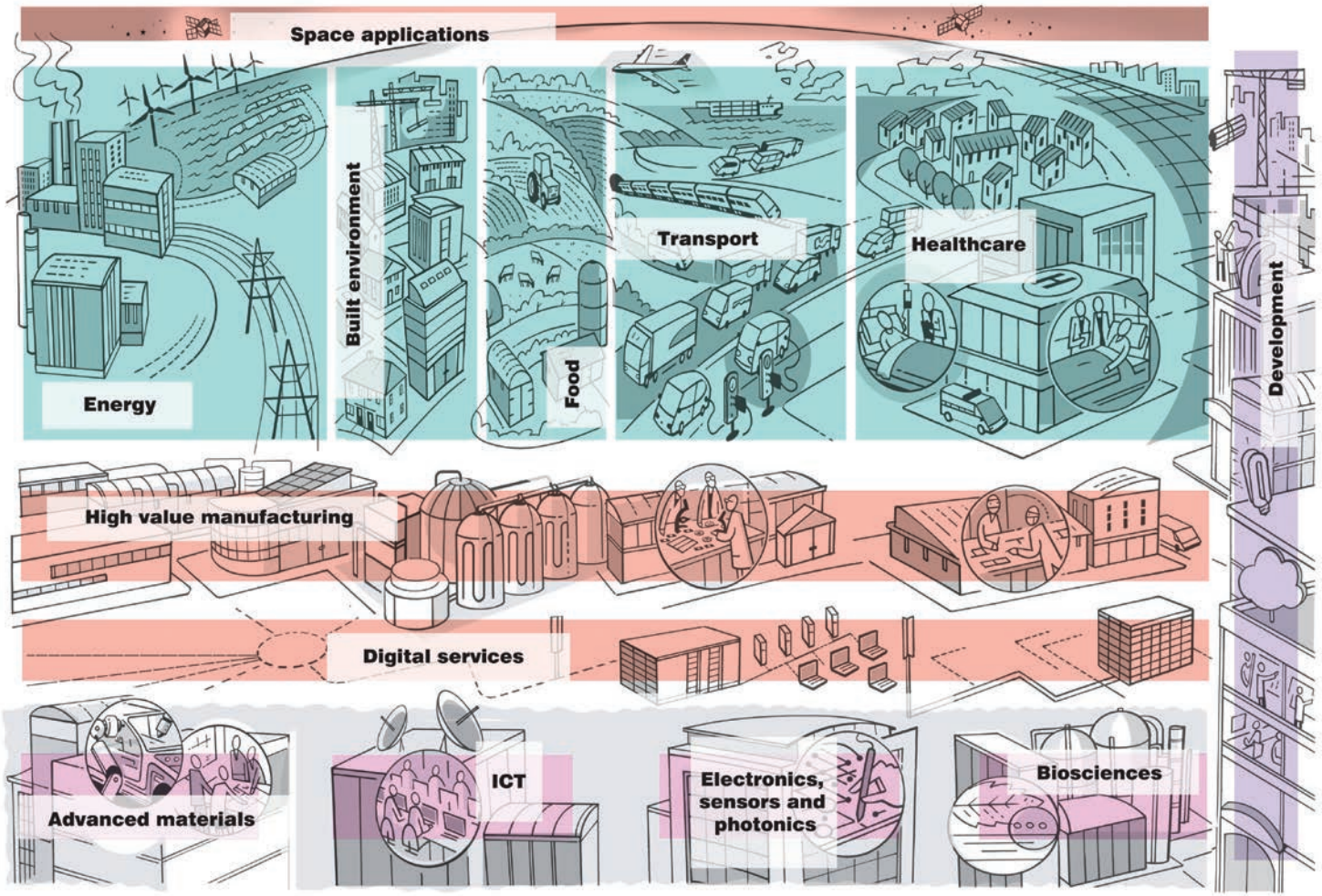
ENABLING TECHNOLOGIES

WHY ENABLING TECHNOLOGIES?

We recognise that the enabling technologies of advanced materials; biosciences; electronics, sensors and photonics; and information and communication technology have a key role to play in underpinning innovation across a range of market sectors, in generating wealth for the UK and in meeting societal challenges.

The Technology Strategy Board's overall strategy, *Concept to Commercialisation*[2], identifies a number of 'challenge-led' areas as priorities for investment, including energy, healthcare, transport and the built environment. It also recognises high value manufacturing and digital services as two competences which take technologies through to high-value products and/or services which can impact on many markets.

Alongside these are the enabling technologies, which are the key to flexibility when addressing market needs. In addition, electronics, sensors and photonics and ICT are often vital in enabling innovation across all markets that rely on the ability to sense, transmit and harness data. A single market or challenge may often require a combination of technologies.



WHAT ARE THE CHALLENGES TO INNOVATION?

Private investors are finding it difficult to invest in higher-risk, early-stage innovation across all four enabling technology areas in the current economic climate, making it hard for innovators to take their initial ideas to a level of maturity that will attract later rounds of investment or the engagement of potential users.

Some challenges to innovation are more prominent in some technology areas than in others.

In **advanced materials**, there are uncertainties in the availability of energy and raw materials and competition from low-cost manufacturing overseas.

Development of a novel product or process in **biosciences** often demands long lead times and expensive capital equipment. In addition, the regulatory field is complex.

The cost of developing and manufacturing products and a fragmented supply chain dominated by small and medium-sized enterprises is a challenge in the field of **electronics, sensors and photonics**. Most businesses cannot afford the high-value capital equipment needed to develop and test their designs and materials.

In **ICT**, those who can realise the value of data and software are often not involved in the development process and so are not best served by current tools. There are also concerns about the 'cloud', particularly around security and data preservation.

Whether the barriers to market entry and innovation are high (as is generally the case in advanced materials, biosciences and much of electronics, sensors and photonics) or low (generally the case for ICT and some of electronics, sensors and photonics), collaboration between elements of the supply chain is essential to ensure UK competitiveness.

In addition, cross-disciplinary working across the enabling technologies and disciplines (for example, design, engineering, mathematics) needs to be promoted.

ENABLING TECHNOLOGIES

WHAT ARE THE OPPORTUNITIES FOR BUSINESS?

The opportunities for business in enabling technologies are very large as they exist across all markets (see opposite).

It is estimated that key enabling technologies as defined by the European Commission (not including software technologies) will have a global market of €1 trillion by 2015[3].

Advanced materials present particular opportunities in the fields of energy and sustainability. Materials technology also has great potential to provide lightweight structures in the transport sector and materials for more efficient energy storage.

There are opportunities in **biosciences** for characterisation and discovery tools, production and processing, and bioinformatics.

In **photonics**, the UK can exploit lasers, sensors and imaging in markets ranging from healthcare to security. There is significant demand for advanced **sensor** systems in aerospace, transport, energy and health; and power **electronics** is fundamental to transport, energy generation, consumer electronics and industrial drives.

ICT presents opportunities for new devices, the processing of huge amounts of data, secure cloud systems and new approaches to software engineering.

As an enabling set of capabilities, nanoscale technologies could provide new offerings in areas such as drug delivery and formulation, photovoltaics and plastic electronics.

Making choices

We will focus our investment and support activities where we believe UK businesses stand to gain most success and where there is some risk in getting new breakthroughs to the demonstrable level of maturity required for business to invest alone.

We will therefore focus our innovation support on the pre-competitive stages, between proof-of-concept and commercial demonstrators, at which collaboration and the cross-fertilisation of ideas can happen within and between sectors.

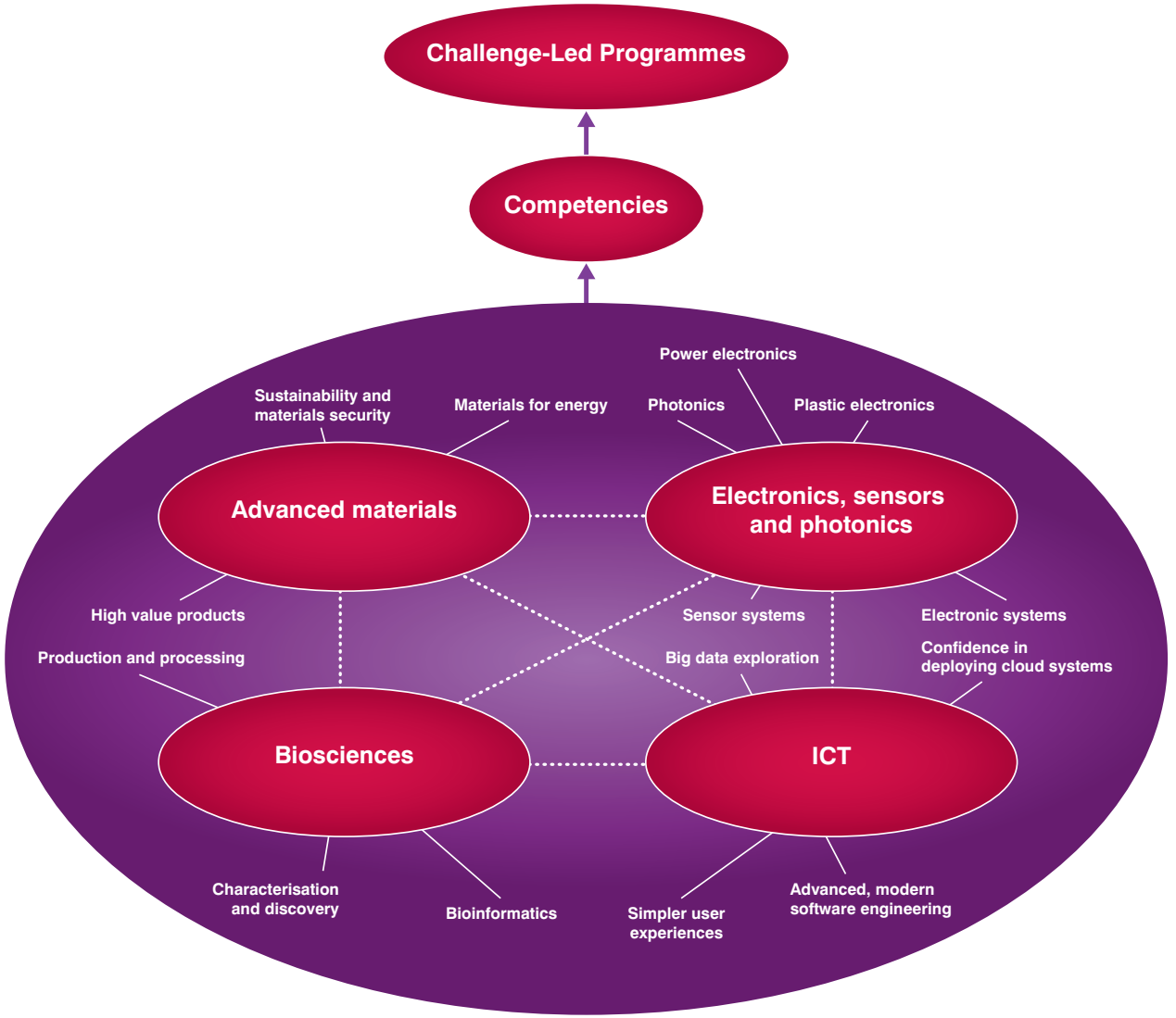
In doing this, we will employ a wide range of our tools to stimulate innovation and knowledge exchange, including and not limited to feasibility studies, collaborative R&D, Launchpad, Knowledge Transfer Partnerships and Smart grants.

Our choices are based on our day-to-day interactions with businesses and researchers, and on an assessment of key areas against the four Technology Strategy Board investment criteria.

We will support the Catapults – a programme of technology and innovation centres – in their enabling technology requirements.

Specific investments in enabling technologies are detailed in the Technology Strategy Board annual delivery plan published at **www.innovateuk.org**

OPPORTUNITIES IN ENABLING TECHNOLOGIES



ADVANCED MATERIALS

WHY ARE ADVANCED MATERIALS A PRIORITY FOR US?

Businesses in the UK that produce, process, fabricate and recycle materials form a critical element in the high value manufacturing (HVM) supply chain. They have an annual turnover of around £197bn and contribute GVA of £53bn[1].

Advanced materials underpin many key business sectors including general manufacturing, construction in the built environment, clean tech and transport.

The interdependency between advanced materials and high value manufacturing, in particular, offers a huge opportunity for innovation and growth in the UK.

Innovation in advanced materials' development and application will strengthen the UK's world-leading position as a provider of high-value-added products, processes and services which have strong potential to bring sustainable growth and high economic value to the UK.

'Grand Challenge gave us exposure to a range of companies and gave us the opportunity to demonstrate our innovation, knowledge and capabilities. The whole project and management was focused so you had to achieve.' Chris McHugh, Technical Manager, Sigmatex

WHAT ARE THE CHALLENGES FOR ADVANCED MATERIALS INNOVATION?

Sustainability in its broadest context (economic, environmental and social)[3] is the most important challenge for advanced materials.

Uncertainty in the future availability of energy and raw materials puts at risk the development of high-value products and drives up the cost of materials for a wide range of businesses.

Around 75% of European entrepreneurs have seen the material costs of their business rise over the last five years and 87% expect prices to continue rising over the next decade[5].

This threatens the sustainability of a whole range of industries underpinned by the availability of materials and may reduce the investment that companies can put into materials innovation.

Competition from low-cost manufacturing overseas presents a major threat to UK industry.

However, the UK can use its strong research and development base to enhance existing materials through design and to bring new products to market faster than the competition.

The Technology Strategy Board has a role to play in stimulating and helping UK businesses to take up these opportunities, playing to UK strengths.

Case study

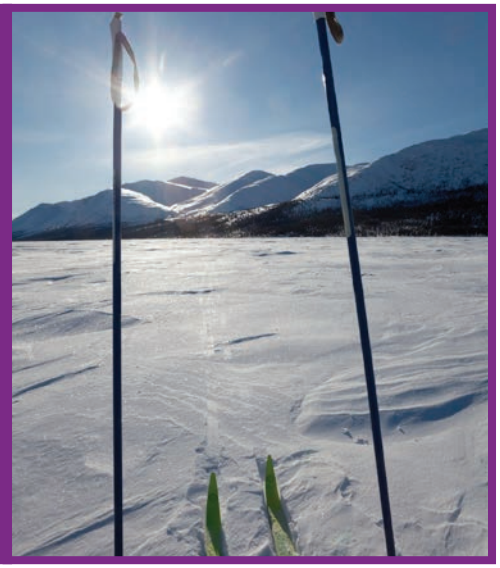
Composites Grand Challenge

We devised the 'grand challenge' process to bring industry players together to stimulate the uptake of fibre-reinforced polymer matrix composites across a range of markets. The total investment of £10m by the 22 companies in the i-Composites consortium and the Department for Business, Innovation and Skills is expected to provide a return of £200m longer term.

One member of the consortium, Sigmatex, a world leader in converting carbon fibre and producing advanced textiles, has been able to immediately exploit its new material for the manufacture of cross-country skis, with sales expected to reach £7m in the first year.

Fostering collaboration among businesses and researchers working in enabling technologies and with businesses working in challenge-led areas is a key part of our strategy.

'Grand Challenge gave us exposure to a range of companies and gave us the opportunity to demonstrate our innovation, knowledge and capabilities. The whole project and management was focused so you had to achieve.'
Chris McHugh, Technical Manager, Sigmatex



ADVANCED MATERIALS

WHAT ARE THE OPPORTUNITIES FOR BUSINESS?

Materials innovation offers significant opportunities for UK businesses in the areas of sustainability and materials security; materials for energy; and high-value markets.

Sustainability and materials security

The advanced materials community has a huge part to play in the security of materials and other world resources such as water and food.

There is a major market opportunity to develop products and services that make better use of the material resources available.

The development of a circular economy in which material resources remain in the value chain for as long as possible demands innovation in both advanced materials and business modelling.

The materials sector, with a strong industry and science base, is well placed to address these sustainability challenges and to help high value manufacturing and construction to grow in the UK through the development of a range of innovative, sustainable and competitive high-performance materials, products and processes.

Materials for energy

There are continuing societal concerns about the environment, natural resources, security of energy supply and fuel poverty.

Materials technology could address challenges facing the energy industry in energy generation, conservation, transmission and storage.

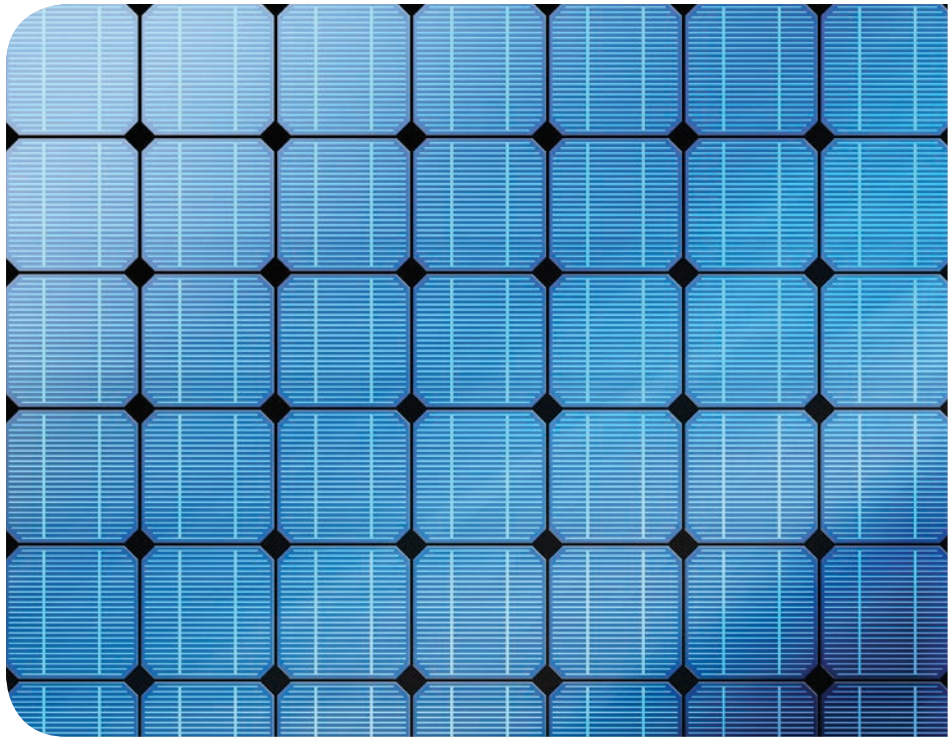
We expect that 30-35GW of new electricity generation will be needed over the next two decades (around two thirds of which by 2020)[6].

Significant advanced materials opportunities can be found in generating, storing and distributing energy to meet these targets.

There is also a demand for materials and related processes that use less energy and/or exhibit greater conversion efficiencies, incorporating a greater use of other renewable resources.

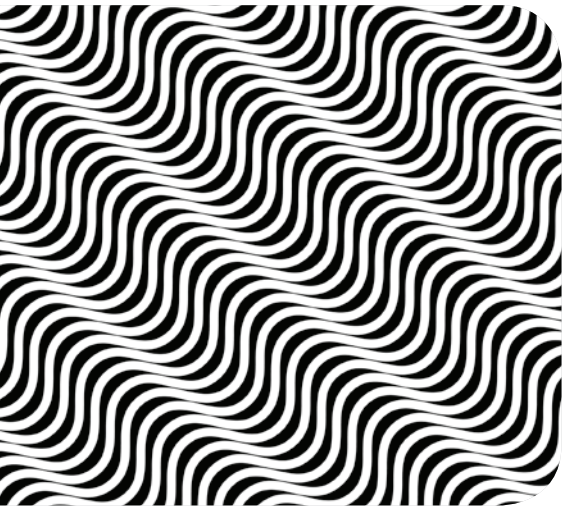
High value markets

We need constant innovation to develop novel materials, surfaces and coatings with improved intrinsic properties (for example anti-microbial) as part of high-value products and services for a range of applications across various sectors, for example healthcare, creative industries and security.



MAKING CHOICES IN ADVANCED MATERIALS

We will invest in advanced materials innovation through technology-inspired competitions as well as through sector-specific challenge programmes where there are particular materials-related needs. These sectors will include transport and energy, where strong materials impact has already been identified, and potentially new areas such as the creative industries, where new opportunities for strong growth may be realised.



Sustainability and materials security

we will invest in:

- lightweight materials (including metals, composites, hybrid structures and other structural materials and their associated joining and assembly technologies) applied to vehicles, structures and devices to reduce energy consumption and emissions, and increase efficiency
- materials with reduced environmental impact through-life (including materials for packaging applications)
- nanotechnology-enabled materials and functionality
- substitution approaches to reduce the use of less sustainable materials or those that may become restricted or banned under EU REACH regulation (Registration, Evaluation, Authorisation and Restriction of Chemicals)
- development of new materials technologies and processes to support a circular economy, for example tracking and through-life management of polymeric and composite materials, renewable raw materials, materials with self-healing or self-repairing properties
- materials for infrastructure and asset protection and traceability, for example as a deterrent to theft
- materials for sustainability of other world resources, for example bio-based and natural materials and composites; water purification.

Materials for energy

we will invest in:

- materials for cheaper and more efficient energy storage and management (chemical, biological, electrochemical, electrical, mechanical and thermal) – from mobile electronic and portable devices to grid-scale, for example batteries, supercapacitors, flywheels, hydrogen storage
- materials for energy transmission/ distribution that minimise energy, power and thermal loss during the transmission and distribution process, including both electrical and liquid fuel-based systems, for example superconductors
- materials for high-durability energy generation at small scale (for example energy harvesting, micro generation) and large scale (for example 'clean' technologies, carbon abatement technologies, catalysts/fuel cells, photovoltaics, solid-state, magnetic materials).

High value markets

we will invest in:

- integration of new materials, coatings and electronics, for example for sensing applications
- materials to survive in aggressive environments with extremes of temperature, corrosion, erosion or stress
- bio-based materials.

BIOSCIENCES

WHY ARE BIOSCIENCES A PRIORITY FOR US?

Biosciences technologies play an important role in the development of a wide variety of products and processes that are an integral part of our everyday lives, from the food we eat to our medical care.

The biosciences could form the basis of a new technological revolution, akin to the industrial or information revolutions, and the UK is well placed to be a major player in this substantial opportunity.

The innovative nature of the industry has positioned biosciences as a growing sector of the economy, with the UK life sciences sector showing strength and resilience in 2011 against the background of a global recession.

Between them, the UK biosciences industries of pharmaceuticals and industrial biotechnology represent more than 13,000 companies[1] and generate a turnover of over £134bn and a contribution to GVA of £41bn.

The food and drink industries, which rely heavily on biosciences, generate a turnover of over £91bn and a contribution to GVA of £25bn.

Primary agriculture represents an additional £7.4bn GVA.

The development and use by business of technologies inspired by biosciences provides opportunities for replacing unsustainable production methods, reducing our reliance on fossil fuels, improving public health, and the development of products in areas as diverse as healthcare and medicine, agriculture and energy.

The creation of a sustainable bioeconomy is at the heart of the European Commission's agenda.

Case study

Ingenza: Genomes UK

We ran a £5m collaborative research and development competition in 2010, called Genomes UK, to stimulate exploitation of high-throughput sequencing. Ingenza, a Scottish SME collaborating with Ark Genomics and the Rowett Institute of Nutrition and Health, is now using state-of-the-art high-throughput sequencing to generate around 300Gb of DNA sequence data to aid understanding of how ruminant animals (such as cattle, sheep and reindeer) are uniquely able to digest certain plant material through specific enzyme action.

Improving the efficiency of energy release from plants is a major focus for biofuel research and development as it could lead to sustainable alternatives to fossil fuels. The project could generate multi-million pound revenues for Ingenza and have applications in other areas such as drug development.

The ability to harness large amounts of data is key to all sectors, tapping into expertise in the UK ICT community. We will invest in programmes to bring biosciences innovators together with ICT, design and engineering to improve the way in which data gets exploited.

WHAT ARE THE CHALLENGES FOR BIOSCIENCES INNOVATION?

Businesses developing innovative biosciences technologies face challenges common to other sectors, including access to competitive debt and equity funding and expertise.

The nature of the sector means these businesses often face additional challenges in commercialising a novel product including:

- long and expensive development pathways and a requirement for expensive capital equipment
- regulation – observed most recently in the food industry where the trend for the development of functional foods marketed with a health claim has meant the move to a more clinical-evidence-based development pathway akin to a pharma-based approach
- collaboration with universities, and translating and licensing university technologies are viewed by some businesses as a challenging, lengthy and expensive process, with varying practices from institution to institution compounding these issues. This is despite a strong historical connection with the academic base
- biosciences technologies have, and will continue to, provide solutions to societal challenges, however the transformative potential of technology advancement in this area, particularly that of genetic technologies, also brings with it moral and ethical considerations. There is still a lack of acceptance among consumers and politicians for this technology in many parts of Europe, especially in food. Although the European landscape concerning genetic technologies is not entirely favourable, we recognise that the UK is home to a number of world-class universities and businesses with expertise in these areas and the global market opportunities are large.

In some instances, the technological advances in this area are occurring so rapidly, as observed in high-throughput sequencing and synthetic biology, that the challenge for industry becomes one of capitalising on the opportunities provided by these technological advances rather than developing new underpinning technology itself. For this reason, we will work closely with our Technology Strategy Board colleagues in challenge-led areas to provide opportunities to exploit the most recent technological innovations.

BIOSCIENCES

WHAT ARE THE OPPORTUNITIES FOR BUSINESS?

Biosciences innovation offers significant opportunities for UK businesses in the areas of characterisation and discovery tools, production and processing, and bioinformatics.

Characterisation and discovery tools

The ability to access genomic information quickly and cheaply provides opportunities for advances in many areas including: improving livestock and crop species by selective breeding; developing novel therapeutics, vaccines and antimicrobials; and refining new or existing enzymatic processes.

The global market for next-generation sequencing technology is estimated to reach $3bn by 2017[7].

This is an opportunity for the UK to develop commercial applications based on early achievements in sequencing chemistry and technologies and core expertise in the Genome Analysis Centre and the European Bioinformatics Institute.

The UK is third globally with regards to the number of healthcare-focused nanotechnology companies[8].

By 2016, the demand for nano-enabled products is estimated to amount to $55.7bn (around 7% of the total demand for healthcare products).

The key areas in the healthcare sector are drug delivery and formulation, diagnostics, and analytical tools and instruments.

Production and processing

There are opportunities for applying technological advances to enable greater production efficiencies for the food and drink, and pharmaceutical industries, both of high importance to the UK economy.

In addition, novel therapies will require the development of bespoke production mechanisms.

There is a strong academic community focusing on industry-driven research in this area.

The global market for environmental goods and services can also be served by biosciences innovation.

The bioplastics market alone is expected to grow by 32.4% a year from 2011 to 2015, reaching an estimated value of $11.14bn in 2015[9].

Bioinformatics

There are great opportunities for UK businesses to develop novel approaches to data interpretation, with the global bioinformatics market estimated to be worth $2.4bn in 2011, reaching $7.6bn by 2017[10].

Bringing functionality to the user, whether clinician or breeder, will revolutionise decision-making and truly realise the potential of ‘omics’ technologies.

MAKING CHOICES IN BIOSCIENCES

We will invest in biosciences innovation through technology-inspired competitions as well as through sector-specific challenge programmes where there are specific biosciences-related needs. These sectors will include food, agriculture and health.

Characterisation and discovery tools

we will invest in:

- commercial application of sequencing technologies focusing on genomics
- phenotyping technologies
- integration of 'omics technologies
- development of biological imaging systems, biosensors, probes/markers, diagnostic platforms.

Production and processing

we will invest in:

- metabolic engineering
- novel manufacturing processes for producing biological products and novel biological production systems
- formulation and delivery approaches for biological products including biopharmaceuticals and functional foods.

Bioinformatics

we will invest in:

- approaches to organise, filter and interpret biological data, including biological system modelling, data visualisation, and user centred design.

ELECTRONICS, SENSORS AND PHOTO

WHY IS ELECTRONICS, SENSORS AND PHOTONICS A PRIORITY FOR US?

In 2005, the total number of transistors in the world was five quintillion. The explosion in the number and complexity of connected devices pushed it to 80 quintillion by the end of 2010 and it is forecast to reach 1,200 quintillion by 2015[12]. That is more than 150 billion transistors for every man, woman and child on earth.

There are more than 8,000 companies in the UK's electronics industry involved in designing and manufacturing products. These companies generate around £29bn a year in revenues and contribute over £12bn to GVA. In 2009-10, the UK's electronics sector was the fifth largest in the world[11].

Electronics, sensors and photonics underpin activity in healthcare, energy, transport, environmental sustainability, built environment and across the consumer market. Whether through sensor systems, embedded systems, power electronics, plastic electronics or photonics, the UK benefits from a strong science base and a long tradition of inventiveness and innovation in the uses of electricity and light.

We see opportunities in five technology streams, all forecast for huge growth:

- photonics
- sensor systems
- power electronics
- plastic electronics
- electronic systems.

Case study

Organic lighting – at increasing scale

Lighting accounts for around 10% of the electricity bill in most homes and for as much as 50% of the electricity bill in offices. The ubiquitous fluorescent lamp is rapidly being replaced by solid state lighting, light emitting diode (LED) and eventually organic light emitting diode (OLED) technologies, as the drive towards more efficient and cheaper lighting is of paramount importance, though not at the expense of white-light quality.

We co-funded a collaborative R&D project led by Thorn Lighting which developed and demonstrated a small area OLED lamp which is set to revolutionise lighting in buildings. The lamp is made by applying an ultra-thin polymer coating onto glass. The world leading polymer material technology was developed by Cambridge Display Technology and is applicable to lighting and electronic display applications.

Subsequently, Thorn Lighting won further funding in our plastic electronics competition, *Building the supply chain*, to demonstrate the manufacturability of a larger area polymer OLED luminaire by 2013. Advances in materials and processing techniques, such as printing and roll-to-roll processing, could make large area printed lighting a reality, completely changing the value chains and business models in the lighting industry and creating growth in the UK electronics industry.

WHAT ARE THE CHALLENGES FOR ELECTRONICS, SENSORS AND PHOTONICS INNOVATION?

The main challenges for the electronics sector in the UK include:

- the prohibitive cost of product development and manufacturing (particularly for early-stage companies)
- a fragmented supply chain
- a general lack of vertically integrated companies that can realise products with an internal supply
- a fiercely competitive global market.

In the past 25 years, many of the large, vertically integrated companies that existed in the electronics sector in the UK have disappeared. Those companies were able to develop internal supply chains for innovative technologies and provide a market outlet for the products. With their demise, the UK is dominated by a large number of small and medium-sized businesses (SMEs), sometimes pre-revenue, developing innovative technologies to systems integrators and end equipment manufacturers who are largely risk averse. The adoption of innovative technologies can be slowed by SMEs lacking integration and demonstration facilities and resources.

Some of the SMEs in the sector have difficulty supplying to large companies, retailers and consumer groups, which often prefer to deal with other large companies to avoid the risks of a poorly understood single source of knowledge or material and a low level of financial security.

Each of the five technology streams faces its own challenges.

Photonics

With the demise of the large corporate and public sector research labs, the UK struggles to exploit photonics technology to its full potential. The UK has around 1500 companies active in the photonics field, but most are SMEs without the resources to fund the expensive capital equipment and facilities necessary to develop and test their designs and materials.

Sensor systems

Integration and demonstration gaps exist and are blocking the value chain through academia, SMEs, systems integrators and instrumentation companies to end-users. The UK has significant presence at each stage of the value chain but has not been able to overcome the skills shortages and risk aversion that is preventing the component and sub-system level technology becoming sensor system solutions.

Power electronics

The lack of cohesion and representation, insufficient collaboration across industry sectors and supply chain barriers, and the gaps between universities, SMEs and start-ups and industry are well recognised.

Plastic electronics

This is an emerging technology with immature supply chains. Innovative companies, often SMEs, are not engaging sufficiently with end-user manufacturers who should be users of the technology. In part, this is because the plastic electronics community has not reached out beyond its borders to interact with potential users of the technology.

Electronic systems

Technology intensive markets such as transport, energy and healthcare need system-level design for applications that transcend traditional areas of specialism, and require cooperative development of hardware and software. The domination of the sector by SMEs in the UK demands better collaborative working.

ELECTRONICS, SENSORS AND PHOTO

WHAT ARE THE OPPORTUNITIES FOR BUSINESS?

The electronics, sensors and photonics sector has strong opportunities for growth, ranging from steady (for example, electronic systems) to dramatic (for example, plastic electronics). Within each technology stream, we can identify technologies and markets with real promise which the UK has the capacity to exploit.

Photonics

The global market for photonic components and systems is already in excess of £250bn and is forecast to exceed £400bn by 2017[13].

The photonics sector is still in its early phases of evolution and is expected to continue to grow very strongly (about 8-10% annually) as new markets emerge.

Sensor systems

The global sensors market is forecast to reach $69bn by 2013[14].

This figure is primarily for sensor components, and the market for sensor systems is up to seven times higher.

UK businesses have a 7% global market share of the sensor and sensor systems market.

There are significant industrial needs in applications areas with considerable UK presence, such as aerospace, transport, energy and health.

Power electronics

The global power electronics market is estimated at £135bn, growing at a rate of 10% a year[15].

The growth of electric propulsion in the automotive sector and of renewable energy in the industry and energy sectors is particularly strong.

UK strength and opportunity is apparent in four sectors where power electronics is fundamental to enabling rapid growth and innovation – transport; energy generation, transmission and distribution; consumer electronics and lighting; and industrial drives.

Plastic electronics

Plastic electronics, also known as printed electronics or organic and large area electronics, is set to revolutionise the electronics world over the next 10 years.

It is still an emerging market, estimated to be worth around $1.2bn today globally, growing rapidly to over $5bn by 2016 as the technology becomes more capable and reliable[16].

There is an opportunity to establish a whole value chain in the UK, and the lower cost of capital equipment to establish production facilities could attract new players into the field.

High-throughput roll-to-roll processing with an additive manufacturing process can reduce material usage and device costs.

Electronic systems

Design of both electronics and software are particular UK strengths, and their cooperative evolution is critical to the competitiveness of UK industry in areas such as robotics, embedded systems and digital communications.

The UK has Europe's largest independent semiconductor design industry, with about half the market in application-specific integrated circuit design.

It is also home to Europe's largest concentration of electronics systems design houses, and many UK companies are leaders in their fields.

The global embedded systems market alone is estimated to be worth in excess of $100bn[17].

MAKING CHOICES IN ELECTRONICS, SENSORS AND PHOTONICS

We will invest in electronics, sensors and photonics innovation through technology-inspired competitions as well as through sector-specific challenge programmes where there are specific electronics, sensors and photonics-related needs. These sectors will include energy and health.

Photonics

we will invest in:

- biophotonics – applying lasers, sensors and imaging etc to medical diagnostics, surgery and therapeutic approaches, etc.
- smart imaging and sensing systems for safety and security markets
- lasers for industrial processes
- innovative solid state lighting
- photovoltaics for low carbon electricity generation.

Sensor systems

we will invest in:

- the design and integration of technologies to develop sensor systems with intelligence and optimised control.

Power electronics

we will invest in:

- key sectors such as energy, where power electronics and associated control/ICT are key enablers of a robust, resilient future electricity system.

Plastic electronics

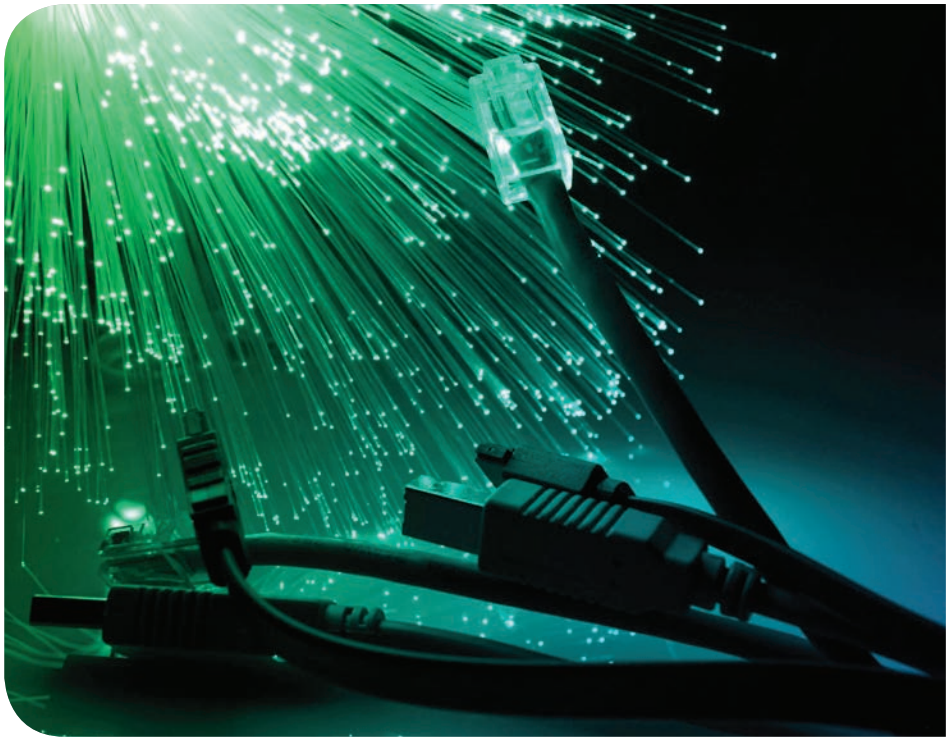
we will invest in:

- demonstrator programmes to prove the capabilities of plastic electronics to potential users in different market sectors.

Electronic systems

we will invest in:

- the engineering of embedded electronic systems tailored to applications in healthcare, transport, the built environment, and in industrial and consumer fields mainly through the ARTEMIS programme.



INFORMATION AND COMMUNICATION

WHY IS ICT A PRIORITY FOR US?

Information and communication technology (ICT) is fundamental to practically every part of modern life and business.

The UK ICT sector includes more than 116,000 companies with revenues of more than £137bn in 2010 and contributing £66m GVA.

It is estimated that the internet, underpinned by ICT and electronics, sensors and photonics, contributes £100bn to the UK economy[18].

Innovation in ICT is necessary to address major societal challenges, such as the development and support for new models of care for the elderly, transport congestion and resource efficiency.

ICT also enables process, product and service innovation across all sectors, leading to increased competitiveness and sustainability.

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TECHNOLOGY

WHAT ARE THE CHALLENGES FOR ICT INNOVATION?

The people who can realise the value of data and software (for example, domain experts) are often not involved in the ICT development process and are therefore not served well by current tools which may be over-engineered and/or unsympathetic to the needs, preferences and values of the user.

New approaches to software design, data visualisation and human-computer interaction are needed, involving complementary disciplines (such as design), to ensure that software is fit-for-purpose.

Unlike many industries, the barriers to entry for software development are relatively low.

This in itself presents an issue in maintaining a standard of quality for the engineering process, given the variety of potential developers that can participate, and the complexity and performance of the software applications that may result from this.

In addition, advances in computer hardware, such as multi-core processing, are not being matched sufficiently by advances in software.

New approaches to software engineering are needed to reduce the time lag.

There may be many concerns about the use of distributed, or cloud, systems, relating to data protection in non-UK, non-EU jurisdictions and control over preservation and deletion, hindering their adoption in some sectors and innovation around new services based on them.

Lack of skills in the UK in programming in general and specifically in multi-core and low-powered environments will make it more difficult for UK companies to adapt to new hardware and potentially make their software run slower on new machines than on old ones.

Case study

Technology-inspired Collaboration Nation

We have invested in more than 200 feasibility studies as part of our 'technology-inspired' programme of competitions to give companies the time and space to assess the feasibility of new technologies and to potentially expand their product/service portfolio. Each feasibility study was awarded £25k towards a three-to-four month project. We have been amazed at the high quality of the results from such short and focused projects.

As a result of one of our feasibility study competitions, Audio Analytic, a technology company specialising in automatically recognising sounds by computer analysis, was able to successfully apply its recognition technology to a system which can classify sounds from security cameras. The system monitors hundreds of video feeds and alerts security guards to crimes and incidents in real time. The technology will also be sold to a range of security system suppliers, including CCTV, video recording and intercoms manufacturers.

Audio Analytic's project showcased at a Collaboration Nation event we held in 2011. We will be investing half of our funds in technology-inspired activities during 2012-2015.

INFORMATION AND COMMUNICATION

WHAT ARE THE OPPORTUNITIES FOR BUSINESS?

We see business opportunities in big data exploration, simpler user experiences, increased confidence in cloud systems, and advanced software engineering.

Big data exploration

Huge amounts of data are being generated from all sorts of devices and made available in close to real time. Examples of the 'big data deluge' can be seen across all sectors (for example, smart metering and transport). It is estimated, for example, that the potential annual value of big data is $300bn to US healthcare and €250bn to Europe's public administration[19]. This unprecedented flow of data creates new opportunities for both humans and machines to derive maximum value from data exploration.

Simpler user experiences

New types of devices are allowing people to interact with machines in new ways, shifting from traditional desktop and notebook experiences to more immersive, intuitive and productive experiences. New devices are allowing users to manipulate content more easily but tablet formats are only the embryonic stage of this change. This will rely on growth of new forms of human machine interfaces, a strong and growing market with a predicted global value of around $3.2bn in 2016[20].

Confidence in cloud systems

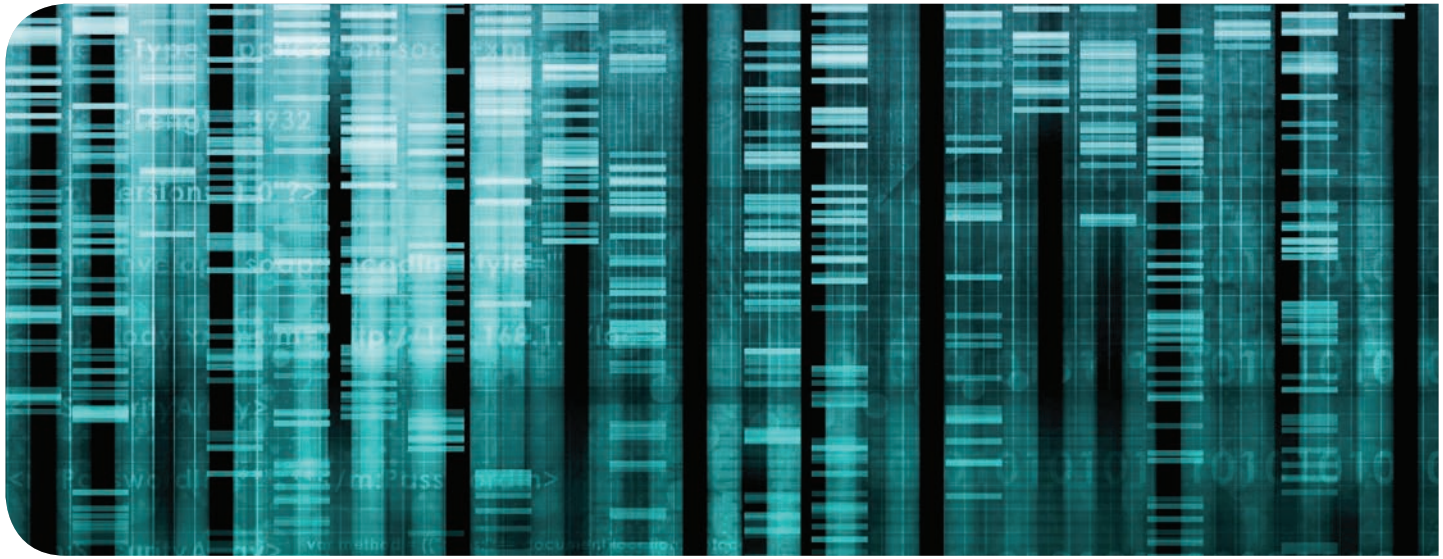
It is predicted that the global market for cloud computing – including the public cloud, the private cloud and the virtual private cloud – will leap from $40.7bn in 2011 to more than $241bn in 2020[21].

In the past, the challenge has been to implement cloud and similar systems. Now it is about giving people confidence to use them and trust them. There are enormous opportunities for companies that create services to improve the way clouds function.

Advanced, modern software engineering

The way software systems are being developed is changing. Professional teams are engineering software, but individual 'hobbyists' are also developing applications that people rely on for important tasks. This implies changes to requirements on quality assurance. There are also more software systems that include intelligent, autonomous or machine-learning behaviours. Thus we need engineering methods that consider systems where the machine drives decision-making processes rather than the user.

The UK would also benefit from an uplift in skills, including an emphasis on the engineering of modern ICT (large data sets, multi-core processors) rather than simply the use of computers. The creation of better software that takes advantage of multi-core systems will mean lower running costs and better efficiency of devices.



TECHNOLOGY

MAKING CHOICES IN ICT

We will invest in information and communications technology innovation through technology-inspired competitions as well as through sector-specific challenge programmes where there are specific ICT-related needs.

Our ICT programme seeks to stimulate innovation in software-intensive technologies, processes and systems. It has close connections with the electronics, sensors and photonics programme, which focuses on the hardware aspects of computing, and underpins the digital programme, which focuses on the business challenges of ICT application in specific sectors.

Big data exploration

we will invest in:

- designing data exploration systems for non-ICT specialists across different sectors, perhaps exploiting simpler user interfaces (below)
- automated and intelligent data cleansing and semantic annotation
- exploring various types of data across application areas or sectors
- reducing the cost of high-fidelity visualisation.

Simpler user experiences

we will invest in:

- 'beyond the screen' – moving from traditional keyboard, mouse, and screen to more immersive interaction with machines (for example haptics, speech, gesture, emotion-sensing)
- improving the user experience of imminent pervasive computing
- changing the software paradigm for existing applications
- fulfilling the changing expectations of users
- how multiple co-operating devices can present a joined-up, quality experience for the user.

Confidence in deploying cloud systems

we will invest in technologies that improve:

- interoperability
- data resilience, tracking and storage
- identity assurance.

Advanced, modern software engineering

we will invest in:

- better tools and languages to support new approaches such as inherent parallelism and design of novel user interface paradigms
- holistic design methods that focus on autonomous/intelligent/machine-learning systems where machines rather than people are making complex and less deterministic decisions
- ways of supporting organisations that can better prepare the UK's talent base for the future ICT industry.

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

Find partners and join our Knowledge Transfer networks on _connect at https://connect.innovateuk.org

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- Advanced Materials – 13, 15-17, 19-20, 22-25, 38.
- Biosciences – 1.6, 3.2, 10-11, 15.11, 20.14-15, 20.2, 20.4, 20.53, 20.59, 21, 72.11.
- Electronics, Sensors and Photonics – 26, 27.1, 27.3, 27.4.
- ICT – 58.2, 61-62, 63.11.

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The Technology Strategy Board is a business-led executive non-departmental public body, established by the Government. Its role is to promote and support research into, and development and exploitation of, technology and innovation for the benefit of UK business, in order to increase economic growth and improve the quality of life. It is sponsored by the Department for Business, Innovation and Skills (BIS). T: **01793 442700 www.innovateuk.org**

T12/115 November 2012