



Department for
Business, Energy
& Industrial Strategy

UK Innovation Strategy

Leading the future by creating it

July 2021



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Secretary of State's Foreword



The Rt Hon Kwasi Kwarteng MP, Secretary of State at the Department of Business, Energy and Industrial Strategy

The UK, along with the rest of the world, has faced exceptional challenges over the past 18 months. Our society, our economy, and our livelihoods have all been affected. In recovering from the pandemic, we must build on this country's innovative foundations to create a robust and agile economy that works for everyone and is fit for future generations. Investment in innovation will be critical to achieving this, and to building a greener, healthier and more prosperous future for the UK.

Innovation is central to the largest challenges the world faces, from climate change and the ageing society to global pandemics. The UK must be in the vanguard of the response to these challenges. Now we have left the EU, we can move quickly to respond to these challenges, and other global opportunities, to cement the UK's position as a world-leader in science, research and innovation. Furthermore, by supporting innovation in places, sectors, and businesses across the UK, we can level up the economy and create high-value new jobs and trading opportunities as we build back better.

The UK can look back on a proud history of changing the world through innovation. From the industrial revolution to the vaccine development of the past year, the impact on our everyday lives is undeniable. We want to rekindle this flame in all UK citizens, helping them to seize the opportunities that the innovation economy will bring.

The next decade will be one that features significant change. With the climate emergency and our net zero target – as well as the pace of technological innovation – the 2020s are a pivotal moment for the UK's future prosperity. That is why Government has published "Build Back

Better: our plan for growth” which focuses on infrastructure, skills and innovation as the foundation of recovery and growth across the economy.

To build on this foundation and seize this moment in history, this UK-wide Innovation Strategy sets out our long-term plan for delivering innovation-led growth. Its primary objective is to boost private sector investment across the whole of the UK, creating the right conditions for all businesses to innovate and giving them the confidence to do so. We will also show direct leadership and action – such as through new missions and backing technologies of the future – clearly signalling where the Government will focus in the future.

The Prime Minister recently reiterated our objective of making the UK a global science superpower, turning world-leading science and ideas into solutions for the public good. The Innovation Strategy contributes to that goal with an ambitious programme of work spanning the innovation landscape setting out our vision for the UK to be a global hub for innovation.

Our partners in the innovation system will be critical to delivering our ambitions, and I have asked Innovate UK and UKRI to operationalise this Strategy in order to achieve our shared objectives. We will work alongside other partners to do this, including universities and other research organisations, charities, research translation organisations such as Catapults, public sector research establishments and research and innovation institutes who will all play a key role in implementation of the Strategy. But most importantly of all this Strategy sends a message to businesses: make innovation central to everything you do and tell us what further steps we can take to help you to do so. Together, we will create the future.

At a glance

The UK Innovation Strategy sets out the government's vision to make the UK a global hub for innovation by 2035.

Our Key Actions

Pillar 1: Unleashing Business – We will fuel businesses who want to innovate.

- Increase annual public investment on R&D to a record £22 billion.
- Reduce complexity for innovative companies by developing an online finance and innovation hub between Innovate UK and the British Business Bank.
- Invest £200 million through the British Business Bank's Life Sciences Investment Programme to target the growth-stage funding gap faced by UK life science companies.
- Consult on how regulation can ensure that the UK is well-placed to extract the best value from innovation.
- Form a new Business Innovation Forum to drive implementation of this Strategy.

Pillar 2: People – We will make the UK the most exciting place for innovation talent.

- Introduce new High Potential Individual and Scale-up visa routes, and revitalise the Innovator route to attract and retain high-skilled, globally mobile innovation talent.
- Support, through Help to Grow: Management, 30,000 senior managers of small and medium-sized firms to boost their business' performance, resilience, and growth.

Pillar 3: Institutions & Places – We will ensure our research, development and innovation institutions serve the needs of businesses and places across the UK.

- Undertake an independent review, led by Nobel Laureate Professor Sir Paul Nurse, Director of the Francis Crick Institute, looking across the landscape of UK organisations undertaking all forms of research, development and innovation.
- Allocate £127 million through the Strength in Places Fund to develop R&D capacity and support local growth across the UK.
- Invest £25 million of funding to the Connecting Capability Fund to help drive economic growth through university-business innovation.

Pillar 4: Missions & Technologies – We will stimulate innovation to tackle major challenges faced by the UK and the world and drive capability in key technologies.

- Establish a new Innovation Missions programme to tackle some of the most significant issues confronting the UK and the world in the coming years.
- Identify the key seven technology families that will transform our economy in the future.
- Launch new Prosperity Partnerships to establish business-led research projects to develop transformational new technologies, with £59 million of industry, university and government investment.

Introduction: Why do we need an Innovation Strategy?

“Some people see innovation as change, but we have never really seen it like that. It’s making things better.” Tim Cook, Apple CEO

“Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less.... I am one of those who think like Nobel, that humanity will draw more good than evil from new discoveries.” Marie Skłodowska Curie, Nobel Laureate in both physics and chemistry

Building Back Better through innovation

Innovation is crucial to the UK building back better. It is at the heart of ‘Build Back Better: our plan for growth’ and so much else we want to achieve, from fighting coronavirus (COVID-19) to achieving net zero and building Global Britain. Boosting innovation in the private sector is an essential part of the UK’s future prosperity and key to achieving UK objectives to be a force for good on global challenges around climate, biodiversity, prosperity and security. We are calling on businesses to invest in innovation, getting British firms to the front of the pack.

The different elements that characterise innovation – discovery, invention, development, and adoption – cannot be readily and cleanly separated. We need the whole ecosystem of businesses, government, R&D-performing organisations, finance providers, funders, international partners and others to come together. The 2020 R&D Roadmap set out the importance of this broad system and how we will nurture it. This Strategy focuses on how we support private sector innovation by making the most of the UK’s research, development and innovation system.¹

The Innovation Strategy comes at the most critical moment for the United Kingdom in the post-war period, due to four factors:

- *We have left the European Union.* To deliver on our Global Britain vision and become an international leader in innovation we must create products and services that are successful in international markets, that provide solutions to the great challenges the world faces, and that promote our values. This international aspect is central to the entirety of this Strategy and all elements contain a global dimension. We are creating an immigration system based on individual merit to bring in the best talent globally, regardless of country of origin, and securing trade deals that allow us to share our innovations more freely with the world. This is the foundation from which we must grow against an increasingly competitive international backdrop.
- *We have experienced the largest economic disruption since the Second World War.* We need to supercharge economic growth to recover our losses and build back better. From this disruption comes great opportunity. The pandemic has shown us that major challenges can be resolved by ambitious investment in, and bold pursuit of, science,

¹ OECD “Research and development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge and the use of this knowledge to devise new applications. R&D covers three activities: basic research, applied research, and experimental development.”

technology, innovation and collective entrepreneurship, including with our international partners. It has also shown the public what UK innovators can deliver when given ambitious support, freedom, and risk tolerance. In short, COVID-19 is our Sputnik moment.

- *We face rapidly increasing competition in the global innovation race.* We cannot rest on our laurels. Other countries – in both the public and private sectors – are investing boldly in innovation. The ambitious approach of countries such as South Korea Israel and the USA require us to learn and adapt to be more focused on how we work with the private sector to support investment in innovation.
- *We sit on the cusp of transformative industrial change unlike any the world has seen before.* Artificial Intelligence (AI) is creating machines that exceed human intelligence, whilst quantum technology will one day compute the currently incomputable, but these are just two examples. The countries that secure leadership in such transformational technologies will lead the world, enjoying unrivalled growth, security and prosperity.

The UK government has therefore placed innovation at the heart of its commitments to the British people:

- *Our Science Superpower agenda.* The Prime Minister has announced our intention to be a science superpower by 2030, placing science, innovation and technology at the heart of his vision for the UK. This involves being to science and technology what we are to finance: a central hub of the global economy, and the country that the world's most innovative people and firms make their home.
- *The 2021 Integrated Review (IR) put science and technology at the centre of our overarching national and international strategy.* The IR sees science and technology as a key arena of systemic competition, with both extraordinary opportunity and severe risk. It highlights that establishing leads in specific technologies such as engineering biology, quantum, and AI is fundamental to our security and prosperity. The Innovation Strategy provides a key path to achieving leadership in these high-tech innovations as well as more conventional technologies, whilst enabling the research and innovation sector to manage risks in international collaborations through adoption of the Trusted Research and Secure Innovation advice.^{2 3}
- *The Defence and Security Industrial Strategy (DSIS).* The DSIS provides the framework for government to work with industry to achieve the ambitions set out in the IR; driving innovation and improvements in productivity to ensure that the UK continues to have competitive, innovative and world-class defence and security industries that underpin our national security and drive prosperity and growth across the UK. The Innovation Strategy will support these ambitions by creating an innovation ecosystem in which defence and security businesses can thrive.
- *Build Back Better: our plan for growth places innovation as one of its three pillars of economic prosperity.* The UK government places strong emphasis on innovation as the way we will produce economic prosperity and build back better. The plan for growth

² CPNI 'Trusted Research'. Available from: <https://www.cpni.gov.uk/trusted-research>

³ CPNI 'Secure Innovation'. Available from: <https://www.cpni.gov.uk/secure-innovation>

includes a range of critical measures to support start-ups, scale-ups, and attract global talent. The Innovation Strategy builds on these steps taken to unleash UK innovators and private sector investment in innovation.

We are in a race to the top. The UK government, therefore, has an overarching goal of making the UK a *global hub for innovation*, placing innovation at the centre of everything this nation does. Through this we seek to generate disruptive inventions, the most tech-centric industry and government in the world, more ‘unicorns’, and a nation of firms and people that all aspire to innovate. Beneath this overarching objective our action is organised under four pillars, which are set out in detail in Part 3:

- *Pillar 1: Unleashing Business* – We will fuel businesses who want to innovate.
- *Pillar 2: People* – We will make the UK the most exciting place for innovation talent.
- *Pillar 3: Institutions & Places* – We will ensure our research, development & innovation institutions serve the needs of businesses and places across the UK.
- *Pillar 4: Missions & Technologies* – We will stimulate innovation to tackle major challenges faced by the UK and the world and drive capability in key technologies.

In Part 1, we examine innovation and why it is important. In Part 2, we explain our vision for innovation in the UK in 2035 and the underlying pillars that will support this vision. Part 3 sets out the steps we will take to achieve our vision and boost innovation across the UK. Part 4 provides detail on how we will implement this Strategy, measure success and maintain progress.

Implementing our innovation vision

This Strategy is only the first step. In the coming months and years, we will maintain a laser-like focus on realising our ambitions for innovation. We will track a range of quantitative metrics to measure our progress, alongside in-depth intelligence from businesses and other innovation stakeholders.

While this Strategy applies to the whole of the UK, it also sits alongside important work being taken forward by the devolved administrations, including Northern Ireland’s Decade of Innovation, ‘a 10X Economy’,⁴ and Scotland’s Innovation Action Plan.⁵ It will be followed by other key strategies which will set out further detail on the UK government’s innovation agenda, including the Net Zero Strategy, the Digital Strategy, the National Cyber Strategy, and the National Space Strategy.

Innovate UK is the government’s innovation agency. As part of UKRI, which is led by Dame Ottoline Leyser, they are responsible for key programmes that drive innovation across the innovation system and fund businesses of all sizes, across all sectors. The programmes they

⁴ Northern Ireland Department for the Economy (2021) ‘10X Economy - an economic vision for a decade of innovation’. Available from: <https://www.economy-ni.gov.uk/publications/10x-economy-economic-vision-decade-innovation>

⁵ Scottish Government (2017) ‘Scotland Can Do: Boosting Scotland’s Innovation Performance: An Innovation Action Plan For Scotland’. Available from: <https://www.gov.scot/publications/scotland-innovation-action-plan-scotland/pages/1/>

deliver create £7 of economic benefit for every £1 of public investment, crowding in private spending. Innovate UK will work with the other UKRI councils, as well as the UK government, devolved administrations and their agencies, and businesses, to deliver on the government's agenda. Under the leadership of its Chief Executive, Indro Mukerjee, Innovate UK will bring forward their plan for how they will help to deliver this Strategy with targeted action in the coming months.

Following publication of the R&D Roadmap in July 2020, we created the Innovation Expert Group (IEG), chaired by Dr Hayaatun Sillem, to provide expert advice to government. The group has been instrumental in shaping innovation policy and developing this Strategy. As we move into the implementation phase, our plan is to establish a new Business Innovation Forum to galvanise action from the business community, drive implementation of the Strategy, and to hold government to account on the actions contained within the Strategy. Dr Hayaatun Sillem has agreed to act as chair of this new group. We are very grateful to members of the IEG who have supported our innovation policy development over the last year.

We are also grateful for the advice of the Prime Minister's Council for Science and Technology (CST) which has informed this Strategy.⁶ We will continue to consult the CST to draw on its expertise as we take forward our innovation agenda.

⁶ CST (2021) 'Scaling the Impact of Innovation in the UK'. Available from: <https://www.gov.uk/government/organisations/council-for-science-and-technology>

Part 1: Innovation today

What is innovation?

We define innovation as ‘the creation and application of new knowledge to improve the world’. It is this process which drives human progress. It is the process that brought televisions to our homes, put planes in the sky, and created the vaccines crucial to ending the COVID-19 pandemic. Innovation turns great ideas into value, prosperity, productivity and wellbeing.⁷ It is the mechanism by which we adapt to new opportunities and challenges.

The UK has a long history of world-leading, and world-changing, innovation. From the industrial revolution onwards, British innovators and innovations have driven forward the engine of global progress. From Ada Lovelace, the first computer programmer, and steam pioneers like James Watt and Thomas Newcomen, to the foundational work of Tim Berners-Lee on the world wide web, which paved the way for the information age; from Edward Jenner creating the first vaccine in the 1790s to Dorothy Hodgkin advancing X-ray crystallography to visualise biomolecules and Anne McLaren leading developmental biology to pave the way for in vitro fertilisation. In recent years we have seen businesses such as Ocado use technology to revolutionise retail. And we have all seen the impact of the researchers and businesses who have created vaccines, diagnostics and treatments in response to the COVID-19 pandemic. The UK has a rich innovation legacy on which to build: the whole world has benefitted from UK innovations and our contributions to human progress.

Why is innovation important?

When we look around us in our daily life, everything we see can be considered a product of innovation. Computers, candles, televisions, satellites, kettles, cars, medicines, and even handwriting – all the products of past human innovation. Innovation does not just happen in physical products: software, designs, art and a wide range of other less tangible innovations are also central to the modern economy.

Innovation is the lifeblood of businesses. It allows firms to compete in the market, creating exciting new products and services for their customers and bringing down their costs by improving their efficiency. Innovative firms are more likely to win a greater share of existing markets and create new markets: many popular products that are highly valued today, such as smart phones or television streaming services, were conceived less than a generation ago. Innovative firms grow twice as fast as firms that fail to innovate.⁸

⁷ The most widely used definition of innovation is from OECD which defines innovation as: “An innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit’s previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process).” OECD (2018) ‘Oslo Manual’

⁸ NESTA (2009) ‘Business Growth and Innovation: The wider impact of rapidly growing firms in the UK city regions’. Available from: https://media.nesta.org.uk/documents/business_growth_and_innovation.pdf

Innovation also creates huge value for society. It is at the heart of promoting wellbeing and quality of life for UK citizens, ensuring our security, and our global contribution to help solve the world's biggest challenges. It is central to the UK's international reputation and influence.

Case Studies: Achieving Net Zero and the Axis Energy Projects and Future Offshore Wind

The UK set a world-leading net zero target to end our contribution to greenhouse gas emissions by 2050. Innovation, essential to achieving this target, has facilitated the rapid development and deployment of a wide range of low-carbon technologies, many of which have become drastically cheaper as they have been put to broad use.

Continued innovation will be crucial to tackling climate change, from early-stage R&D to deployment of technology at scale. We will continue to support R&D and innovation to tackle climate change, including through our £1 billion Net Zero Innovation Portfolio, announced in the Prime Minister's Ten Point Plan for a Green Industrial Revolution, as well as our forthcoming Net Zero Strategy.

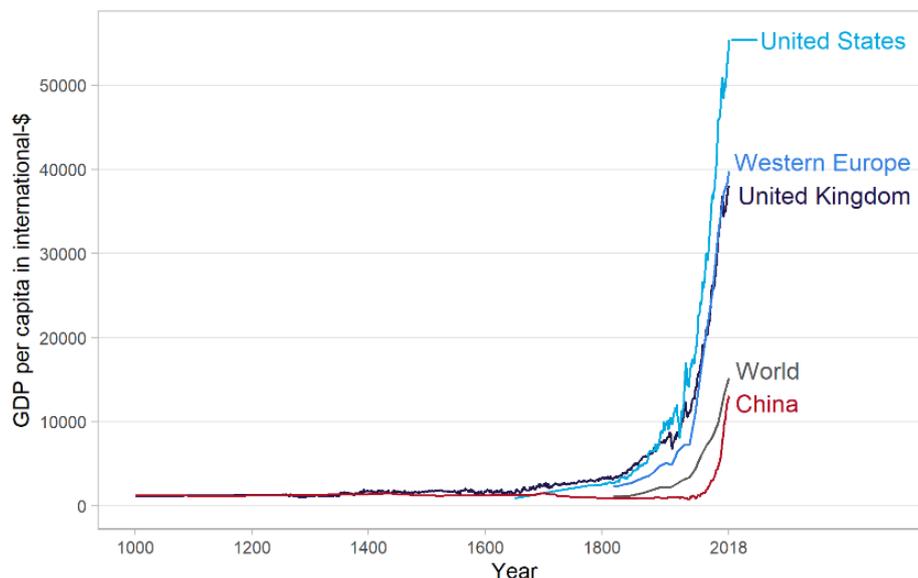
The Axis Energy Project, a project made possible through the Energy Entrepreneurs Fund, provided by the UK government. Based in Aberdeen, Scotland, Axis Energy developed a novel mooring system and foundation capable of accommodating the largest offshore floating wind turbines with excellent stability even under severe loading conditions contributing to our decarbonisation efforts. So far, the innovation has increased Technology Readiness Levels from research to deployment stage, and has shown that it is able to achieve a 30% reduction in levelised cost of energy and reduced operating costs.

The challenge: Innovation created the modern world, but progress is slowing

Innovation is vital for economic growth and increased productivity, creating more and better-paid jobs⁹. It enables businesses to grow and improves UK competitiveness.¹⁰ In the last 100 years alone, GDP per person in the UK has increased by 340% – largely thanks to innovations enabled by technological developments like electrification and transportation advances. Figure 1 shows regions and leading prosperous nations GDP per person since 1000 AD.

Figure 1: GDP per capita, 1000 to 2018

GDP per capita adjusted for price changes over time (inflation) and price differences between countries – it is measured in international \$ in 2011 prices.



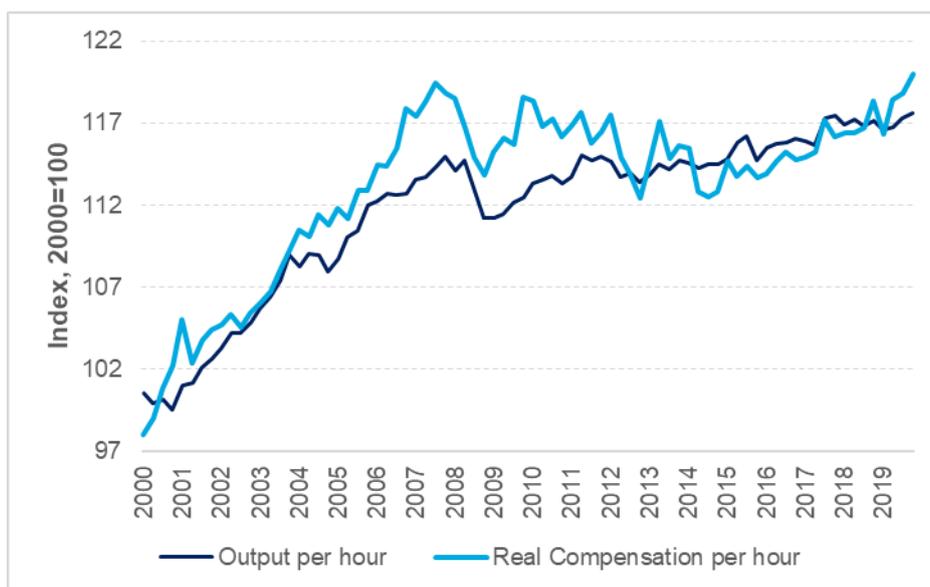
Source: Maddison project Database 2020 (Bold and van Zanden 2020)

Growth itself has been falling for several decades, from 4% per year in the 1950s and 1960s to 2% in the 2010s. In the UK, our productivity has fallen behind comparator countries, and is now around a fifth lower than Germany, France, and the US.

⁹ There is a positive relationship between product innovation and revenue productivity and firms that increase innovative sales see increased productivity. Hall, Bronwyn H. (2011) 'Innovation and productivity'. No. w17178. National bureau of economic research; Hodges D. (2010) 'Investigating the links between innovation and productivity: an analysis of UK firms', BIS, 2010; Criscuolo C. (2009) 'Innovation and Productivity: Estimating the core model across 18 Countries' in OECD 'Innovation in Firms – A Microeconomic Perspective', Paris: OECD (2009).

¹⁰ Between 2000-2008, innovation was estimated to have accounted for 51 per cent of labour productivity growth. NESTA (2012) cited in BIS (2014) 'Innovation, Research and Growth', pg 25.

Figure 2: UK Productivity and total labour compensation, 2000-2019



Source: HM Treasury Calculations

This trend is broadly visible across the western world,¹¹ suggesting a systemic problem that, if addressed, could unlock a path to greater prosperity.

It has been argued that the major cause of slowing growth and productivity over recent decades is the slowing rate of innovation.¹² One key marker of this in the UK is our decline in the rate of growth in R&D spending – both public and private. In the UK, R&D investment declined steadily between 1990 and 2004, from 1.7% to 1.5% of GDP, then gradually returned to be 1.7% in 2018.¹³ This has been constantly below the 2.2% OECD average over that period.

But it is not only that the amount of R&D investment that has declined in the UK.

A growing view also suggests that transformative research has slowed, or at least become far less efficient, suggesting broader problems with the way that we innovate. For example, the cost of every new drug has doubled every nine years since 1950.¹⁴ Bloom et al report that ‘The number of researchers required today to achieve the famous doubling of computer chip density is more than 18 times larger than the number required in the early 1970s’.¹⁵ It has been argued

¹¹ World Bank (2020) ‘Global Productivity: Trends, Drivers, Policies’. Available from: <https://www.worldbank.org/en/research/publication/global-productivity>

¹² Fernald, J.G. (2015) ‘Productivity and Potential Output before, during, and after the Great Recession’. NBER macroeconomics annual, 29(1), pp.1-51.

¹³ ONS (2020) ‘Gross Expenditure on R&D (GERD): Total as a percentage of GDP’. Available from: <https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/timeseries/glbh/gerd>

¹⁴ Known as ‘Eroom’s Law’. Scannell J.W., Blanckley A., Boldon H. and Warrington B. (2012) ‘Diagnosing the decline in pharmaceutical R&D efficiency’. Nature Reviews: Drug Discover, 11

¹⁵ Bloom, N., Jones C.I., Van Reenen J., Webb M. (2020) ‘Are Ideas Getting Harder to Find?’. American Economic Review, 110 (4): 1104-44.

there is a sharp decline in the number of new 'platform' technologies, like computing, being created.¹⁶

This is not to say that contemporary innovation does not add value – there are several reasons transformative innovation requires greater input today than it did in 1950 – but it is clear that a bold approach that backs innovators will allow for greater returns on our efforts.

The opportunity: The UK is ideally placed to lead a renewed global spirit of innovation.

Addressing this challenge requires substantial and ambitious change within our innovation ecosystem focused on a number of fundamental issues, many of which are shared by other nations:

- Business investment in R&D has fallen relative to our international peers.
- There are low rates of technology adoption by firms that lead to underutilised knowledge.
- We are at risk of a 'brain drain', the UK being a net exporter of talent.
- Our workforce has skills gaps in some key areas which are at risk of growing in the coming years.
- Our regulatory system often favours incumbent businesses over innovative new ones.
- Growth is increasingly due to consumption, not due to investment.
- Data, research and IP must be safeguarded to maintain competitiveness.

This Strategy aims to address these problems. We believe the UK is in a unique position to lead a renewed global spirit of innovation. To do this, we can build on our remarkable existing innovation system, ranked fourth in the world on the Global Innovation Index. We have world-leading assets:

- We have one of the greatest innovation heritages in the world, having birthed modern science in the 17th century and transformed it in the 20th.
- We are a global home to a number of key sectors likely to transform our world in future decades, such as life sciences, AI, and quantum.
- We are also home to high-employment, high R&D investment sectors such as automotive and aerospace, who are key players in new technology development. We will publish the 'Jet Zero Strategy' this year.
- We have Europe's best venture capital markets, with the highest volume of investment into tech companies in 2020 at \$14.9 billion, and one of the leading centres of global finance.

¹⁶ Cohen T. and Southwood B. (2019) 'Is the rate of scientific progress slowing down?'. Available from: https://www.agrarheute.com/media/2020-01/innovation_scientific_progress.pdf

- We are the birthplace of 100 ‘unicorns’ – innovative companies valued at \$1 billion or more. This is more than France, Germany and the Netherlands combined.
- We have the world’s leading university system by size, with four of the top ten universities in the world and 18 in the Top 100.
- We have the global scientific language and an inclusive culture, meaning talent from anywhere in the world should make the UK their home.
- We have a rich diversity of funding sources for R&D, including a wealth of research charities such as the Wellcome Trust, Cancer Research UK, and the British Heart Foundation. Our national academies complement these sources by providing grants, prizes and fellowships to support and celebrate research, development and innovation activities.
- We have a global reputation for R&D excellence and leadership, which puts us in a strong position to capitalise on the interconnectedness of global innovation.
- We have a global network that supports collaboration between researchers and innovative businesses, expanding the potential for UK innovation.

Each of these are major pulls for global talent, catalysts for global connectivity, and key tools for international influence. Many comparatively wealthy countries lack all these assets, suggesting we have tremendous potential both to go further and to collaborate with partners in the pursuit of mutual advantage. We will leverage these strengths whilst building on them and creating more. Together they make us ideally placed to be the hub of a new global innovation economy.

Case Study: Kick-starting the mobile money revolution in East Africa

Over 2003-05 UK aid R&D and other support enabled Vodafone to launch a mobile currency service to support micro-finance. It led ultimately to services like M-Pesa, which is now used by over 28 million people in East Africa. In Kenya before M-Pesa, only 26% of the population had access to formal financial services. The typical way for workers to send money to their families was by hand or by sending heavily disguised packages on public transport, both highly risky methods. A survey of Kenyan women found that of the 37 per cent of women who owned a business, 96 per cent said that M-Pesa helped them scale their venture. In Kenya, mobile money has helped an estimated 185,000 women move from farming to business or retail occupations.

Source for ‘Kick-starting the mobile money revolution in East Africa’ case study.^{17 18}

¹⁷ GSMA (2019) ‘Harnessing the Power of Mobile Money to Achieve the Sustainable Development Goals’. Available from: <https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2019/10/GSMA-Harnessing-the-power-of-mobile-money-to-achieve-the-SDGs.pdf>

¹⁸ Tavneet S. and Jack W. (2016) ‘The long-run poverty and gender impacts of mobile money’. *Science*, 354(6317), pp. 1288-1292. Available from: <https://science.sciencemag.org/content/354/6317/1288>

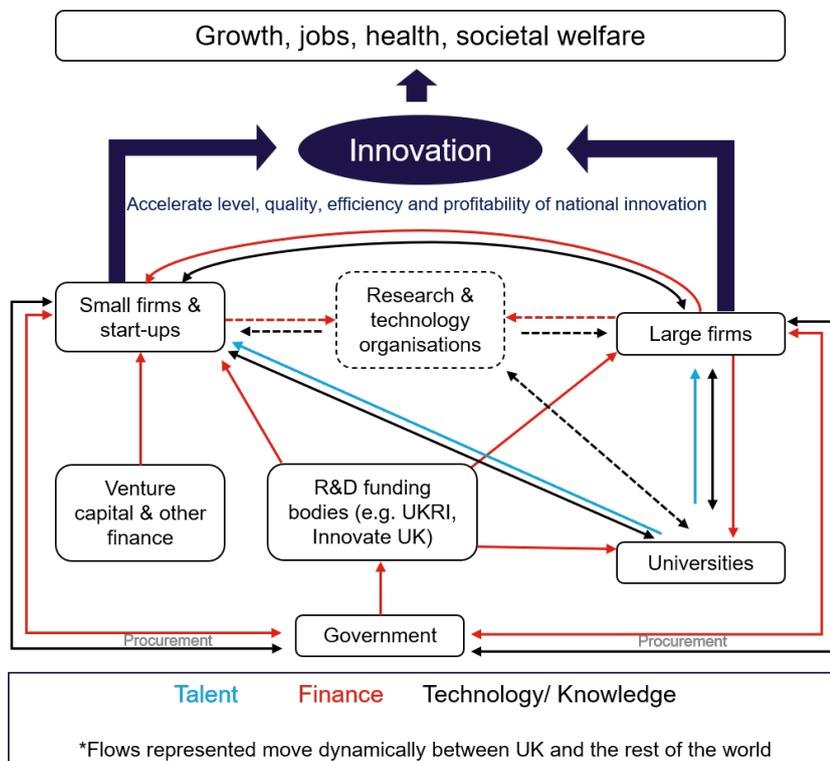
The Innovation System

Innovation does not flow neatly in one direction from research to application; it is unpredictable and serendipitous, involving constant cycles of learning, testing, refining and discovery. The innovation process features innovators, businesses and researchers at the cutting edge, doing applied research or generating new products and services. But it also involves those businesses seeking to effectively adopt and implement existing innovations to improve their productivity, boost their profit margins and provide better value goods and services for consumers.

The research that universities and other publicly funded institutions do is also a crucial part of the innovation process, from basic research through to applied and translational research. Universities often work closely with businesses, charities and others to support research, and facilitate its commercialisation to meet a huge variety of social and economic goals. The interaction between universities and business is therefore vitally important for innovation.

More broadly, the innovation process occurs in an ecosystem in which companies, public research institutions, further education providers, financial institutions, charities, government bodies and many other players interact through the exchange of skills, knowledge and ideas, both domestically and internationally.

Figure 3: Innovation Ecosystem



Source: Graphic based on Luke Georgiou (Improving the Framework Conditions for R&D, 2015)

Part 2: Innovation tomorrow – Learning from the pandemic to create the world’s best innovation ecosystem

Innovation created the path out of the pandemic

For the past 18 months, an object 10,000 times smaller than the width of a human hair has had an unprecedented impact on our lives – the damage done by COVID-19 has affected all of us.

Yet during this COVID-19 pandemic, our innovation ecosystem has come to the rescue. The response to the pandemic is arguably the finest moment in the history of UK innovation. Our ability to understand COVID-19, and our path out of it, relied on innovation past and present and our ability to coalesce global innovation and international partners under a shared vision.

The COVID-19 pandemic shows how UK innovation can achieve amazing things. UK clinical trials identified the first effective COVID-19 drug, Dexamethasone, as a way to significantly cut mortality in patients with severe and critical COVID-19, saving hundreds of thousands of lives globally.¹⁹ This built on long-term investment in our clinical research infrastructure through the National Institute for Health Research (NIHR) and the NHS. Testing technologies, such as PCR, LAMP and Lateral Flow, protected our hospitals, care homes, and broke chains of transmission to reduce R. Our ability to rapidly deploy this built on our deep pool of genetic expertise, growing in part from our post-war public investment in the Cambridge Laboratory of Molecular Biology, and from private companies like Oxford Nanopore and Optigene. Our world leading ability to track the evolving threat of new variants likewise relies on our innovation ecosystem’s strength in this area.

The UK government and its partners helped facilitate this, including through the RECOVERY trial funded by UK Research and Innovation (UKRI) along with the NIHR, and enacted by our brilliant science base. The government also established the Vaccine Taskforce, working with the team led by Dame Kate Bingham to expedite and co-ordinate research efforts in order to secure access to the most promising vaccines for the UK population and make provision for international distribution. The Vaccine Taskforce, leveraging a wide range of UK and international public & private expertise, laid the foundation of our path out of COVID-19.

The Vaccine Taskforce successfully brought together the collective effort of government, industry and academia behind a single innovation mission which contributed to the UK deploying the most ambitious vaccination programme in history. Funding through the NIHR and UKRI to the University of Oxford’s vaccine research built the foundations for its success, along with subsequent funding from the Vaccine Taskforce to enable clinical trials and early manufacturing. The UK Government invested over £300 million to scale up the UK’s manufacturing capabilities for vaccines now and for future pandemics. Nurturing and retaining this eco-system to continue to deliver innovative technologies, and respond quickly to future emergencies, is an essential legacy of the work of the Vaccine Taskforce.

¹⁹ Group, R. C. et al. (2021) ‘Dexamethasone in hospitalized patients with Covid-19’. N. Engl. J. Med. Available from: <https://www.nejm.org/doi/full/10.1056/NEJMoa2021436>

Our innovation success during COVID-19 also sets us a clear challenge: to learn from it in order to improve how government departments, public organisations and industry can work together and deliver a step-change in innovation across the country.

We will base our plan to build back better on key lessons from COVID-19

We have identified ten core innovation lessons from the pandemic:

- *Prioritise innovation:* We must place innovation at the heart of government, as we did in our COVID-19 response. This involves viewing and valuing our research, development and innovation system as a critical national asset that will more than pay for itself. We spent more on our government response to COVID-19 than we did on all innovation in at least the last thirty years combined. In the pandemic, our long-term investment in R&D came to fruition in ways we could not foresee, with many blue-skies investments in genetics and synthetic biology quickly finding new uses, and applied investments finding utility in ways not previously envisaged. When the next unexpected opportunity or pandemic comes, our innovation ecosystem must be even more prepared to meet it.
- *Place bold portfolios of bets:* We must be prepared to invest at risk, with a portfolio mindset. With the Vaccine Taskforce, we took a portfolio approach with the knowledge that value for money could not be assessed at the individual spending decision level. At present, value for money is too often assessed on a piece-by-piece basis, which prioritises low risk approaches and also increases bureaucracy by requiring greater oversight. A portfolio mindset in innovation means creating major successes by accepting that some failure is inevitable. Such failure is not 'waste', but rather the overhead for success.
- *Use the weight of public sector procurement to drive innovation:* We must build procurement in from the outset where possible. In the Vaccine Taskforce, UK government made clear its intent and process to purchase the outcome of the innovation pipeline, allowing industry to make the necessary investments by helping to manage risks and providing confidence. We will ensure that government procurement is proactive and long-term, signalling to industry our direction of travel and providing a route to market for innovative new products and services. This will be aided by ongoing government procurement reform post-EU Exit that aims to simplify the process, increase flexibility and enable public bodies to procure more innovative solutions from industry.
- *Embrace empowered teams:* At its core, the Vaccine Taskforce was a small, empowered team with a clear expert Senior Responsible Officer (SRO). This allowed swift decisions, agility, and the ability to take risks in a way that lengthy committee-based decision-making struggles to provide. The focus on a clear SRO is also a common feature of other great innovation successes such as the Manhattan Project and Apollo Program, and of US ARPA agency programs.
- *Pursue speed:* The RECOVERY trial and Vaccine Taskforce achieved success in historically unprecedented time. We need to consider how we can learn from this in how we support innovation, so that we can realise the enormous benefits at speed, as well as avoid the costs of delay in losing the race to create breakthrough products.

- *Pursue public-private partnership:* In the Vaccine Taskforce, the private sector was fully engaged from the beginning and throughout, and the UK government was able to leverage their enormous experience and capability. It allowed the private sector to deliver for government, and vice versa, providing the essence of effective partnership.
- *Innovation is international:* Without international cooperation and collaboration, the rapid development of COVID-19 vaccines would not have been possible. For example, the UK leveraged the strong science relationship it has built with countries like Brazil in recent years to facilitate overseas trials of the Oxford/AstraZeneca vaccine, which enabled the efficacy of the vaccine to be quickly and confidently assessed.
- *Bring discovery and engineering side by side:* We must view discovery, invention, and development as existing in a cycle, not as siloed separate parts. The full range of expertise was present throughout the Vaccine Taskforce mission. Even now, discovery researchers seek to predict new variants, in turn guiding the vaccine design teams whilst logistics experts identify how to secure supply chains, repeating the cycle of discovery, invention, and development.
- *Build, not just design:* Manufacturing and logistics are critical elements of an R&D ecosystem. The Life Sciences Vision, published July 2021, highlights the importance of manufacturing for UK health resilience, and the importance of proximal R&D in increasing the speed of innovation. Difficulties with the supply of vaccines have highlighted the need to have national, or at least allied, manufacturing and logistic capabilities for key R&D sectors.
- *Value non-monetized benefits:* We must realise that the non-monetised benefits of research, development and innovation investment are profound. The networks that grew from prior R&D investment were central to our Vaccine Taskforce success. A long-term legacy of COVID-19 must be to keep, and replicate, the creation of innovation networks. We must therefore prioritise a systems-level approach to R&D investment, realising that these factors are valuable in nurturing innovation.

If we can learn these lessons, we will create an innovation ecosystem that transforms the innovation potential of this country.

Vision 2035: The UK as a global hub for innovation

We have four objectives – which we refer to as ‘Pillars’ – in this Strategy which, if delivered, will achieve our vision of the UK as a global hub for innovation by 2035:

- *Pillar 1: Unleashing business* – We will fuel businesses who want to innovate.
- *Pillar 2: People* – We will make the UK the most exciting place for innovation talent.
- *Pillar 3: Institutions & Places* – We will ensure our research, development & innovation institutions serve the needs of businesses and places across the UK.
- *Pillar 4: Missions & Technologies* – We will stimulate innovation to tackle major challenges faced by the UK and the world and drive capability in key technologies.

Tracking progress towards our vision

Achieving our objectives will require years of co-ordinated activity between the public and private sectors. We will need to be clear about how we measure success and how we track our progress. As we implement this Strategy we will examine a range of quantitative indicators, including:

- *International comparators*, such as:
 - the Global Innovation Index,
 - the World Bank’s Ease of Doing Business Survey
 - OECD cross country data covering innovation activity with comparator countries
- *UK-focused studies*, such as
 - the UK Innovation Survey
 - ONS’ publications covering R&D expenditures
 - Small Business Surveys covering innovation, entrepreneurship and finance.
 - A wide range of other quantitative metrics, including new research.

We will also keep talking to all types of businesses, innovators, universities, local leaders, research establishments and the innovation community to get their feedback on innovation in the UK. Taken together this quantitative analysis and qualitative intelligence will enable us to track progress and course-correct if we are at risk of falling short in any particular area.

Part 3: Achieving Vision 2035

Pillar 1: Unleashing Business – We will fuel businesses who want to innovate

Private sector R&D and innovation is paramount if we are to compete with international competitors and accelerate growth. This Pillar sets out the steps we are taking to create an ecosystem that encourages and enables all UK businesses to innovate. We will ensure innovators can access the right private finance at the right stage and provide targeted public support where there are gaps in private markets. We will ensure businesses have access to the right infrastructure to innovate and grow, including transport, digital and data, energy and utilities. We will create the world's most agile regulatory system, consult on the development of a pro-innovation competition regime, and continue to safeguard UK intellectual property. We will unleash innovation through international trade and develop an innovation to export pathway. We will use government procurement as a lever to pull through innovation from idea to market. We will improve our overall ability to commercialise new ideas, drive the adoption of technologies by businesses and celebrate the innovations that businesses bring.

We need a surge of business-led innovation

We are committed to increasing direct public expenditure on R&D to £22 billion per year. However, public investment alone will not be sufficient to deliver the step change in innovation that this country needs. We need to see a significant increase in private sector investment in innovative activity. Private investment in innovation in the UK lags behind international competitors and UK firms adopt and diffuse innovation less than firms in leading countries.

To be a global hub for innovation means having companies of all sizes creating breakthrough new products, becoming more efficient, and scaling to full growth, all with an eye to the international as well as domestic market. Some UK firms are world-leading innovators, in sectors like financial services, aerospace, life sciences, clean maritime, creative industries and many more. The UK has a vibrant ecosystem of innovative start-ups, with more 'unicorns' (start-ups that have grown to be worth more than \$1 billion) than any other country in Europe.²⁰ The UK is also seeing a growing number of scale-up businesses, who are more likely to undertake innovation activity than conventional SMEs, make an impact across a whole range of sectors and markets.²¹ We will continue to support these businesses and recognise that scale-ups require bespoke support due to their distinct needs.

Through this Strategy we want to create the conditions for all businesses to innovate. Our analysis and discussions with businesses suggest that there are system-wide changes we must make to create the optimal policy environment for innovation to

²⁰ Tech Nation (2020) 'Tech Nation Report 2020'. Available from: <https://technation.io/report2020/#13-unicorns>

²¹ Data from the ONS showed a 25% increase since 2012 in businesses with high growth potential and the ambition to innovate. Includes companies that grow either employment or turnover by 20% a year over 3 years ONS (2020) 'High Growth by District and Industry'. Available from: <https://www.ons.gov.uk/businessindustryandtrade/changestobusiness/businessbirthsdeathsandsurvivalrates/adhoc/11097highgrowthbydistrictandindustry>

occur. This Pillar looks to boost private investment in innovation by addressing market failures, providing businesses with the clarity and confidence they need to invest.

Finance to Unleash Innovation

Businesses' ability to access the right type of finance at each stage of development is critical to allowing innovators to develop their ideas and enabling businesses to grow. While the UK already has a robust R&D funding system, we want to ensure that it is easy for businesses and innovators to navigate, address any outstanding gaps, and encourage a more connected supply of public and private sector finance.

The steps on the innovation finance journey typically involve progression from the founder's own resources, grant funding, seed equity and later venture and institutional capital – and ultimately debt finance, once a business has demonstrated it is able to generate sufficient cashflows.

Case Study: Axial3D and its ground-breaking 3D imaging and printing offerings for healthcare sector

Axial Medical Printing Ltd, trading as Axial3D, aims to be the leading developer of systems for generating 3D printed models for surgical planning. Founded in 2014, the models assist consultants with pre-operative planning procedures.

Axial3D, based in Belfast, Northern Ireland, has developed ground-breaking 3D imaging and printing offerings for the healthcare sector. Surgeons using its solutions report an average 62-minute reduction in the time taken for critical surgeries, and an 18% decrease in the time of stay in hospital for patients. Invest NI has provided Axial3D with support in areas such as R&D and skill development. Recently Axial3D was the recipient of a grant award as part of the 'Business-led innovation in response to global disruption' competition run by Innovate UK. To date, Axial3D has raised £3 million in additional funding to accelerate growth, bringing total fund-raising to date to £6 million. The company's solutions were used in more than 200 hospitals globally last year and it is aiming to add another 500 hospitals in 2021.

Thanks to its vibrant financial sector and deep capital markets, the UK is a good place for businesses to access the funding they need for innovation. However, the economy does not stand still, and our support for innovative businesses recognises this. This is why, for instance, UK government has agreed to take forward all of the recommendations in Lord Hill's UK Listing Review. This independent review has made a series of recommendations aimed at modernising markets regulation to encourage more innovative high growth companies to list in the UK, taking advantage of EU exit to change rules previously set at the EU level.

The UK also has the most mature venture capital market in Europe in 2020. At least £8.8 billion was raised to start and grow innovative businesses,²² more than France and Germany combined.²³ Over the last five years, investment in UK deep tech companies has increased by 291%. Between 2018 and 2020 venture capital investment in UK R&D intensive businesses was at a level equal to 0.17% of GDP.²⁴

Alongside private capital markets, the UK has an array of public interventions designed to enhance the funding ecosystem, with Innovate UK and the British Business Bank playing a key role. UK government has continued to strengthen its support offer for innovative businesses in particular.

However, gaps remain. Information asymmetries and coordination failures mean that smaller, earlier-stage businesses can be overlooked by investors, and IP-rich companies with substantial intangible assets can find it difficult to secure debt finance.²⁵ Information failures make it harder for some SMEs to navigate financial markets and identify the right type of finance to suit their needs, whilst others lack the investment readiness and skills to stand a good chance of securing it. To help close these gaps, UK government is currently consulting on reforms to help smaller SMEs access capital markets, via the Wholesale Markets Review.

We want to continue bringing together effective private markets with well-targeted public investment. Through the work of our key public bodies and by working alongside industry, we want to ensure the system is easy for businesses and innovators to navigate, and that UK innovators can access the right type of finance at the right time in order to grow.

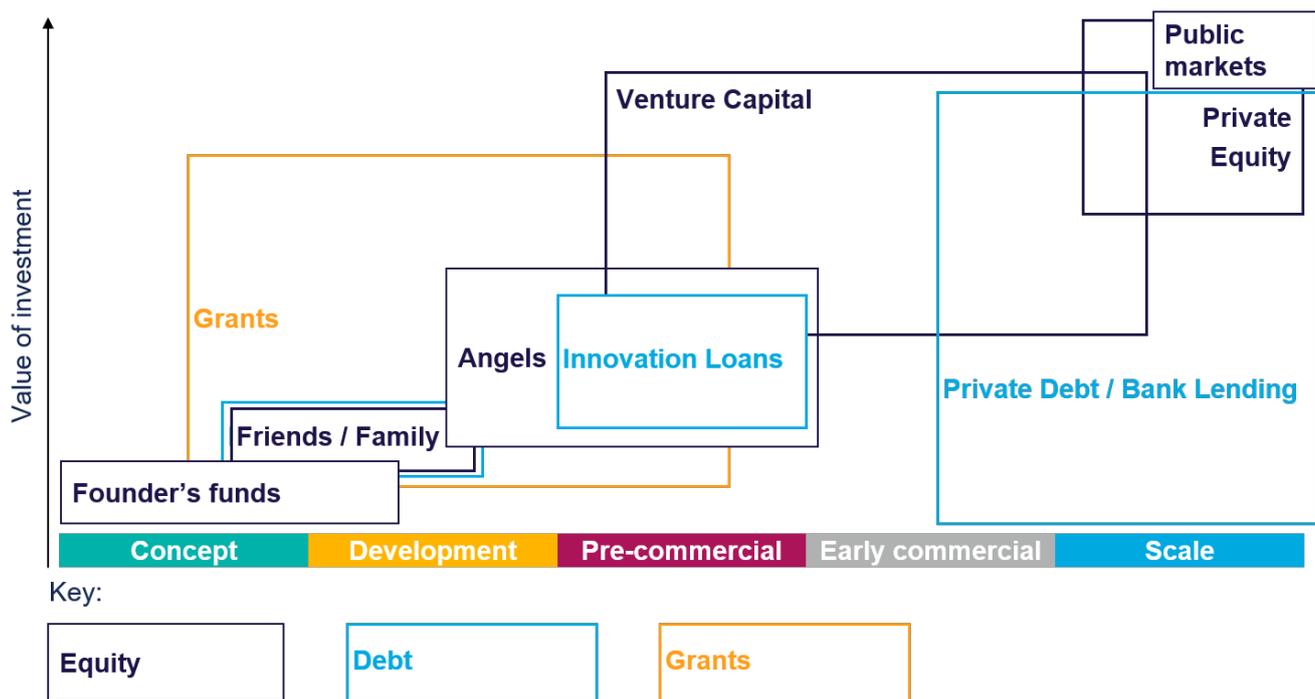
²² British Business Bank (2021) 'Small Business Finance Markets Report 20/21'. Available from: <https://www.british-business-bank.co.uk/research/small-business-finance-markets-report-2021/>

²³ Tech Nation (2020) 'Tech Nation Report 2020'. Available from: <https://technation.io/report2020/#11-global-investment-trends>

²⁴ British Business Bank (2021) 'Small Business Equity Tracker 2021'. Available from: <https://www.british-business-bank.co.uk/small-business-equity-tracker-2021/>

²⁵ HM Treasury (2017) 'Patient Capital Review – Industry Panel Response'. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/661397/PCR_Industry_panel_response.pdf

Figure 4: Innovation Funding Landscape – Illustrative Overview



Source: British Business Bank and Innovate UK

The first step is to make private markets function as effectively as possible. The UK benefits from a diverse ecosystem of finance for innovative start-ups, including angel investors, equity crowdfunding platforms, and venture capital funds. UK government co-invests alongside private investors where private capital alone is insufficient to enable innovative companies to start, grow and scale-up.

Bank lending is the most viable route to finance for established businesses. There is a high level of success in applications for debt finance by innovative businesses.²⁶ However, businesses with potentially valuable intellectual property but a limited track record of generating sales may be perceived as a risky investment and therefore struggle to access capital. As we shift increasingly towards a knowledge-based economy, it will be vital to future-proof our finance market such that intangible assets – including intellectual property – are properly considered as part of lending decisions.²⁷

To support this, **UK Finance is devising training that upskills the next generation of lenders.** This will improve lenders’ understanding of business innovation and support their ability to assess risk when lending to innovative businesses. UK Finance will seek to raise awareness and understanding of business innovation, the impact it has on business risk and the availability of different types of finance. UK Finance and its members will also continue to raise awareness of the availability of a range of finance options for innovative businesses. This will build on existing work by lenders such as Barclays, whose Funding Readiness Programme

²⁶ BVA BDRC ‘SME Finance Monitor’. An independent report by BVA BDRC. Data from applications made Q1 2017 to Q4 2020 shows that across all SMEs, typically over 75% (83% for Q3 2019 to Q4 2020) of all applications for all products resulted in a facility.

²⁷ British Business Bank (2018) ‘Using Intellectual Property to Access Growth Funding’. Available from: https://www.british-business-bank.co.uk/wp-content/uploads/2018/10/502-IP-Report_singles.pdf

– part of its Eagle Labs platform – aims to demystify funding options available to entrepreneurs and provide the skills required to fund business growth.

Initiatives like the Newton Venture Program, established in 2020, are also helping to increase diversity in the access to finance system. The program aims to train the next generation of venture investors across the innovation ecosystem (including venture capitalists, Limited Partners, angel investors, accelerators, incubators, and technology transfer officers) with a mission to make the venture landscape more diverse, inclusive and representative of the population it serves.

To drive greater investment into innovative businesses across the UK, it will be important to unlock alternative sources of capital. The UK has the third largest pensions market in the world, but only a fraction of its investment supports innovation via UK-based venture capital and private equity funds. Defined Contribution (DC) pensions currently account for £670 billion of the UK's pensions market and are growing significantly in size. Unlocking just a small portion of this for investment into productive finance assets could generate improved returns for pensions savers, while increasing the supply of private finance for innovation. Facilitating increased institutional investment into illiquid assets will also be an important step towards closing the gap between the UK and US venture capital markets.

To this end, HM Treasury, the Bank of England, the Financial Conduct Authority and the Department for Work and Pensions (DWP) are meeting regularly as a jointly-convened industry working group – the Productive Finance Working Group – to focus on devising solutions to the current barriers to investment in illiquid assets for DC pension schemes. The group is working to ensure that the conditions are in place to allow DC pension schemes to invest in a new fund structure, the Long-Term Asset Fund. This complements a range of work by DWP to facilitate increased investment, including:

- Assessing whether certain costs within the cap on fees that managers of pensions can pass onto members – the ‘charge cap’ – affect pension schemes’ ability to invest in a broader range of assets, to ensure that pension schemes are not discouraged from such investments.
- New rules, announced by DWP in June 2021, to allow pension schemes to smooth performance fees over multiple years, to reduce the likelihood of a breach of the charge cap. These fees may be required in order to invest in certain forms of productive finance such as scale-up companies’ private equity. The rules also require pension schemes to publish their net returns, and will come into force in October.
- A new call for evidence launched in June 2021, seeking to understand how the DC market could be consolidated to build the scale necessary for better outcomes for savers – including through greater ability to access innovative investment opportunities.

The UK government will engage closely with pension funds and the investment industry to understand the scope for industry-led initiatives that take advantage of these opportunities.

The UK government also supports innovative firms to access private finance through the Catapult Network. Many Catapults use their sector-specific knowledge and capability to

improve businesses' access to finance capacity and match them with prospective investors. The 2021 Catapult Review recommended that Catapults should share best practice across the network and proactively broker introductions between businesses and investors. Innovate UK's Investor Partnerships programmes also helps firms to access further private finance, using grant funding to leverage equity investment from private sources of finance. £25 million of grant funding has leveraged £69 million of equity into 108 SMEs, and £288 million of additional follow-on investment.

Providing targeted public support

Alongside these measures, UK government will seek to crowd-in additional investment in innovation where there are gaps in private markets. The British Business Bank is an important delivery partner in our efforts to make finance markets for smaller businesses work more effectively, allowing those businesses to prosper, grow and build UK economic activity. Up to the end of last year, the Bank had supported the provision of £42 billion worth of finance to 170,000 small and medium-sized businesses across the UK, not including its COVID-19 debt and equity finance schemes. In 2020, the Bank supported around 21% of all announced equity deals (13% from existing equity programmes and 11% from the Future Fund) compared to 10% in 2019.²⁸

The Bank forms a key part of our innovation funding system and will continue its efforts to facilitate investment in innovative companies. Funds supported by the Bank are more likely to invest in technology and intellectual property-based businesses than the overall equity market – 49% of deals supported by the Bank are in this sector, compared to 40% of the wider market.²⁹

Since the first fund was launched in 2017, the British Business Bank's regional funds have helped innovative companies access venture capital outside London and South East England while also building better regional business ecosystems. The Northern Powerhouse Investment Fund now provides 16 per cent of all equity investment in the region it covers. By March 2021 the Fund had directly invested £256m in over 840 ambitious SMEs across the investment region. Those deals attracted an additional £310m of investment from the private sector.

The regional funds are delivered by specialist fund managers with a track record of investing in innovation. In addition to providing funding directly, these fund managers also work with the Bank's UK Network and local partners to build networks that help connect innovative companies and potential investors.

²⁸ British Business Bank (2021) 'Small Business Equity Tracker 2021', p67. Available from: <https://www.british-business-bank.co.uk/small-business-equity-tracker-2021/>

²⁹ British Business Bank (2021) 'Small Business Equity Tracker 2021', p72. Available from: <https://www.british-business-bank.co.uk/small-business-equity-tracker-2021/>

Case Study: G2O Water Technologies

G2O Water Technologies is a Manchester-based water treatment company that has received a total of £1.03 million of equity investment, including £400,000 through the Northern Powerhouse Investment Fund and £200,000 through the Finance Durham Fund, both managed by Maven Capital Partners. This was bolstered by £435,000 from private investors. The funding will enable the company to carry out the next stage of its technical development and forge industrial partnerships. The deal is a prime example of how one of the UK's most active private equity firms can help attract additional investment for pioneering businesses – wherever they are based in the country.

More broadly, equity deals supported by the Bank are becoming more regionally diverse, with the proportion of deals undertaken in London reducing sharply in recent years, from 68% in 2016 to 42% in 2020.

This year, the British Business Bank has launched the Life Sciences Investment Programme, a £200 million investment targeting the growth-stage funding gap faced by UK life science companies. The programme aims to mobilise significant third-party capital alongside the BBB's investment. In addition, through the UK-UAE Sovereign Investment Partnership, Mubadala has made an £800 million commitment to investment in the UK life sciences sector.

The British Business Bank has also launched Future Fund: Breakthrough, a new £375 million UK-wide programme that will co-invest alongside private investors directly in later funding rounds at high-growth, innovative firms. The programme will focus on R&D intensive companies and will aim at accelerating the deployment of breakthrough technologies which can transform major industries, develop new medicines, and support the UK transition to a net zero economy.

Table 1: British Business Bank Programmes

British Business Bank Programmes	Description
Start Up Loans	Offers loans (from £500 to £25,000, at 6% interest) alongside free mentoring and support to individuals who are starting a new business or who have been trading for less than two years.
Regional Angels Programme	Aims to reduce regional imbalances in access to early-stage equity finance, by increasing the aggregate amount of early-stage equity capital available to smaller businesses across the UK.
Regional Funds	Three funds - covering the North of England, Midlands, Cornwall and the Isles of Scilly - provide debt and equity finance, in the form of co-investment by the public and private sectors.
Enterprise Capital Funds	Combines private and public money to make equity investments in high growth businesses.
Managed Funds Programme	Makes investments in large-scale, private sector managed fund of funds, that invest in venture and growth capital funds backing innovative businesses. The programme aims to draw in institutional capital to this asset class.
British Patient Capital	Invests in best-in-class venture and growth capital funds and works to encourage more investors to make allocations to this asset class.
National Security Strategic Investment Fund	A joint initiative between HMG and BBB, that invests in advanced technology firms supporting long term equity investment.
ENABLE Programmes	Supports lenders, such as banks and non-bank financial institutions, to unlock more lending to smaller businesses through a portfolio-level guarantee.
Recovery Loan Scheme	Provides lenders with a government-backed guarantee of 80% of the loan value to facilitate lending (including asset and invoice finance) to smaller businesses.

Innovate UK

Innovate UK plays a critical role in providing funding to innovative companies through the early stages of idea development, and to commercial success. This is achieved through challenge-led competitive grant-funding programmes, pre-commercial procurement contracts and loans. In 2020/21 Innovate UK awarded £986 million, supporting over 4,500 organisations.³⁰

One mechanism that Innovate UK uses to provide access to finance for innovative firms is Innovation Loans. The Innovation Loans scheme provides affordable and flexible finance to small and medium-sized businesses. It offers loans up to £1.6 million for highly innovative late-stage projects with a clear route to commercialisation and economic impact. A total of £155.7 million of commitments have been made so far. Innovate UK has extended the Innovation Loans pilot, providing a further £20 million in finance for innovative companies in 2021.

UKRI's wider commercialisation activity includes the work of the UK Innovation and Science Seed Fund (UKI2S). UKI2S plays an instrumental role in addressing finance gaps for early-stage science and technology start-ups and SMEs from PSREs and select research institutes and organisations. Backed directly by UKRI and the Defence Science and Technology Laboratory, its portfolio of 70 companies have gone on to attract over £640 million in private investment and created over 700 high-value jobs. **UKRI have provided a further £10 million funding for UKI2S in 2021.** This will allow UKI2S to continue to provide early-stage, high-risk, patient capital for high-potential businesses arising from world-class research carried out in partner laboratories, campuses and Catapults across the UK. This will back the creation and growth of high potential science-based businesses, leveraging significant private investment and creating hundreds of jobs across the UK.

Case Study: Zentraxa Ltd

Zentraxa, a spinout from the University of Bristol following early investment in BrisSynBio by BBSRC and EPSRC, is manufacturing biopolymers for use in highly functional adhesives in medical and industrial settings. They are establishing a new niche in the synthetic peptides market, which is projected to be worth more than \$425 million by 2023. Zentraxa received grant funding of £232,000 from Innovate UK, aligned with £110,000 investment from UKI2S which leveraged £337,000 from private investors and which in turn was amplified by £188,000 of co-investment from the BBB's Managed Funds Programme. This spectrum of support, from spinout stage to the current round of public and private funding, will help to take Zentraxa's innovative products into market testing and allow them to expand their employee base, secure more contracts and refine the technology.

³⁰ This includes Innovate UK 'core' programmes as well as the programme they manage such as Catapults, Aerospace Technology Institute and SBRI.

Improving accessibility of public support

Through our engagement with businesses, we have consistently heard that the public funding landscape is complex to navigate for firms seeking finance to innovate. As is evident from the above, public support in this area is led by multiple bodies with overlapping activities which can be hard for early-stage businesses to access. To make finance more accessible and signpost firms towards the available support:

- **Innovate UK will develop an online Innovation Hub** to sit alongside and complement the British Business Bank's existing Finance Hub, with clear links between the two to provide innovators with a complete view of government-backed funding options. This will make it easier for businesses to navigate the funding offer across both institutions. Innovate UK and BBB will introduce improvements as swiftly as possible within the next 12 months, by consulting with users and stakeholders to develop and implement an improved digital solution.
- **Innovate UK (as part of UKRI) and the British Business Bank will jointly investigate how businesses interact with different parts of the public support landscape.** This will maximise accessibility for qualifying businesses through:
 - exploring how the UKRI system could be simplified, and bureaucracy reduced, so that applicants are not required to submit the same information twice;
 - signposting the availability and application requirements of future funding opportunities, to help businesses access the right financing options to scale;
 - enhancing investment readiness through Innovate EDGE, which helps businesses to develop the evidence they need to access further public finance and move towards private investment;
 - linking these services to the Innovation Hub where appropriate, saving time and effort for businesses and SMEs by providing them with a single portal for their innovation finance needs.

Case Study: TotalControlPro Ltd

TotalControlPro Ltd is a Northampton-based SME that delivers an affordable, accessible manufacturing platform to put customers in control of their production facility and provide real-time visibility to the entire enterprise. In 2019 it took out a £300,000 Innovation Loan to develop its synchronised cloud manufacturing system. The company has now expanded its Manufacturing Platform to clients around the world, with six interconnected modules and full third-party connection. Strategic Director and Co-Founder Dolores Sanders was also a winner of an Innovate UK Women in Innovation award.

Tax incentives

R&D tax credits are an important part of the UK government's support for innovative business, incentivising businesses to invest in R&D by allowing companies to claim an enhanced corporation tax deduction or payable credit on their R&D costs.

At Budget 2021, the Chancellor announced a review of R&D tax reliefs covering all aspects of the two schemes: the R&D Expenditure Credit, and R&D tax relief for SMEs. The review aims to ensure that the reliefs are up-to-date, internationally competitive, and effectively targeted on activities that drive the best outcomes for the UK economy. A consultation was published alongside the Budget, exploring the nature of private-sector R&D investment in the UK, how it is supported or otherwise influenced by the R&D relief schemes, and where changes may be appropriate. UK Government will consider R&D tax relief options in light of evidence from this consultation.

At Budget 2021, a new tax super-deduction was also announced. It allows companies to claim 130% capital allowances on qualifying plant and machinery investments. The change makes the UK's capital allowance regime more internationally competitive, lifting the net present value of our plant and machinery allowances from 30th in the OECD to 1st.

Also important are the UK's world-leading tax-advantaged venture capital schemes: the Enterprise Investment Scheme (EIS), the Seed Enterprise Investment Scheme (SEIS) and Venture Capital Trusts (VCTs). These schemes encourage investment in higher-risk, early-stage innovative businesses that often face the biggest challenges in accessing growth capital. In 2018/19 alone, they generated over £2.6 billion of funds for business across the three schemes.

Infrastructure

Infrastructure underpins the innovation economy. Transport, digital and data, energy and utility networks are vital enablers of innovation. Infrastructure can improve ease of access, efficiency and collaboration by businesses, which can directly impact how innovative they can be. Maximising the potential of the UK's innovation ecosystem also means ensuring businesses can access the right infrastructure to innovate and grow. As the National Infrastructure Strategy sets out, UK government wants to deliver an infrastructure revolution: a radical improvement in the quality of the UK's infrastructure to help level up the country, strengthen the Union, and put the UK on the path to net zero emissions by 2050.

By building on our existing infrastructure and using opportunities such as those identified in the UKRI research and innovation infrastructure report³¹ and the UK R&D Roadmap, we will seize opportunities for the next generation of research and innovation infrastructure.

Digital infrastructure is a key enabler. Digital services and networks underpin the UK's ambition to be a world leading science, technology and cyber power, allowing industry to grow and innovate. The Department for Digital, Culture, Media and Sport's (DCMS's) Ten Tech Priorities³² set out our ambition to roll out world-class infrastructure nationwide. The UK government is spending £5 billion to make sure homes and businesses across the country benefit from gigabit-capable broadband – including those in harder-to-reach areas. DCMS is also taking forward a wide-ranging programme of work to drive the rollout of 4G and 5G networks across the UK, including investing £200 million through our 5G Testbeds & Trials

³¹ UKRI 'Creating world-class research and innovation infrastructure'. Available from: <https://www.ukri.org/our-work/creating-world-class-research-and-innovation-infrastructure/>

³² DCMS 'Our 10 Tech Priorities'. Available from: <http://techpriorities.co.uk/>

Programme to ensure the UK is at the forefront of global 5G innovation, maximising the use-cases and benefits of this transformative technology.

To further strengthen our innovation infrastructure, **UKRI is investing £50 million into a portfolio of over a dozen infrastructure projects.** This will underpin the UK's position as a science superpower by supporting projects that cross all disciplines and span the research and innovation spectrum. The package will cover the first year (2021/22) of time-critical projects and scoping for future investments, including a boost to the world's largest and most sensitive radio telescope, carbon capture technologies, a state-of-the-art airborne research laboratory and a £17 million investment in digital research infrastructure.

Looking ahead, we need to ensure that our infrastructure is future proofed. One of the focus areas will be identifying how common, interoperable digital tools and platforms, as well as physical testing and innovation spaces can be brought together to form a digital and physical shared infrastructure for innovators. Examples of these include digital twins, simulation and emulation tools, synthetic environments, test beds and living labs. Supporting and enabling this shared infrastructure will help remove time, cost and risk from the process of bringing innovation to market.

One example can be seen in the use of digital twins throughout the Formula 1 racing lifecycle by McLaren and Dell.³³ During a race, high-fidelity digital representations of vehicles are fed by hundreds of thousands of data points every second, informing race strategy and decision making. Before a car even reaches a track, AI and simulated environments are combined through digital twins with real-world testing to enable data-driven engineering changes every 20 minutes on average. The insights from this type of rapid innovation are being applied across the economy, including in healthcare and transport.

Given its importance, UK **government will launch a consultation later this year** to seek input from business, academia and individuals across the UK **on the potential value of and options for a UK capability in digital twinning and wider 'cyber-physical infrastructure' to help unleash innovation.** This will support the work of the National Digital Twin Programme, which was established in response to the National Infrastructure Commission's report 'Data for the Public Good'.³⁴

World-class Regulation

Innovators operate in a complex environment of legal, voluntary and regulatory frameworks. A well-designed regulation system provides certainty to reduce investment risk and the clarity needed to make markets function effectively. It can encourage innovation, create consumer confidence, steer development of new products, and enable the rapid but safe adoption of new and disruptive technologies.

³³ Dell Technologies, McLaren Racing (2021) 'Data-driven innovation starts at racing's edge to improve race car aerodynamics – and speed'. Available from: <https://www.delltechnologies.com/en-gb/case-studies/customer-stories/mclaren-racing.htm#collapse&pdf-overlay=//www.delltechnologies.com/asset/en-gb/solutions/business-solutions/customer-stories-case-studies/3-dell-technologies-gce-2-page-cxo-case-study-mclaren-customer-review-29032021-green-edward.pdf>

³⁴ National Infrastructure Commission (2018) 'Data for the Public Good'

The UK government's approach to regulation has evolved over the past ten years. Initiatives such as the Red Tape Challenge and the 'One In, Two Out' policy sought to reduce regulatory burdens on firms. Building on this, the 2019 'Regulation for the Fourth Industrial Revolution' white paper set out how regulation can actively support and promote the development and adoption of innovations. This approach can be seen in our work with regulators through the Regulators' Pioneer Fund, assisting and enabling experimentation through the use of regulatory sandboxes and cutting-edge healthcare solutions. However, we can, and must, go further.

Historically, regulation has sometimes stifled innovation. Some of the current regulatory standards inherited from the EU are based on an overly restrictive interpretation of the precautionary principle. Loosely, this principle can be summarised as 'look before you leap'. When used proportionately, for example as it appears in the 1992 Rio Declaration on Environment and Development, it ensures that a lack of total scientific certainty that something is dangerous is not used as an excuse to postpone cost-effective measures to prevent serious harm to the environment or health. This principle is being placed on a statutory footing through the Environment Bill to reflect its important role in international environmental policy, for example, the successful Montreal Protocol which effectively tackled the damage to the ozone layer caused by CFC gases. The UK approach recognises that the principle should be applied proportionately, and there must be sufficient evidence that the risk of environmental damage is credible and real.

However, when applied disproportionately the precautionary principle can err too much on the side of caution, reversing the burden of proof and placing it on the Innovator to demonstrate no possible harm from an innovation. While the UK has world-leading strengths across our regulatory frameworks, we must continuously improve to facilitate the increasing pace of innovation and change.

The precautionary principle can be interpreted in ways that can produce more harm than good. In some cases, the precautionary principle has become a policy of blocking all potential harms, even a possibility of harm, without a balanced analysis of likely benefits. One example is Genetically Modified (GM) crops, where the EU relied on a strict interpretation of the precautionary principle which resulted in the absence of any significant adoption of GM crops in the EU and the departure of European companies working on GM technologies to the USA and other countries. This was despite the potential these technologies have in contributing to our work to tackle climate change.

While the UK has world-leading strengths across our regulatory frameworks, we must continuously improve the regime to facilitate the increasing pace of innovation and change. The Taskforce on Innovation, Growth and Regulatory Reform (TIGRR) has now proposed options for how the UK can further reshape its approach to regulation and seize new opportunities from exiting the EU with its newfound regulatory freedom. As recommended by the Taskforce's recent report, **we will consult on how regulation can ensure that the UK is well-placed to extract the best value from innovation** – including on the need for and benefit of a new proportionality principle for regulation.

Standards are one important regulatory tool. The importance of standards is growing with the increasing globalisation of commerce, the emergence of new technologies and the need for interoperability. In new markets, including digital, the Internet of Things and AI, products from different manufacturers need to be able to seamlessly ‘talk to’ each other to provide value to consumers. Leading the development of global standards, including through working with multilateral institutions and focusing our efforts in key areas, allows UK businesses to benefit from knowledge transfer, be thought leaders, and export on a global stage. This work will also help de-risk innovation and position the UK as a force for good around the world, promoting the benefit innovation can bring whilst minimising the scope for its abuse.

This championing of experimentation also sees the start of a new £3 million round of the Regulators’ Pioneer Fund (RPF), launched on 20 May 2021, which enables regulators to test and pilot ambitious and experimental approaches to regulation that can improve their ability to support innovation. The RPF’s success can be seen from its previous project supporting the Medicines and Healthcare Products Regulatory Agency (MHRA). One of the key challenges in both validating and developing new medical devices and software is having access to representative patient data, which cannot be freely or cheaply shared as there is a need to protect patient privacy. Using RPF funding, MHRA aimed to address this challenge by developing a first-of-its-kind synthetic dataset that mimics real patient data with very high fidelity. These datasets are designed to help researchers and companies develop and validate their innovative new AI and medical devices. This development will support bringing safe products to market sooner, enabling patients to benefit from the latest technical advances.

We will use the opportunity of EU Exit to create the world’s most agile regulatory system, focussed on continual adaptation to new products and technologies. We have created the Regulatory Horizons Council to this end. It acts as a strong voice in government for the creators of new technologies, ensuring a continual pressure to adapt our regulatory environment to be pro-Innovation whilst also being safe. **We will commission the Regulatory Horizons Council to consider how best to support innovation through regulation, including looking at whether there are a set of high-level guiding principles for regulation that may apply broadly to any sector of innovation.** We will ask the Council to work with regulators, industry, government, and other stakeholders as they see fit. They will develop and test their recommendations, source tangible case studies of pro-innovation regulation in action, and ultimately present their conclusions to government. This will build on and complement the publication of the Plan for Digital Regulation in July 2021, setting out the UK government’s pro-innovation approach to regulating digital technologies. It outlines the principles for digital regulation to: promote innovation; achieve forward-looking and coherent outcomes; and exploit opportunities and address challenges in the international arena.

In addition, we will bring forward action to improve regulation in the following areas:

- **We will maintain global leadership in regulation through regulatory diplomacy, and extend the reach of the ‘Agile Nations’ network by engaging more countries.** The UK spearheaded the establishment of Agile Nations, an inter-governmental regulatory co-operation network, at the end of 2020. This will make it easier for

businesses to introduce and scale innovations across their markets while upholding protections for citizens and the environment.

- **We will publish a joint Action Plan on Standards for the Fourth Industrial Revolution** with the British Standards Institution (BSI), the National Physical Laboratory (NPL) and the UK Accreditation Service (UKAS). This plan will champion an agile approach to standardisation to respond to fast-paced technological change and foster synergies between standardisation, policy making and strategic research work that are needed to underpin innovation across sectors.
- **The UK Measurement Strategy will be published this Summer.** It will outline how the UK will capitalise on its world-leading status to provide the measurement infrastructure that the UK needs to innovate and be safer, healthier, greener and more prosperous.

A pro-innovation competition regime

Competition and innovation are intrinsically linked. A competitive market creates incentives for firms to innovate and develop better quality products and services. The Competition and Markets Authority (CMA) promotes effective competition in UK markets by regulating anti-competitive behaviour, reviewing mergers to ensure they do not reduce competition, and investigating and remedying entire markets that have competition problems.

We are committed to a best-in-class competition regime. As outlined in our plan for growth, **we are consulting on reforms to ensure that the competition framework is effective for an innovative modern economy.** This will include updating and strengthening enforcement of competition law to ensure it is agile and effective, for both businesses and consumers.

In the digital sector, there is a growing consensus that the concentration of power amongst a small number of tech companies is restraining competition and holding back innovation. Addressing this market failure will help spur the development of new products and services and level the playing field for UK digital SMEs.

To this end, **we are consulting on setting up a new, pro-competition regime for digital markets.** This will tackle the concentration of market power in big digital companies, protect consumers, and promote innovation. This follows the recommendations of the government-commissioned Furman Review, which called for a new Digital Markets Unit (DMU) to address these unique competition issues.

Capitalising on data

The Economist famously noted that “the world’s most valuable resource is no longer oil, but data”.³⁵ Global networks of data flows are critical to our prosperity and modern way of life. They fuel consumers and businesses, including start-ups, SMEs and large corporations. The ability to collect, share and process personal data is crucial for the digital economy.

³⁵ The Economist (2017) ‘The world’s most valuable resource is no longer oil, but data’. Available from: <https://www.economist.com/leaders/2017/05/06/the-worlds-most-valuable-resource-is-no-longer-oil-but-data>

The National Data Strategy set out the UK government's vision for harnessing the power of responsible data use and launched a national conversation on how to make the most of data's opportunities. The public consultation demonstrated that people welcome the idea of data as a strategic asset and that it should not just be considered a threat, but an opportunity to drive productivity and innovation. It also highlighted that data must be made to work for everyone.

The UK government will therefore prioritise regulatory certainty in the use of data – not only to build trust, but to lower compliance costs for businesses, and remove unnecessary barriers to international data flows which could impede innovation and growth for UK companies.

To this end, the Department for Health and Social Care (DHSC) has recently published a draft of *Data saves lives: reshaping health and social care with data*: a strategy that sets out how data will be used to improve the health and care of the population in a safe, trusted and transparent way. The strategy recognises that data was essential to all aspects of our response to COVID-19, and that we now have an opportunity to apply these approaches to long-term challenges and the immediate tasks of rebuilding from the pandemic.

One avenue of innovation opportunity is smart data: the secure sharing of customer data with authorised third parties. Better use of smart data will support innovation by enabling start-ups, scale-ups and existing businesses to enter the market, develop and provide innovative services, and drive growth and productivity in relevant sectors. Smart data can also help smaller providers to grow and compete more effectively – for example, by facilitating better comparison of goods and services when competing for customers. The potential impacts of smart data on productivity could be as high as a £27.8 billion increase in UK GDP.³⁶ In Autumn 2021, UK government will publish a policy framework to focus and prioritise government's role in enabling better data availability in the wider economy. This will set out how government can intervene to create an environment where data is appropriately usable, accessible and available across the economy.

Case Studies: Open Banking and the Global Open Finance Centre of Excellence

CMA's Retail Banking order in 2017 mandated the nine largest UK banks to share customer data (with consent) and required them to fund implementation of Open Banking, enabling personal customers and small businesses to share their data securely with other banks and other third parties. As of 2021, over three million UK people and businesses are using open banking. The potential estimated annual benefits of Open Banking-enabled services are up to £12 billion for consumers and £6 billion for businesses.

The Global Open Finance Centre of Excellence in Edinburgh is an example of the potential of data sharing initiatives. The centre aims to support data sharing and data-driven innovation in fintech, economic and social research, innovation and talent development.

³⁶ Ctrl-Shift (2018) 'Data Mobility: The personal data portability growth opportunity for the UK economy'

Case Study: The Digital Sandbox pilot – Financial Conduct Authority (FCA) & City of London Corporation (CoLC)

The FCA's engagement with industry and experience running innovation services indicated that a digital testing environment would be a valuable addition to the ecosystem – enabling digital solutions to be tested, which could reduce time to market.

The FCA collaborated with the CoLC to pilot a 'digital sandbox'. The 11-week pilot, which ended in February 2021, provided support to innovative firms tackling challenges caused by COVID-19. 94 organisations applied for the digital sandbox pilot and 28 were selected to take part in the pilot to test their innovative solutions.

The FCA's evaluation of the pilot found that access to a digital testing environment accelerated development times for the vast majority (84%) of participants, as well as benefitting other aspects such as improving product design and refining early-stage business models. A second phase of the pilot, focused on sustainable finance, will be launched later this year.

Artificial intelligence (AI) has changed the way we process and communicate data. That is why **UK government will publish the National AI Strategy** in Autumn 2021, co-ordinated by the Office for AI. Following on from the nearly £1 billion partnership between government, industry and academia, the National AI Strategy will set out how we intend to build on the UK's early lead in AI while also supporting businesses and the public sector to responsibly adopt AI.

Value of design to innovation

Design is core to successful innovation. Great design means putting the needs, wishes and behaviours of people at the heart of the innovation process, so that new ideas are truly desirable as well as being technically feasible and financially viable. Design brings ideas alive and makes them tangible, providing the impetus for growth and ultimately value to shareholders. Good design is for people and the planet, an increasingly critical focus.

Design is key to a strong pro-innovation economy. Design generated £85.2 billion GVA in 2016 (7% of GVA total and an increase of 52% since 2009), with 68% of designers working in non-design firms such as aerospace, automotive and banking. Research shows that design applied to science and technology research accelerates commercialisation and increases value³⁷ and that organisations that invest in design also invest in R&D.³⁸

The Design Council supports businesses use design to innovate and grow. 'Designing Demand' was a five year programme which supported 5,000 businesses – from yacht building to clothing – to use design and branding. It showed that for every £1 invested in design, businesses generated £20 in increased revenues, £4 in net operating profit and £5 in

³⁷ Design Council (2015) 'Innovation by Design: How design enables science and technology research to achieve greater impact'

³⁸ Design Council (2018) 'The Design Economy 2018: The state of Design in the UK'

increased exports. Businesses supported were twice as likely to remain in business five years after the last recession, had improved their brand image and increased productivity, with their turnover growth exceeding their employment growth.

Safeguarding Intellectual Property

The Intellectual Property (IP) regime gives researchers, inventors and creators the confidence to develop something new. It helps innovators reap the rewards of their investments, promoting investment in research and innovation. IP is vital to the UK economy: in 2016, firms in the UK private sector invested an estimated £134.3 billion in knowledge assets, of which £63.8 billion was protected by IP rights.³⁹ ⁴⁰ Use of IP has been linked with an increase in firm performance, with ownership of IP rights being strongly associated with improved economic performance at firm level.

The UK IP system – led by the Intellectual Property Office (IPO) – is consistently highly regarded around the world.⁴¹ However, we must build on this strong foundation. The ability to identify IP in research is critical to achieving impact. To this end, **the IPO will expand its IP education programme for research education**. This will enable it to reach more researchers so they can fully leverage their intellectual property to commercialise their ideas.

Furthermore, the IPO recognises that SMEs need the right support commercialising their IP. This coming year, **the IPO will support growing and recovering businesses to research and develop innovative products and processes, and secure and manage new IP rights**. Specifically, it will help with the costs that businesses face when acting to leverage their IP assets or negotiate the IP landscape, in order to seize opportunities and mitigate risks that SMEs face.

Effective use of IP rights can also help UK firms operate internationally. To bolster innovative companies' and researchers' ability to confidently collaborate, export and invest overseas, **the IPO will launch the International IP Service**. This will provide easy access guidance and support that will help innovative UK companies to make informed decisions about navigating the international IP environment.

The UK IP system's ability to keep pace with technological change is central to its high performance. **This year the IPO will consult on the protection of inventions and creations made by AI with minimal human input** and on whether improved licensing or copyright

³⁹ ONS (2021) 'Investment in intangible assets in the UK: 2018'. Available from: <https://www.ons.gov.uk/economy/economicoutputandproductivity/productivitymeasures/articles/experimentalestimatesofinvestmentinintangibleassetsintheuk2015/2018>

⁴⁰ IPO (2020) 'Use of Intellectual Property rights across UK industries'. Available from: <https://www.gov.uk/government/publications/use-of-intellectual-property-rights-across-uk-industries/use-of-intellectual-property-rights-across-uk-industries>; This equates to 6.8% and 3.2% of total GDP, respectively. Industries with an above average use in IP rights accounted for 26.9% of UK non-financial value-added output, 15.5% of total UK employment and 52.1% of goods exported.

⁴¹ GIPC 'U.S. Chamber 2021 International IP Index'. Available from: <https://www.theglobalipcenter.com/report/ipindex2021/>; Value Ingenuity 'International IP Index Map'. Available from: <https://www.valueingenuity.com/ip-index/map/gb/>

exceptions could make it easier for innovative businesses and researchers to use copyright material for data mining, including with AI systems.

In addition, it is increasingly important for innovation that standards and patents can span across multiple disciplines and sectors. In some cases, standards require the use of specific, patented technologies, called Standard Essential Patents (SEPs). Access to such SEPs on fair, reasonable and non-discriminatory terms is therefore essential for firms that must comply with the standard. To gain further understanding of the issues faced by industry, the IPO will lead a call for views to better understand how the current framework for SEPs is functioning to support innovation, and to establish whether change is needed.

The Patent Box tax incentive is a further measure that supports the retention of IP in the UK, by allowing businesses to pay a reduced rate of tax on profits arising from exploiting patents and other qualifying products. Its aim is to encourage the commercialisation of inventions by companies in the UK.

The Centre for the Protection of National Infrastructure (CPNI) and the National Cyber Security Centre (NCSC) have developed 'Secure Innovation': guidance which aims to highlight the risks undertaken by start-ups and growing companies in the innovative and emerging technology space, and provide practical steps to protect their intellectual property.

Unleashing innovation through international trade

As a sovereign nation, we must take advantage of our ability to be agile and responsive to global opportunities. In support of business objectives, we will promote an open, free and fair rules-based trade system – positioning the UK as a global services, digital and data hub which seizes international opportunities to share ideas and export our innovation to new markets.

The UK's vision for the temporary movement and presence of professionals will support our position as a global leader in services trade, improving access to overseas markets and giving UK businesses access to the talent and skills that they require to drive innovation.

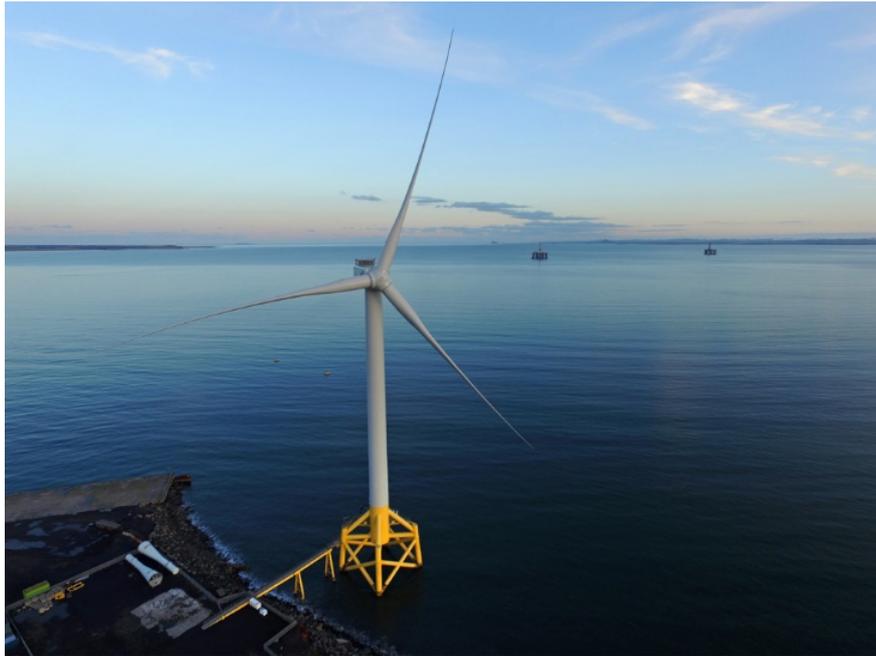
New Free Trade Agreements and reduced market access barriers will help innovative UK businesses to access new markets. Exporting plays a key role in enabling pioneering sectors and technologies to become world-leading, which in turn drives growth and creates jobs. **We will propose world-leading 'innovation chapters' within Free Trade Agreements with strategic partners.** These chapters will build on the precedent-setting Innovation chapter agreed in principle for the UK-Australia FTA and highlight our ambition to be a global leader in innovation to our allies. We will also pursue ambitious digital trade chapters, including provisions on championing data flows internationally. These will prevent unjustified barriers to data crossing borders, while maintaining the UK's high standards for personal data protection.

To enable more innovative UK firms to access international markets, BEIS, FCDO, DIT and UK Export Finance will work together to develop an innovation to export pathway that supports business to consider supply chain development, finance requirements and export potential as an integral part of the innovation process. A tangible example of this approach is the memorandum of understanding between UK Export Finance and the Offshore Renewable

Energy Catapult. This aims to promote the expertise of UK offshore wind companies abroad and will help bring global trading opportunities to UK suppliers and propel UK renewables exports.

We will also publish a new Export Strategy to help raise the exporting culture in the UK and support small, innovative companies to internationalise and grow.

Levenmouth demonstration wind turbine is part of the Offshores Renewable Energy Catapult - the UK's leading innovation centre for offshore renewable energy.



Credit: Offshore Renewable Energy Catapult

Employing public procurement to stimulate innovation

Public procurement accounts for about a third of all public expenditure, with around £292 billion spent on goods and services every year.⁴² There is enormous potential to make better use of this spend to provide a route to market for innovative new products and services. By procuring more innovative solutions, the public sector can be a driver of innovative new ideas, providing innovative firms with the foothold they need to succeed in the market, fuelling the scale-up ecosystem and facilitating wider adoption of new tech services. At the same time, procuring more innovative products and services can lead to better and cheaper public services in the long run.

The UK Government should be a leading customer of innovation. There is more that the UK public sector could do to drive innovation and support innovative small businesses through procurement or precommercial procurement activities. There are isolated examples of good practice, such as those nurtured by the Small Business Research Initiative for pre-commercial procurement, and work to increase government spend through contracts with SMEs.⁴³ However, the overall culture, expertise and incentive structure of the public sector means there is a low appetite for risk and experimentation.

To change the culture of public sector procurement and make it more pro-innovation takes time. Recent developments have shown significant progress, including the UK government's 2020 Green Paper on Transforming Public Procurement and publication of the Social Value model, which requires central UK government departments to take account of social value in qualifying procurements. Under the model 10% of the tender evaluation is to be scored against broader outcomes such as innovation.

Furthermore, the Government Commercial Function has taken steps to support market-driven innovation in public policy through its innovation network, which brings together commercial leaders from across the public sector and wider industry. The network advocates to their customers for greater use of iterative, innovation-friendly competitions and industry challenges as part of policy design and solution identification. A cross-government working group is also being convened to change UK government's approach to public procurement, by changing how it engages with innovators in policy designs and solutions, facilitating genuine collaboration between government and industry.

⁴² HM Treasury (2019) 'Public Expenditure Statistical Analysis 2019'. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/818399/CCS001_CCS0719570952-001_PESA_ACCESSIBLE.pdf; Combined figure of gross current procurement (£220,428 million, page 80) and gross capital procurement (£71,583 million, page 81).

⁴³ During 2019/20, the central government departments spent £15.5 billion with SMEs, £1.3 billion more than in the previous year. This represents 26.7% of all central government spend; a 1.1% improvement on the previous year.

Case Study: Defence and Security Accelerator (DASA)

DASA is a cross-government defence and security organisation which aims to find and fund exploitable innovation to support UK defence and security quickly and effectively. It also aims to support UK prosperity through supporting potential suppliers (especially SMEs and start-ups) in the defence and security sectors, leading to a more diverse and innovative market.

DASA brings together the Armed Forces, security organisations, and government departments with the best science and technology innovations from a diverse range of business and academia. DASA helps scout out and fast-track project development, and works in partnership with SMEs, enablers and end users to help exploit their innovative solutions to the most pressing issues in defence and security. Over the last 4 years, DASA has funded over £140 million to innovative projects with industry and academia.

Case Study: First of a Kind: Demonstrating Tomorrow's Trains Today (2017)

Transreport was funded throughout the first round of First of a Kind (FOAK1): a Department for Transport SBRI competition, supported by Innovate UK, for focussed technology innovation to make rail travel faster, cleaner and greener.

Transreport developed 'Passenger Assistance' – a smartphone app enabling real-time assistance for rail passengers with specific needs, allowing them to place requests in advance for assistance they may require at stations or in-carriage. Rollout of this technology across the UK has increased railway accessibility, helping disadvantaged groups to make use of public transport,

The recognition and funding provided by DfT through FOAK increased the attractiveness of the product to private investors. RDG procured Transreport's solution at the end of FOAK1 and rolled out 'Passenger Assistance' across the rail network in Spring 2020. Transreport is now establishing a Glasgow office to expand its work into Scotland.

The recently published National Procurement Policy Statement sets out innovation as one of the key strategic national priorities which all contracting authorities should consider when undertaking procurement, highlighting the importance of improving innovation in the supply-chain. Alongside the Green Paper and future reform, this will help tackle the cultural barriers by enabling and encouraging Contracting Authorities to procure more flexibly and prioritise innovation in their procurement activity. It signals that innovation has the potential to drive better outcomes across society, and that UK government can drive wider adoption of innovation throughout the supply chain. The statement also highlights that commercial teams should take a broad view of value for money that includes improving social welfare or wellbeing, supporting responsible innovation.

One challenge is that it is not always clear to businesses where the opportunities are when trying to sell innovation to the public sector, and how their innovation capability can map

to government objectives. Effective demand-signalling between UK government and the market is essential. To address this, **UK Government departments and public sector delivery bodies will, where appropriate, produce a clear overall policy problem statement that describes the priority outcomes, that they want to solve or achieve** – aligning with the Public Value Framework. Departments may choose to do so through their public Outcome Delivery Plans, which set out problem statements and high-level delivery strategy for each priority outcome. The Project Outcome Profile is a new tool developed by the Infrastructure and Projects Authority and will help support teams to identify how they are contributing to the UK government's priority outcomes. To drive further demand-signalling, subject to national security requirements, **every major project⁴⁴ should publish an outcome statement linked to their problem statement**, that clearly sets out their unmet needs, and thereby opportunities for the market to bring solutions to the project. This will allow innovation to fill the gaps by matching unmet needs to market solutions.

⁴⁴ Major projects are defined as those which: require spending over and above departmental expenditure limits; require primary legislation; and are innovative or contentious. More information can be found at <https://www.gov.uk/government/groups/major-projects-authority>

Getting technologies to market

The commercialisation of new ideas is critical to enable new innovations to have real impact on people's lives. We must do more to improve our ability to commercialise – the process of taking new ideas and technologies to market – and exploit fully our underlying research base.

The UK has been successful in commercialising within certain fields of research such as the life sciences, including through programmes like the Biomedical Catalyst (BMC).⁴⁵ We are also at the forefront of adapting cutting-edge innovations from the national security and defence sector for commercialisation as dual-use technologies.

However, we can do more to enhance and simplify the broader system of support for commercialisation, both to aid enterprising innovators in their early stages and to accelerate innovations through the later stages of deployment and scale-up.^{46 47}

As an important first step towards this, UKRI will set out its vision and ambition for UK leadership in research commercialisation, learning from the most successful approaches. **UKRI will establish a UKRI-wide Commercialisation Funding Framework.**

Case Study: Wootzano

The Royal Academy of Engineering Enterprise Hub supports the UK's brightest technology and engineering entrepreneurs to realise their potential by providing equity-free funding, mentorship and coaching, and connection to an exceptional community of engineers and innovators. To date, 153 early-stage entrepreneurs and 98 scale up business leaders have been supported, raising almost £500 million in follow-on funding, reaching valuations in excess of £600 million and creating over 1000 jobs.

Wootzano Ltd is a robotics company based in the North East of England that makes highly dexterous robotic systems to handle delicate items. Their robotic system, Avarai, is a state-of-the-art fruit packaging robot which can estimate weight, cut fruits to weight and sizes, identify defects and measure quality, pick and delicately place into punnets. Dr Atif Syed, founder and the CEO of Wootzano, joined the Enterprise Fellowship Programme in 2018. Since embarking on the Fellowship, the team has been growing steadily and raised approximately £2.36 million in follow-on funding. They have recently signed a contract worth over £300 million with a Spanish customer and are in the process of building a manufacturing base in the North East of England.

⁴⁵ MRC (2018) 'MRC Translational Research 2008-2018'. Available from: <https://mrc.ukri.org/publications/browse/10-year-translation-research-evaluation-report-2019/>; Companies established since 2008 commercialising research projects supported by the CiC and DPFS components of BMC secured over 40 per cent of all equity investment in UK start-ups in the biotechnology and medical technology sector in 2018, and were valued in total at £2.7 billion.

⁴⁶ RAEng (2015) 'The Dowling Review of Business-University Research Collaborations'. Available from: <https://www.raeng.org.uk/publications/reports/the-dowling-review-of-business-university-research>

⁴⁷ BEIS (2021) 'UK R&D Roadmap survey: summary of responses'. Available from: <https://www.gov.uk/government/publications/uk-research-and-development-roadmap/uk-rd-roadmap-survey-summary-of-responses-webpage#rd-survey-results>

This will include offering long-term, stage-gated funding to commercialise new and improved technologies, products, processes or services.

In addition, **Innovate UK will continue to strengthen its provision of support for commercialisation capability** through programmes such as the Innovation to Commercialisation of University Research (ICURe), and Knowledge Transfer Partnerships (KTPs) – which ensures a flow of people with expertise from academia to business.

Case Study: Qioptiq Ltd and the two-year Knowledge Transfer Partnership with the Business School at Cardiff University

Qioptiq Ltd, based in Saint Asaph in Wales, entered into a two-year Knowledge Transfer Partnership (KTP) with the Business School at Cardiff University. The partnership enabled the company and university to develop a state-of-the-art industry-leading forecasting system, utilised to ensure more effective management of inventory whilst still allowing the flexibility to enable sound judgmental interventions. Delivering opportunities to introduce major cost savings, this KTP created new jobs in North Wales. This was followed by winning an £82 million six-year contract win in 2017 to service night vision equipment for the Ministry of Defence – harnessing support available to tap into the significant potential for trade both in the UK and worldwide.

Commercialisation and our world-leading research base

The commercialisation of ideas from the UK's world-leading research base is critical to deliver our ambitions. In recent years, UK universities have become more effective at attracting investment and bringing ideas to market. Their performance is now, in many respects, competitive with the USA in terms of patents, spinouts, income from IP and proportion of industrial research.⁴⁸ Of the top ten universities ranked by levels of funding raised by spinouts, the UK has five.

However, we need to build on this. We know that the UK's performance in this area is largely driven by a small number of the most research-intensive universities. One of the UK's challenges is to enhance the technology transfer skills and expertise of a broader range of universities, and to make the UK university sector as accessible as possible to investors.

We want to invest and support key initiatives which create incentives for universities to work together to pool their expertise and collectively improve the way they engage with the investment community. A key lever for doing so is the Connecting Capability Fund (CCF), which is supporting a number of regional commercialisation initiatives, including the Midlands Innovation Commercialisation of Research Accelerator (MICRA); the Northern Accelerator (in the North East); and Northern Gritstone. This £125 million initiative is encouraging universities in England to collaborate together in research commercialisation and working with business,

⁴⁸ Comparison of latest data from US AUTM Licensing Survey and UK HEBCI Survey for 2018-19

and has funded 18 projects, involving 60 universities, and more than 128 individual businesses and investors.

Another important lever is Higher Education Innovation Funding (HEIF) which supports and incentivises universities in England to engage and work with business, public sector and others, as well as supporting entrepreneurial activities of academics and students. HEIF generates £7.30 for every £1 of funding, plus a further £1.80 through investment in spinouts. HEIF increased from £160 million per annum to £250 million per annum between 2016 and 2020, and will continue to be an important incentive for universities to develop the breadth of their collaborations with businesses and other partners.

Further development of the new Knowledge Exchange Framework in England will also be important to enable universities and others to assess their performance and share best practice in this area. It is underpinned by the Knowledge Exchange Concordat, which includes key agreed principles for universities that are being implemented across the UK.

To drive further progress, we will facilitate an on-going conversation between the investment community and university investment and technology transfer offices. In this way, we can discuss the initiatives that are in place to improve the UK system and make it easier to navigate from an investor perspective, and identify on-going issues and areas for improvement.

We will also build our evidence base by funding (through Research England) a University Commercialisation and Innovation Policy Evidence Unit (UCI) at Cambridge to further build our evidence base on commercialisation.

Case Study: Northern Gritstone Inc

Northern Gritstone Inc was founded by the Universities of Leeds, Sheffield and Manchester as a ground-breaking new investment company to build investor confidence by creating an IP-spinout pipeline of sufficient scale and quality to launch a new, regionally focussed investment vehicle to provide funding to spinouts in the region.

It has received a total of £7 million from the Connecting Capability Fund, that includes additional funding announced as part of the Innovation Strategy, and aims to raise up to £500 million from strategic corporate partners, institutional investors, and qualifying individuals, creating one of the largest dedicated investors into university science and technology-related IP in the country.

To date the project has: improved commercialisation rates; enabled rapid assessment and mapping of '20 commercially viable (completed) projects'; underpinned the growth in the combined deal flow from the partners; de-risked technical and commercial projects; and designed a new investment vehicle.

Driving the adoption of technologies by business

For the UK to reap the benefits of innovative ideas they must be widely adopted. We must embed a pro-innovation culture and provide businesses with access to the support, knowledge and skills required to take advantage of the latest innovations.

Adapting to changing environments, exploiting new opportunities or overcoming challenges is vital to the health of the UK economy. While the UK is a world leader in taking the first steps at the frontiers of innovation,⁴⁹ adoption and the use of innovation by firms across the economy is relatively low by international standards.⁵⁰ This lack of adoption typically leads to lower profits for the firms, and lower growth and productivity for the economy as a whole.^{51 52 53}

We want to see more businesses actively engaging and investing in innovation for their own benefit and for the consumers they serve. We will create the certainty needed to give businesses confidence to invest in adoption of new technologies and processes, accelerating their deployment and driving improvements in productivity.

To support the adoption of foundational digital technologies, the UK government will **launch Help to Grow: Digital later this year** – as announced in our plan for growth. This aims to support 100,000 small businesses to adopt digital technologies that will save them time and money, helping them recover from the pandemic. The launch will sit alongside the launch of **Help To Grow: Management**, helping to create the conditions for businesses to adopt innovation.

This will build on our existing business support programmes that help drive adoption and develop business innovation capability, including those delivered through Growth Hubs and Be the Business in England and by Scottish Enterprise, the Welsh Government and Invest Northern Ireland. This year we are reforming Local Enterprise Partnerships (LEPs), to build on their valuable work to date, while improving quality and access to the business support schemes they deliver through Growth Hubs. This, combined with the hubs in the north of England, Scotland, Wales and Northern Ireland, will improve the support available to local businesses across the whole of the UK, helping them develop the capabilities they need to innovate and become more competitive and productive.

Innovate UK will expand EDGE, initially launched in January this year, and it will work alongside Growth Hubs in England, and programmes delivered by Scottish Enterprise, Invest Northern Ireland, and the Welsh Government. This will provide innovative

⁴⁹ The UK ranks first amongst its comparator countries by field-weighted citation impact and in the 2020 Global Innovation Index (GII), the UK is noted as the 4th most innovative economy in the world and rank 10th for knowledge impact.

⁵⁰ Compared with other countries, adoption rates for basic technology have increased, whilst the adoption of advanced technology has been slow. However, UK tech adoption rates among businesses are close to the EU average but far behind the leaders, with a particular weakness in supply chain management (ranked 23rd in OECD in 2017)

⁵¹ ONS 'UK Innovation Survey'

⁵² Hall, B.H. (2011) 'Innovation and productivity'. No. w17178. National bureau of economic research

⁵³ Hodges D. (2010) 'Investigating the links between innovation and productivity: an analysis of UK firms', BIS, 2010; Criscuolo C. (2009) 'Innovation and Productivity: Estimating the core model across 18 Countries in OECD, Innovation in Firms – A Microeconomic Perspective', Paris: OECD (2009).

businesses with the wrap-around support and leadership and management skills they require to scale up, commercialise, access new markets, and internationalise and will accelerate growth in the UK's most innovative businesses.

In the manufacturing sector, where there are high barriers to adoption, the Made Smarter programme⁵⁴ supports SMEs through intensive one-to-one advice, training, networks, and co-funding for digital transformation. **This year we have invested a further £8 million to continue Made Smarter Adoption in the North West of England and to begin scaling-up support in the West Midlands, North East of England, and Yorkshire & the Humber.** This will support the adoption of industrial digital technology amongst manufacturing SMEs and builds on the success of our Made Smarter North West Pilot. Learning from these approaches, we will continue to embed adoption into the design of innovation programmes, and empower industries and sectors to identify their innovation needs to drive the market for innovation.

Case Study: Made Smarter North West Pilot – Increasing Adoption of Industrial Digital Technology by SME Manufacturer

The BEIS-funded £20 million Made Smarter North West Pilot, which went live in January 2019, is focused on increasing the adoption of industrial digital technology by SME manufacturers.

In 2021, the Pilot has worked with more than 1,200 manufacturing SMEs and developed an offer proven to help SME manufacturers invest in digital transformation projects that increase their productivity and competitiveness, resilience, and drive down their emissions. Intensive advice and £3.7 million in matched grant funding from the Pilot have leveraged £10.2 million in private investment into Industrial Digital Technology adoption.

Ahead of a full impact assessment, the Pilot's interim independent evaluation found that 84% of supported firms surveyed experienced increases in productivity, 60% are better able to participate in digital supply chains, 25% reported exports benefits and another 25% reported reduced carbon emissions. Evaluators also found strong impacts on job creation, with 30 new jobs created in a sample of 36 supported firms.

Additional information on 'Made Smarter North West Pilot – Increasing Adoption of Industrial Digital Technology by SME manufacturer' case study⁵⁵.

Collaboration between businesses is an important channel of knowledge sharing and exchange; the more cooperation a firm is engaged in, the more likely the firm is to introduce innovations. In line with its mission to drive economic growth, **Innovate UK will include the adoption and diffusion of cutting-edge innovation in its objectives**, with a strong focus on

⁵⁴ Made Smarter is the UK's Industrial Digitalisation initiative, setting out the required collective action by business and Government to drive a prosperous the Fourth Industrial Revolution for the manufacturing sector. It comprises four core activities: Leadership – providing national leadership for digitalisation of UK manufacturing; Innovation – innovating the next generation of industrial digital solutions; Adoption – helping manufacturing SMEs adopt existing solutions to drive growth, productivity and efficiency; and Skills – helping upskill the UK's manufacturing sector.

⁵⁵ Focus on increasing the adoption of industrial digital technology include: Additive Manufacturing; AI, Machine Learning, and Data Analytics; Robotics and Automation; Industrial Internet of Things and Connectivity; and Virtual and Augmented Reality

driving an effective innovation ecosystem. This will include the role of their successful collaborative R&D programmes, networks and infrastructure like the KTN and Catapult centres, as well as how they work together with other UKRI councils, funding agencies in Scotland, Wales and Northern Ireland, and PSREs.

Celebrating Innovative businesses

Recognising and celebrating innovative businesses can bring direct benefits to the company and encourage competitors to strive to do more. The Queen's Awards for Enterprise are a prestigious award for UK businesses and a globally recognised royal seal of approval. The Queen's Awards for Enterprise: Innovation has been awarded to 1,035 companies since the category's inception in 2000. 48 of the 205 recipients of the 2021 Awards were Innovation winners. It recognises businesses who demonstrate strong commercially successful innovative products or services. Benefits reported by recipients include excellent marketing opportunities; worldwide recognition as an outstanding British company; increased turnover and international trade; and a boost to the morale of staff, partners and stakeholders. Winners are permitted to use the esteemed Queen's Awards for Enterprise emblem on their products for the next 5 years.

Case Study: Queens Award for Enterprise: Innovation – SnapDragon Monitoring

SnapDragon Monitoring, based in Edinburgh, Scotland, is an online brand protection company dedicated to fighting fakes online, were winners of the Queen's Award for Enterprise in the Innovation category in 2020. Using clients' intellectual property rights (such as trademarks, design rights and patents) and backed by AI-driven technology, SnapDragon Monitoring's pioneering software, Swoop, monitors the world's busiest online marketplaces for copycat goods, identifying suspect infringements for removal. They applied for a Queen's Award as they are passionate about the work that they do and are determined to raise awareness of the dangers of counterfeits.

Public sector innovation

While public sector innovation is not the focus of this Strategy, UK government institutions and the wider public sector itself has an impressive historic track record of innovation – ranging from the National Physical Laboratory where Alan Turing developed early computers, to the Science and Technology Facilities Council whose laser technology is powering safety devices around the world.

In April 2021, the UK government published The Mackintosh Report and new guidance to support the translation of public sector innovation into wider social benefits, new high-tech jobs, businesses and economic growth. **The Government Office for Technology Transfer will be set up this year** to support public sector organisations in identifying wider uses for their innovations for social, financial or economic benefit. This new unit will establish knowledge and technology transfer infrastructure within government, administer a grant fund to support opportunities at their earliest stages, and an early-stage investment fund to invest in more developed ideas emerging from PSREs and other innovators in the public sector.

Another example of public sector innovation is the Open Innovation Team (OIT), a cross-government unit that works with academics to generate analysis and ideas for policy. Set up in 2016, it operates as an in-house consultancy, responding to the demands of customers across government and generating income to cover its costs.

Over the past five years, the OIT has delivered more than 75 policy projects for 13 government departments and public sector organisations. It has collaborated with over 900 experts from more than 270 organisations, supporting policy development in a wide range of areas, including education, growth, justice, policing, housing, foreign policy, health, youth services, social care and civil service reform. The OIT's emergence and operating model are notable for a number of reasons:

- *Intrapreneurship*: the team was the brainchild of a mid-ranking official who spotted an opportunity to introduce a new kind of service and persuaded seniors to let them test it out.
- *Cost recovery*: the OIT works like a business, covering its costs by generating income from a variety of sources, including sponsorship deals, paid project work and training.
- *Demand-led*: rather than concentrating on a certain idea, policy area or type of work, the team focuses on responding to requests for support from customers across government.
- *Adaptation*: the team is evolving its offer over time, testing new types of products and services and new kinds of partnership as it seeks to increase its impact.

Pillar 2: People – We will make the UK the most exciting place for innovation talent

COVID-19 has shown the rich diversity of domestic and global talent and skills needed for world class innovation. In this Pillar we set out how we will provide businesses with the skills they need, by developing the UK's workforce and attracting and retaining global talent. We will promote a richer diversity of skills critical for innovation and ensure our training pipeline delivers the diverse set of skills needed by presenting a broad skills agenda. We are investing in Institutes of Technology to deliver a new learning offer; increasing support for technical and entrepreneurial skills; and piloting schemes to help interdisciplinary innovators. We will open our borders to the world's best innovators and make the UK a global hub through the Office for Talent; open up new and improved visa routes for innovators, and offer a reviewed funding offer for globally-mobile talent. We will tackle excess bureaucracy, giving innovators back control and creating the lowest-friction, most innovator-friendly research, development and innovation system.

Businesses need access to talented people with the right knowledge, skills and experience to drive innovation-fuelled growth. A far greater number of UK citizens should see a future for themselves and their families in innovation, and the world's brightest, most motivated, and most entrepreneurial minds should look to the UK as the 'place to be', allowing us to become the leading global hub for top talent.

The availability of the right skills in the workforce plays a key role in where investors decide to invest and therefore is central to our competitiveness as a destination for Foreign Direct Investment (FDI).⁵⁶ But innovative UK firms are in some cases struggling to access the skills they need to grow.⁵⁷ In innovative emerging technologies, the UK is falling behind countries like the US, Canada, Germany, Switzerland, Singapore and Ireland in identifying and providing the training needed to fully exploit future opportunities.⁵⁸

To address these issues, it is vital that the UK's workforce, and the education and training system that feeds it, has sufficient scale, diversity and breadth to meet the challenges and opportunities of a more innovative economy and society. Whether people are continuing education, retraining, moving from another sector, returning following a career break, or coming to the UK from abroad, our agenda must be to develop an inclusive and highly skilled workforce that meets the needs of business. This means getting the right mix of specialised, entrepreneurial and leadership skills to adopt innovations, lead enterprises, develop innovative ideas, and progress them to commercial projects. We need the world's leading researchers, innovators and entrepreneurs to see the UK as the place to progress their ideas and to establish and grow innovative businesses.

To achieve this aim, we are taking action in four areas:

⁵⁶ EY (2019) 'EY UK Attractiveness Survey 2019'. Available from: https://www.ey.com/en_uk/attractiveness

⁵⁷ ONS 'UK Innovation Survey'

⁵⁸ HVM Catapult (2020) 'Manufacturing the Future Workforce'. Available from: <https://hvm.catapult.org.uk/mtfw/>

- *We are promoting a far richer diversity of skills critical for innovation.* We have become too reliant on a narrow set of pipelines to train science and technology talent, so we will make sure our skills pipeline covers the full skills complement that our innovation ecosystem needs – including in programming, technical, and engineering fields.
- *We are opening our borders to top talent.* World-leading innovators should see the UK as the place to make their ideas reality. We are reforming our migration system to be open to them and let them change the world here.
- *We are tackling excess bureaucracy to give innovators back control.* Growth in bureaucracy around the world is stifling excellence in research, innovation and entrepreneurship – greatly slowing progress. We will set the global lead in reversing this.
- *We are creating a truly innovator-friendly agile regulatory system.* Innovative entrepreneurs should see the UK as the place to start and scale their business. We encourage regulators to continually horizon scan to adapt to the latest emerging technologies, not protecting incumbent players.

R&D People and Culture Strategy: targeted action to address issues in the R&D sector

There are strong links between the skills and talent that our R&D system attracts, creates and nurtures, and the needs and opportunities of our most innovative businesses. That is why we are taking specific steps to support the needs of the R&D system – from the researchers undertaking basic, translational and applied research in universities, the NHS and other places, through to innovators at the cutting edge of private sector R&D.

The UK has a highly talented and skilled R&D workforce but there are significant challenges. The R&D roadmap set out the need to ensure that we have an R&D workforce that can meet the needs of a more innovative economy and society. This includes opening up career pathways to enable greater mobility and encouraging more diversity, and recognising all of the people who contribute to making R&D successful, including technicians and support staff.

Our recently published R&D People and Culture Strategy reflects and expands on the commitments made in this Pillar. It sets out a number of clear actions to tackle long-term challenges in the R&D workforce, looking in greater depth at three themes:

People: Redefining what it means to work in R&D in the 21st Century – valuing all the roles that make it a success and ensuring the UK has the capability and capacity it needs.

Culture: Co-creating a vision of the culture we want to see within the sector – working together to make lasting change happen so that researchers and innovators from all backgrounds can thrive and do their best work here.

Talent: Renewing the UK's position as a global leader in R&D in attracting, retaining and developing talented people, making sure careers in UK R&D are attractive to talented individuals and teams both domestically and internationally.

The R&D People and Culture Strategy is a **call to action** for the wider sector. We want to galvanise the research and innovation system to make change happen for the long term. We want to engage those working in both business and academia to drive towards our vision of a system and landscape that enables talented individuals and teams to thrive, working collaboratively across business and academia to pursue R&D goals which deliver sustained impact.

Promoting a diverse skills base

Innovation ecosystems rely on a wide range of skills, such as technicians, engineers, discovery scientists, technologists, entrepreneurs, and investors. Here we outline the steps we are taking to make sure our training pipeline is delivering the full skills complement that our innovation ecosystem needs.

The UK government's skills agenda

The innovation workforce is built by the education and skills system. In England, the UK government's Skills for jobs white paper,⁵⁹ published in January 2021, focuses on giving people the skills they need to thrive in the workforce and boost productivity. Through the Prime Minister's Lifetime Skills Guarantee, the UK government is ensuring people have opportunities to upskill and reskill at different points in their life.

The reforms being brought forward by the UK government as part of this programme ensure that businesses and learning institutions can work together to identify and target skills gaps. In England, the Department for Education (DfE) has launched a pilot strategic development fund as part of the Skills Accelerator. This programme, which includes College Business Centres, will explore how targeted support can help further education (FE) providers, working together collaboratively, to address skills and innovation priorities that local employers have identified. These pilot Centres may, for instance, support incremental innovation by giving local businesses access to specialist equipment and facilities.

Earlier this year, DfE launched the first Emerging Skills Project with the High Value Manufacturing Catapult and Institutes of Technology, building on work supported by the Gatsby Foundation.⁶⁰ This pilot project is attempting to future proof the skills system by driving the adoption by industry of the skills needed to exploit emerging technologies and other innovations (known as the 'Skills Value Chain' approach). **We will launch a second project later this year** and explore further how the Skills Value Chain could be adopted by government and the innovation ecosystem – including by Catapults and Innovate UK.

Skills Value Chain

The Skills Value Chain is comprised of three activities, delivered in sequence:

1. Convening centres of innovation, employers, and providers to undertake 'foresighting', which establishes emerging skills needs in a sector and analyses the gap in current provision and future need.
2. Developing course content and modular training to meet the need identified through foresighting.
3. Delivering skills diffusion by training trainers, delivering funded learner uptake to employees in the sector, and working with high-quality providers to make the courses widely available.

Building on this work, **the Gatsby Charitable Foundation will support centres of innovation to work with industry and training providers to expand industry's capacity to forecast its emerging skills needs.** This will develop a shared view of how the skills of the

⁵⁹ DfE (2021) 'Skills for jobs: lifelong learning for opportunity and growth' Available from: <https://www.gov.uk/government/publications/skills-for-jobs-lifelong-learning-for-opportunity-and-growth>

⁶⁰ HVMC (2020) 'Manufacturing the Future Workforce'

future workforce can be developed to enable business to take advantage of new and emerging technologies, the opportunities of innovation, and more productive systems and practices. This will prepare the way for future Emerging Skills projects and an expanded use of the Skills Value Chain.

Furthermore, **UKRI, through Innovate UK, will develop a leadership role in identifying critical innovation emerging skills gaps** and will be recognised as an authoritative voice on future skills implications for businesses. They will draw on networks of engagement and partnerships across key sectors to provide foresighting and evidence gathering, and feedback to businesses, training providers and funders on skills implications to ensure both current and future skills gaps are met.

Realising our potential in Science, Technology, Engineering and Mathematics (STEM)

STEM skills are critical to the innovation process. UK Government is already focused on boosting the profile of STEM and encouraging young people to consider obtaining STEM skills. For example, UKRI supports two major programmes: the STEM Ambassadors programme (see case study) and the CREST awards for project work in STEM subjects. This recognises around 60,000 young people every year and has a positive impact on attainment, particularly in those in receipt of free school meals. The UK government has also supported the Advanced Maths Support Programme, Stimulating Physics Network, Enthuse bursaries, Teaching for Mastery and Isaac Physics. Together, these programmes support STEM uptake in schools and colleges, enhancing the next generation's mathematical and scientific skills on which the STEM sector will depend.

Institutes of Technology (IoTs) are a key part of the system for business as unique collaborations between further education colleges, universities, and businesses. They provide tailored higher technical education and training in key STEM sectors, such as digital, construction, advanced manufacturing, and engineering, to respond to the needs of business in the local area. **UK Government is investing up to £290 million to establish a comprehensive network of IoTs across England.** They will establish relationships with other key providers of technical skills in the wider education system, such as University Technical Colleges, so that there are clear progression pathways for students to support them.

Case Study: STEM Ambassadors

The STEM Ambassador programme, delivered by STEM Learning, is a network of 33,000 volunteers from 7,000 STEM employers who give their time and enthusiasm to help bring STEM subjects to life and demonstrate their relevance to young people. By working with schools, colleges, and youth and community groups, STEM Ambassadors play a key part in inspiring young people of all backgrounds, making them aware of the wide range of opportunities available and the various career pathways. STEM Ambassadors are representative of the local population, enabling young people to be inspired by “people like them”: 57% of them are under 35, 45% are women, 14% have an ethnic minority background.

Increasing training and utilisation of technical skills

Technical skills are critical to the R&D endeavour. However, the UK lags behind competitors in this area, as highlighted by the 2019 Augar review.⁶¹ As the technical complexity of R&D has increased, our technician workforce has decreased. A far lower fraction of people complete technical qualifications (level 4&5) or high-value apprenticeships relative to our core competitors. We also have markedly lower numbers of technicians in University R&D than was the case thirty years ago, meaning that many researchers have to perform technical functions which would be better suited to trained technicians.

DfE's Skills for jobs white paper announced several key policies to increase the provision of technical training. These include:

- *The Lifelong Skills Guarantee*, which guarantees anyone who has left school without A levels to undertake technical skills training.
- *The Lifelong Loans Guarantee*, which allows individuals up to 4 years' worth of higher education loan funding.
- Increases in apprenticeship funding flexibility, active promotion of technical skills training, and increases in skills funding flexibility to give FE colleges more flexibility to respond to local needs.

Nurturing interdisciplinary innovators

Many great innovations have come about from people moving between fields and bringing new ideas. For example, Demis Hassabis moved from game design and neuroscience to artificial intelligence, growing a team that combined insights from both former fields to influence the direction of AI. These people are the 'glue' that link different fields. In addition, many of our most innovative firms have been started by academics who have taken a great idea from the lab and turned it into a successful business. We want to learn from this and encourage interdisciplinary innovators who have breadth across disciplines and who can thrive both in academia and in business. The design and creative sectors are instrumental elements of the innovation system too and form part of that rich mix which needs to be in place to achieve our innovation ambitions.

As set out in the R&D People and Culture Strategy, we will design a pilot to help researchers acquire skills and knowledge beyond their own discipline. This will encourage employers and funders to go further to support researchers who want to take their skills and experience into new areas. It will also encourage funders to ensure criteria for grants are supportive of interdisciplinary and intersectoral research, and of researchers moving between fields.

We also want to make it as easy as possible to move between academia and industry, to enable valuable cross-pollination of research expertise and business know-how. To this

⁶¹ DfE (2019) 'Post-18 review of education and funding: independent panel report'. Available from: <https://www.gov.uk/government/publications/post-18-review-of-education-and-funding-independent-panel-report>

end, **we will provide support for flexible, cross-sector training programmes, which will encourage more movement and collaboration between academia, industry, government and the third sector.**

Business and entrepreneurial skills

Business skills are also vitally important. Businesses need leadership and commercial skills to successfully scale. UKRI, through Innovate UK, will work with partners to support business growth – by developing and scaling targeted programmes to address the commercial and leadership skills needed to increase innovative business capabilities.

Good leadership and management is a key enabler for driving up firms' productivity and can boost a firm's capacity to innovate. A 2012 study suggested that, overall, the UK is mid-table when it comes to management practices amongst G7 countries.⁶² Closing this gap could result in a 7% productivity uplift for the UK economy.⁶³ To address this, **Help to Grow:**

Management will support 30,000 senior managers of small and medium sized businesses across the UK to boost their business's performance, resilience, and long-term growth through a practical management training programme delivered by world-class business schools.

We will also focus on increasing our support for entrepreneurial skills, especially in the academic sector. In the longer-term, we will work with the sector to develop a range of measures to ensure people with brilliant ideas can better understand how to get investment, networks of contacts, scaling support, and other key business skills.

Becoming a global hub for top talent

We know that exceptional people and teams are key to vibrant innovation ecosystems. The location of new high-tech industries around the world is in part a function of where the early scientific and entrepreneurial leadership happened to be located.⁶⁴ If we are to lead the industries of the future, we must place people, teams and firms at the centre and make the UK the best place in the world to work in R&D.

But we currently are losing the global competition to top talent. More inventors leave the UK each year than arrive here.⁶⁵

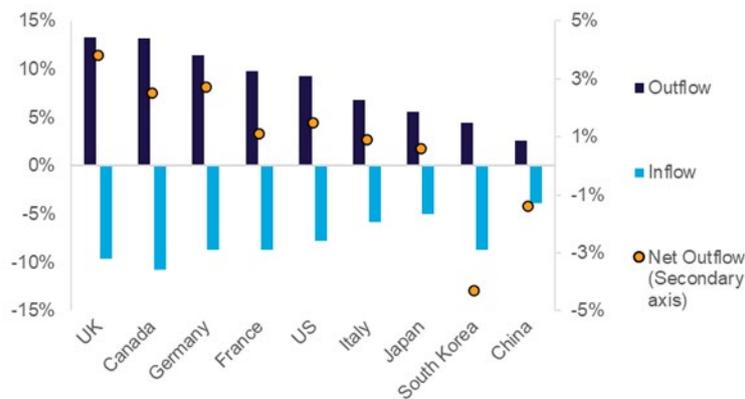
⁶² BIS (2012) 'Leadership & Management in the UK – The Key to Sustainable Growth'

⁶³ CBI (2019) 'Great job: solving the productivity puzzle through the power of people'. Available from: <https://www.cbi.org.uk/articles/great-job-solving-the-productivity-puzzle-through-the-power-of-people/>

⁶⁴ Zucker L. and Darby M. (2014) 'Movement of Star Scientists and Engineers and High-Tech Firm Entry', NBER 2014; Zucker L., Darby M. and Brewer (1998) 'Intellectual Human Capital and the Birth of U.S. Biotechnology Enterprises', American Economic Review, 1998, vol. 88, issue 1, 290-306

⁶⁵ WIPO (2013) Measuring the International Mobility of Inventors: A New Database'. Available from: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_econstat_wp_8.pdf

Figure 5: Summary of international mobility of researchers for the UK and comparator countries, 1996-2015.



Source: Scopus, published in https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/660855/uk-research-base-international-comparison-2016.pdf

We are therefore setting a target of reversing this brain drain by 2030, with action in three priority areas:

- **We are opening our borders to top talent from everywhere in the world**, via a merit-based system rather than one based on country of origin.
- **We will ensure our funding system can attract and enable the very best researchers and innovators**, opening up opportunities for talented people and teams to pursue ambitious, long-term goals.
- **We are making a bold offer to early career innovators**, making the UK the best possible home for those starting out in a career in innovation.

Opening our borders to top talent

We are making the United Kingdom the easiest country in the world for top Innovative Talent to enter, continuing our proud history of talented researchers and teams seeking opportunities here and creating the future. In the mid-twentieth century, we benefited from a surge of high-skilled migration that helped seed the Cambridge Life Sciences cluster, including Sydney Brenner, Max Perutz and James Watson, and we must do the same today.

This openness to global talent has key benefits for the United Kingdom:

- It greatly expands the amount of talent we have available to innovate. Talent is equally distributed globally, meaning most of the top talent is not home grown.
- It diversifies the perspectives and skills we have available. Each education system and culture has its own strengths and limitations. The wider the range of perspectives and backgrounds, the more likely we are to find the hidden treasure we seek.
- It makes us a global hub for science and technology. Science operates through social networks. In the 1960s and 70s, the Cambridge Laboratory of Molecular Biology trained a generation of America's top molecular biologists, forging lasting links between the UK and the US biotech sectors. Today, DeepMind places the UK at the forefront of the global AI endeavour.

For the first time, we have created a dedicated cross-departmental unit, the Office for Talent, driving a proactive approach to bringing talent to the UK. The Office for Talent's roles include:

- Advertising to Innovators the benefits of making the United Kingdom their home.
- Ensuring the UK is open and welcoming to highly skilled migrants.
- Coordinating pro-active recruitment of top talent in critical priority sectors.

As well as developing our own talent, we want the UK to be a magnet for the world's best innovators and entrepreneurs. Skilled migration is strongly associated with higher levels of innovation and entrepreneurship,⁶⁶ and individuals from overseas bring complementary skills, knowledge, and ideas to the workplace.⁶⁷ A diverse workforce with a global outlook can identify opportunities and new openings, and access to overseas talent is crucial for driving the growth and competitiveness of high-growth businesses. The Global Talent visa route is open to those who are leaders or potential leaders in the fields of academia or research, arts and culture, or digital technology. In May 2021, we delivered on our commitment in Build Back Better: our plan for growth to expand the route so that global prize winners automatically qualify, and the UK government will look to broaden the list of prizes later this year.

Furthermore, as part of our plan for growth, the UK government will introduce a new **High Potential Individual route** to make it as simple as possible for internationally mobile individuals who demonstrate high potential to come to the UK. Eligibility will be open to applicants who have graduated from a top global university. The UK government will explore the scope to expand eligibility to other characteristics of high potential. There will be no job offer requirement, giving individuals the flexibility to work, switch jobs or employers and make contributions to the UK economy. The route will also allow eligible individuals to extend their visa and settle in the UK, subject to meeting specific requirements.

A scale-up route will also support UK scale-ups by allowing talented individuals with a high skilled job offer from a qualifying scale-up at the required salary level to come to the UK. Scale-ups will be able to apply through a fast-track verification process to use the route, so long as

⁶⁶ Burchardi K.B. et al (2020) 'Immigration, Innovation and Growth'. Available from: <https://www.nber.org/papers/w27075>; For immigration to influence innovation takes time and scale: across US counties, an influx of 2,500 high-skilled immigrants adds one more patent per 1,000 population over 5 years. The receiving county also experiences net job creation in the same period.

⁶⁷ BIS (2015) 'The impacts of migrant workers on UK businesses'

they can demonstrate an annual average revenue or employment growth rate over a three-year period greater than 20%, and a minimum of 10 employees at the start of the three-year period. UK Government will explore whether scale-ups who can demonstrate an expectation of strong growth in future years may also qualify following a review. The route will allow eligible individuals to work, switch jobs or employers. Individuals will be able to extend their visa and settle in the UK, subject to meeting specific requirements.

A revitalised Innovator route will allow talented innovators and entrepreneurs from overseas to start and operate a business in the UK that is venture-backed or harnesses innovative technologies, creating jobs for UK workers and boosting growth. We have reviewed the Innovator route to build a competitive offer. We will do this by:

- *Simplifying and streamlining the business eligibility criteria.* Applicants will need to demonstrate that their business venture has a high potential to grow and add value to the UK and is innovative.
- *Fast-tracking applications.* The UK government is exploring a fast-track, lighter touch endorsement process for applicants whose business ideas are particularly advanced to match the best-in-class international offers. Applicants that have been accepted on to the Department for International Trade's Global Entrepreneur Programme will be automatically eligible.
- *Building flexibility.* Applicants will no longer be required to have at least £50,000 in investment funds to apply for an Innovator visa, provided that the endorsing body is satisfied the applicant has sufficient funds to grow their business. We will also remove the restriction on doing work outside of the applicant's primary business.

The new Global Business Mobility visa will also allow overseas businesses and innovative companies greater flexibility in transferring workers to the UK, in order to establish and expand their businesses.

These reforms will sit alongside the UK government's Global Entrepreneur Programme (GEP) which has a track record of success in attracting high skilled migrant tech founders with IP-rich businesses to the UK. The programme will focus on attracting more international talent to support the growth of technology clusters including through working with academic institutions from overseas to access innovative spinouts and overseas talent.

Through the Graduate Route we are also granting international students with UK degrees 2 years, 3 years for those with PhDs, to work in the UK post-graduation. This will help ensure that we can attract the best and brightest from across the world while also giving students time to contribute to our innovation needs.

These are all in addition to our existing skills visa schemes for those with job offers in the UK.

Ensuring our funding system can attract and retain the very best researchers and innovators

We need the brightest minds in the world exploring new frontiers to find tomorrow's innovations. This work is often by its very nature unpredictable, requiring people to take risks, to pursue ideas long-term, and not to worry about short-term failure. It also requires the ability to defy consensus and explore areas that others think are fruitless. It is increasingly expensive and technology dependent, requiring substantial equipment and support.

We must therefore look at the attractiveness and competitiveness of our offer to globally mobile talent, which we will review with the aim to retain, attract and support the very best researchers, innovators and their teams. We have begun working with partners, including UKRI and the National Academies, to review our capacity to attract and develop the most outstanding research and innovation talent across all career stages. Attracting and retaining these highly sought-after individuals and teams will add to the UK's strength as a collaborative science superpower. These people bring reputational benefits to their host institutions and ask the bold and creative research questions that extend the frontiers of knowledge. We are assessing whether there are gaps or shortfalls in our offer, and if so, how they can be addressed. As part of this we will explore whether we should change duration and types of support, including what role fellowships can play in delivering better support for talented people and their teams.

Constant evaluation to reduce bureaucracy system-wide

We also need our outstanding researchers and innovators to be free to innovate, not bogged down in grant writing and form filling. Through the independent Review of Research Bureaucracy led by Professor Adam Tickell, we will look to ensure that these systems encourage the positive culture we want to see while minimising the bureaucratic overhead. The overarching goal of the Review is to advise on a substantial reduction in unnecessary research bureaucracy in government and the wider sector, supporting our researchers to focus on research and related activities which contribute to a healthy research base. Our ambition is to reduce research bureaucracy so that only essential elements remain, resulting in a major improvement in the quality of the working lives of individuals and teams conducting research.

As part of its work, we will ask the Tickell Review to consider how the UK government can monitor the delivery of its bureaucracy reduction ambitions, including what role external scrutiny could play. Suppressing bureaucracy requires continual vigilance and UK government will put in place mechanisms to monitor levels of bureaucracy and ensure we are keeping it permanently in check.

If we are to win the global race for key innovations, people must be able to act quickly, flexibly, and with an attitude of risk taking. This applies equally to our scientists and researchers as it does to our entrepreneurs and investors. We made addressing research bureaucracy a manifesto commitment - focusing on freeing up researcher time, placing more trust in the judgement and talent of individuals and less in formal process, whilst ensuring sufficient accountability by tracking resource spend transparently. If we can accelerate the process of research, we can accelerate innovation. To begin addressing this we have already reduced the

bureaucratic burden, for example removing UKRI's requirement for even the most open-ended, curiosity-driven research proposals to set out a 'pathways to impact' plan.

Backing early career innovators

Richard Feynman said that science is the belief in the ignorance of experts. Those fresh minds at the start of their career can be especially effective at bringing new ideas and perspectives, break down paradigms, and may be less scarred by failure.

Many of the most fundamental advances in the history of science and technology were made by those at the start of their career. But such voices risk becoming disempowered in our system, with too much weight being given to the views of those with long, established track records. **We will therefore take steps to ensure early career researchers and innovators are central to government R&D policy**, to support and help drive innovation. In the R&D People and Culture Strategy we have set out how we will give a stronger voice to early career researchers. Alongside this, we will look to go further in reviewing how talented early career researchers and innovators can interact with and advise government on science, research and innovation policy, bringing new perspectives.

Case Study: Ground-breaking innovations produced by early career researchers – examples of Young Innovators Award Holder (2020)

Kate Walker is a Product Design Engineering graduate and a founder of ExpHand Prosthetics, which provides life-changing upper limb prosthetics that give children their independence back. They provide 3D printed prosthetics direct to consumers at a price of only £400. These prosthetics allow children to grip and pick up objects and to have the ability to independently complete daily tasks. ExpHand Prosthetics features a lightweight design suitable for young children and is available in customisable colours to suit a child's personality. The device itself is manufactured in-house and sent directly to consumers. ExpHand Prosthetics will begin by selling in the UK, but its mission is to make prosthetics accessible to children across the globe.

Helm Innovation Ltd, founded by Madelaine Dowd, is the product of the Grand Safety Challenge at the Royal College of Art. Helm Innovation's design solutions were awarded "Best innovation" as well as "Most immediate life-saving potential". They have worked under the guidance of the Lloyd's Register Foundation with support from industry leaders and regulators including UK Maritime Pilots Association, Marine Accident Investigation Branch, RNLI and Port of London Authority. They have developed a new Maritime Piloting innovation which can be applied elsewhere as a rapid escape solution, saving thousands more lives.

Making innovation open to everyone

A diverse workforce increases the opportunity for creativity and innovation within firms. Studies show that firms with more diverse teams are more innovative.⁶⁸ Increased diversity is shown to lead to higher efficiency in knowledge-intensive industries, drive inventions and increase economic growth.⁶⁹

The UK can only achieve its goals for innovation if we draw on the talents of all parts of society. Promoting an inclusive innovation sector will be a central objective across all the innovation programmes the UK government takes forward in the coming years.

Many groups of people are under-represented among innovators. For example, between 2000 and 2015, just 7% of the people who applied for patents in the UK were women.⁷⁰ International research suggests that this represents a misallocation of talent and results in significant productivity losses.⁷¹ In the United States, researchers have calculated that the rate of invention could quadruple if talented people from disadvantaged groups participated at the same rate as people from better-off backgrounds.⁷² This research, and studies from different countries, suggests that exposure to innovation in childhood is an important influence on likelihood to become an innovator later in life.

Case Study: Women in Innovation Award Holder Agnes Czako, Founder AirEx

AirEx is a technology start-up developing and scaling-up efficiency technologies in the domestic retrofit sector, to tackle fuel poverty and climate change. Its IoT-enabled smart ventilation control (Smart Air Brick) aims to reduce fabric heat loss in homes without compromising damp and indoor air quality.

Securing Ofgem approval for their product, as one of only a handful of companies under the Energy Company Obligation (ECO3) Innovation scheme, triggered significant commercial traction with utilities. They also successfully closed a seed funding round in 2019 through angel investors (£520,000 EIS investment) and grew their core team by 50%.

To date, AirEx has raised £1.5 million private sector funding and commercially sold 1,700 units and gained significant revenue traction from social landlords, energy companies and retrofit installers.

Research by NESTA shows that while there are several initiatives already running that help give young people exposure to innovation, they do not currently operate at a big enough scale and are not always targeted at those who would benefit most from support. NESTA estimates

⁶⁸ Schneider J. and Eckl V. (2016) 'The Difference Makes a Difference: Team Diversity and Innovation'

⁶⁹ Ozgen et al. (2013); Garnero et al. 2014

⁷⁰ IPO (2016) 'Gender Profiles in UK Patenting. An Analysis of Female Inventorship.'

⁷¹ Van Reenen J. (2020) 'Innovation Policies to Boost Productivity. A policy proposal'. The Hamilton Project.

⁷² Bell A., Chetty R., Jaravel X., Petkova N. and Van Reenen J. (2017) 'Who Becomes an Inventor in America? The Importance of Exposure to Innovation'. NBER Working Paper No. 24062, December 2017. The Equality of Opportunity Project.

that, for example, less than 2% of school pupils in the UK take part in such an initiative each year.⁷³ We may also be missing opportunities to link invention schemes with initiatives that seek to help young people develop creative and entrepreneurial skills - all of which are important in creating future innovators. To support the ambitions of the Innovation Strategy, NESTA will explore how it could work together with BEIS to identify and test ways to improve and scale up the opportunities that young people have to develop innovation skills and mindsets from an early age.

⁷³ Gabriel M., Ollard J. and Wilkinson N. (2019) 'Opportunity Lost: How inventive potential is squandered and what to do about it'. Nesta

Pillar 3: Institutions & Places – We will ensure our research, development & innovation institutions serve the needs of businesses and places across the UK

The global R&D response to COVID-19 has shown the rich diversity of structures and approaches that comprise a successful innovation ecosystem.

The third key pillar of our Innovation Strategy will ensure our innovation system is structured, funded, and located in a way that delivers our science superpower and innovation vision. We will make it simpler for businesses to interact with public institutions like UKRI. We will review and take forward international best practice of R&D and innovation institutions. We are creating the UK Advanced Research and Invention Agency, adapting lessons from the US ARPA to fit the UK's research, development and innovation ecosystem. We will drive greater benefits from our R&D system to more places across the UK, including through Freeports, and by setting out our approach to maximising regional and local impacts of research and innovation.

The process of innovation is rarely a factory-like, linear, mechanical process. We must have a flexible and diverse approach to innovation policy, with a rich and complementary ecosystem of institutions, nurtured by government and valued by the private sector. The system is complex given the range of innovation-intensive businesses – from the large businesses pulling innovation through their supply chains to stimulate organic growth; high-growth start-ups and scale-ups; and those smaller businesses who are adapting and using innovation to remain competitive.

Research and innovation organisations and institutions provide expertise, funding, skilled personnel, facilities and coordination of innovation efforts. The private sector needs to know about and be able to engage with these organisations at the right point in their innovation journey to effectively utilise them. This will be key to the successful delivery of this Strategy and our objectives for economic growth.⁷⁴

The UK has a vibrant mix of innovation institutions, including our world-class universities; Catapults; National Academies; Public Sector Research Establishments such as the National Physics Laboratory and the Defence, Science and Technology Laboratory; the Royce, Turing and Crick institutes; and Harwell, amongst others, and including those in Scotland, Wales and Northern Ireland such as the Fraunhofer Centre for Applied Photonics at the University of Strathclyde in Glasgow, the Compound Semiconductor Applications Catapult in Newport, and the Precision Medicine Centre of Excellence at Queen's University Belfast. **Annex A** provides fuller detail on the UK's innovation institutions.

⁷⁴ BIS (2015) 'Research and Innovation Organisations in the UK'

Case Study: 3fBio – feeding the world with sustainable protein.

As the world's population increases and the demand for protein grows, sustainable protein production is needed. To address this demand, 3fBio, a University of Strathclyde spinout, developed ABUNDA mycoprotein - a fermented food ingredient, rich in protein and fibre and naturally fortified in B12, zinc and iron. 3fBio, trading by the name of 'ENOUGH' is based in Glasgow, Scotland. It was initially supported by the IBioIC (Industrial Biotechnology Innovation Centre) incubating scientists in its Scale Up Centre, alongside grant funding of £237,000 since 2016 for four collaborative projects with academics and IBioIC. The process is more resource efficient than both animal and plant farming.

The company has since secured Venture Capital Series A funding (£6 million) and SuperBIO grant (€60,000), indirect benefits from €17 million PLENITUDE Bio-Based Industries Joint Undertaking grant, and is constructing a pilot plant and lab facilities in Glasgow. Most recently, 'ENOUGH' has secured a further €42 million in Series B Venture Capital funding and it will be participating at COP26 in November 2021 to highlight how its zero waste protein could contribute to sustainable food production.

Source for 3fBio Case Study.⁷⁵

Navigating the system

While the UK's system of institutions is well established, businesses are not always aware of what support is available or most suitable for them. To ensure that businesses can innovate, embrace global opportunities and respond to emerging challenges in a coherent way, businesses need an easily navigated, agile and responsive innovation system that delivers the right support at the right time.

To drive innovation, we need to maximise on our research base potential, and nurture university-business interaction, including by supporting the mobility of skilled personnel between business and academia to facilitate knowledge sharing. The ability to navigate this system will be key. Academies, the Catapult Network, Research Councils (in particular the Engineering and Physical Sciences Research Council and Science and Technology Facilities Council), universities and local business groups are amongst those who have provided invaluable support to date. We will be considering how to simplify access to institutions for businesses and organisations not familiar with the institutional landscape.

We must improve the interaction between universities and business. Business-research partnerships play an important role in driving innovation activity at the local level and will be essential for levelling-up the UK's economy. Initiatives such as Konfer, a free online brokerage tool, make it quick and easy for businesses to connect to research and innovation opportunities at universities and research organisations, as does the leadership shown by the National

⁷⁵ European Biotechnology (2021) '€42 financing round for mycoprotein specialist'. Available from: <https://european-biotechnology.com/up-to-date/latest-news/news/eur42m-financing-round-for-mycoprotein-specialist.html>

Centre for Universities and Business. In Scotland, Interface brings businesses, particularly SMEs, together with universities or colleges.

UKRI, including Innovate UK, will develop a simpler way for businesses to understand and interact with the UKRI institutional structure. This will include developing tailored web content and guidance, and exploring development of a digital portal to provide a gateway to all relevant support across the ecosystem for innovative businesses. It will build on strong relationships between businesses and individual councils to streamline the institutional ecosystem, helping it work better for all businesses.

Reviewing our R&D and innovation organisational landscape

As noted above, the UK already has a wide range of first-class innovation organisations. But the world is changing fast, with competitive advantage in research, development and innovation increasingly contested. We have already learnt from some of the most historically transformative examples to diversify how we do R&D and innovation, allowing us to capture a richer range of breakthrough inventions. ARIA, for which we are currently legislating, is an example of this. It is modelled on the early ARPA but adapted to the UK context.

One size does not fit all, with different types of research and innovation being suited to different lab structures, funding agencies, and locations. We must continue to learn from the best in the world. The United States, for example, has a much larger network of national labs than the UK, as well as a series of Advanced Research Projects Agencies. Germany has organisations such as the Max Planck and Fraunhofer Societies which provide weight and coherence across a diverse mix of research, development and innovation activities, working closely with universities and industry.

We will therefore undertake an independent review, led by Nobel Laureate Professor Sir Paul Nurse, Director of the Francis Crick Institute, looking across the landscape of UK organisations undertaking all forms of research, development and innovation. This review will highlight the strengths to be nurtured and any comparative weaknesses to be tackled, and make recommendations for addressing them.

Case Study: Learning from the leading laboratories of the 20th Century

When looking at the origins of modern technology revolutions, we often find that a single laboratory was particularly central. Institutions like Bell Labs, the Cambridge Laboratory for Molecular Biology, and Xerox PARC became hubs for much wider networks, such as the Cambridge Life sciences park. They were often funded either via government money or via a tech monopoly, and generated trillions of pounds of value, demonstrating a market failure in the economics of innovation.

Despite very different topics and sizes, these laboratories had striking commonalities: they brought a critical mass to pursue a long-term vision; created cycles of discovery and invention; had very small teams in a flat hierarchy with a focus on the employment of professional scientists; and gave freedom to take risks through generous full internal funding and evaluation.

Today, the UK is home to a wide range of cutting-edge innovation institutions. Among many examples are: the University of Warwick National Automotive Innovation Centre which is driving the future of the automotive industry from the heart of the United Kingdom; Lincoln Agri-Robotics as the world's first global centre of excellence in agricultural robotics; and the Catapult network, which is designed to support innovation and de-risk the transition from research to commercial delivery in a range of key sectors.

The MRC Laboratory of Molecular Biology, located on the Cambridge Biomedical Campus



The MRC Laboratory of Molecular Biology (LMB) is a world-leading research institute, nicknamed 'The Nobel Prize factory'. Dedicated to understanding important biological processes at the molecular level, the LMB generates and uses knowledge to tackle major problems in human health and disease. LMB scientists pioneered DNA sequencing, structural biology including cryo-EM, and monoclonal antibodies.

Recently, LMB researchers developed the first cells with a synthetic genome that make artificial polymers from building blocks not found in nature, which holds immense potential for novel biology-inspired materials, from plastics to drugs. The LMB has a number of strategic partnerships with industry, such as the fundamental science 'Blue Sky' collaboration with AstraZeneca.

Bell Laboratory (Bell Labs) in New Jersey was the birthplace for many technological innovations in the 20th Century. Researchers who worked at Bell Labs are credited with multiple information technology and communications developments such as the first transistor (now a critical component in modern computers) and the silicon solar cell (the first step towards solar-power). The continuous record of accomplishments by Bell Labs, including nine Nobel Prizes awarded for work completed there, demonstrates how a successful core model can foster world-class innovation. Part of Bell Labs' success lies in its creation of a culture of collaboration and creativity, housing multidisciplinary thinkers under one roof. This has allowed Bell Labs not only to set the framework for new and lucrative consumer products, but establish entire new industries.

Case Study: The Janelia Research Campus

The Janelia Research Campus is the HHMI scientific research campus opened in 2006. Nobel Laureate Tom Cech, Gerry Rubin and other HHMI leaders believed there was a need to create a stronger collaborative environment across scientific disciplines to effectively pursue some of the most 'profound questions' in science and technology. For inspiration, they studied historical models including the Medical Research Council Laboratory of Molecular Biology and AT&T's Bell Labs. They are currently operating in the Mechanistic Cognitive Neuroscience and 4D Cellular Physiology research areas.

Appointed as the Executive Director of the Janelia Research Campus and HHMI Vice president in 2020, Ronald Vale, together with leading experts across multiple fields including Kristin Branson, Vivek Jayaraman and Luke Lavis, form the Senior Leadership of the Campus today. The extensive collaboration and interdisciplinary environment of the campus is aimed to bring together the incredibly diverse expertise of chemists, physicists, computer scientists and engineers 'to share their expertise and invent new technologies that will reshape biomedical research', breaking down barriers between discovery and invention. This approach has led to wide ranging public and private sector collaborations, including with Google Brain and DeepMind, and Janelia has produced leading neural recording probes and new forms of imaging technology including one which won the Nobel Prize.

Sources for Learning from the leading laboratories of the 20th century case study.⁷⁶ Sources for Janelia Research Campus case study.⁷⁷

⁷⁶ Nokia (2018) '2018 Nobel Prize in Physics laureate Arthur Ashkin delivers his Nobel Lecture at Nokia Bell Labs'. Available from: <https://www.nokia.com/about-us/news/releases/2018/12/18/2018-nobel-prize-in-physics-laureate-arthur-ashkin-delivers-his-nobel-lecture-at-nokia-bell-labs/>;

The UK Advanced Research and Invention Agency (ARIA)

In 1958, Sputnik caught the west by surprise. In response, the United States created the Advanced Research Projects Agency (ARPA) with a broad mission of preventing strategic surprise. ARPA had a radically different model to today's funders, empowering brilliant program managers to exercise their judgement in order to fund research that many would view as certain to fail.

ARPA helped deliver many of the fundamental technologies we rely on today, including the first internet, GPS, interactive computing, and stealth technology. More recently, it gave strong early pushes to autonomous vehicles, quantum computing, molecular biology, mRNA vaccines and antibody therapies. Many of these seemed far-fetched at the time of their birth.

We are creating the UK Advanced Research and Invention Agency (ARIA) to bring and adapt the ARPA model of R&D to the United Kingdom, empowering the world's most brilliant and innovative minds to find and solve some of our most pressing challenges, as well as find opportunities that the rest of the system is missing. ARIA will have strongly empowered programme managers able to exercise judgement and take risks on technologies unlikely to be pursued by existing agencies. It will form nationwide networks pursuing these challenges.

Case Study: The origins of personal computing and the internet at ARPA and DARPA's role in new technology for COVID-19

ARPA, now DARPA (Defense Advanced Research Project Agency), has a clear focus on achieving transformational change, with a lean structure, high risk tolerance, and inspiring leadership. ARPA played a vital role in the creation of ARPANET, a precursor for the Internet. As DARPA, it has also progressed the necessary advances that enabled the creation of today's computers and communication systems.

ARPA corrals a vibrant innovation ecosystem involving diverse collaborators across multiple sectors. While its effort mainly focused on military operations, the commercial sector was able to adopt and expand the agency's discoveries across multiple sectors including manufacturing, entertainment, education and health. DARPA recently played a key role in funding mRNA and antibody technology for tackling COVID-19.

Just as the creators of ARPA could not foresee its invention of interactive computing just a few years after its birth, we do not know what ARIA will create. That is the point.

Nokia Bell Labs 'History': <https://www.bell-labs.com/about/history/>

⁷⁷ Janelia Research Campus 'Models of Inspiration': <https://www.janelia.org/models-of-inspiration>; Janelia Research Campus 'History': <https://www.janelia.org/about-us/history>; HHMI 'Ron Vale Named Next Executive Director of Janelia Research Campus and HHMI Vice President': <https://www.hhmi.org/news/ron-vale-named-next-executive-director-of-janelia-research-campus-and-hhmi-vice-president>; HHMI 'Howard Hughes Medical Institute Breaks Ground For Janelia Farm Research Campus': <https://www.hhmi.org/news/howard-hughes-medical-institute-breaks-ground-janelia-farm-research-campus>

Sources for The origins of personal computing and the internet at ARPA and DARPA's role in new technology for COVID-19 case study.⁷⁸

Levelling Up and innovation across the UK

As well as reviewing the mix of institutions needed to deliver a step-change in UK innovation, it is vital that we think about where innovation happens. We need to embed innovation across the country, drawing on geographical and sector strengths in places and creating markets on a scale large enough to have a global impact. To do this, we need to ensure more places in the UK host world-leading and globally connected innovation clusters, creating more jobs, growth and productivity in those areas.

Vibrant business clusters attract investment and talented workers, and enable companies to grow. Strong and innovative supply chains influence the location and success of global corporations. This can all lead to further investment in the skills of local people, quality jobs, and opportunity. Working together in a local cluster or supply chain to innovate and do things differently can improve productivity and enrich local economies.

The UK's research and innovation system has remarkable strengths across the country. There are globally significant innovative firms and thriving clusters of dynamic small and medium-sized firms in all parts of the UK. However, we still have too few strong innovation clusters. Too many places are not yet fulfilling their innovation potential, missing out on the good jobs and growth that a thriving local innovation economy can bring, and not enough places are seeing the economic benefits of innovations developed elsewhere through the adoption of those innovations.

Addressing this challenge will be a central part of meeting the government's objectives for levelling up the UK economy: increasing research and innovation activity in more places, and supporting adoption and diffusion, would have a major positive impact on the UK's overall economic performance and would create jobs, growth and productivity gains across the country.

As we have sought to address this challenge, we have benefitted from extensive advice from the Place Advisory Group to help us understand how to ensure that research and innovation benefits the economy and society in nations, regions and local areas across the UK. This group agreed that any approaches to make the most of research and innovation in places need to focus on:

- Increasing economic growth by building R&D capacity through targeted investments in places with strong R&D potential;
- Increasing private investment, including from overseas, by supporting places to develop and promote effective research, development and innovation strategies;

⁷⁸ DARPA (2016) 'Innovation at DARPA': https://www.darpa.mil/attachments/DARPA_Innovation_2016.pdf; Usdin S. (2020) 'DARPA's gambles might have created the best hopes for stopping COVID-19': <https://www.biocentury.com/article/304691/darpa-s-gambles-might-have-created-the-best-hopes-for-stopping-covid-19>; DARPA 'About DARPA': <https://www.darpa.mil/about-us/timeline/modern-internet>; DARPA 'Paving the Way to the Modern Internet': <https://www.darpa.mil/about-us/about-darpa>

- Maximising the local societal and economic impacts of R&D by leveraging our world-class research and innovation to benefit communities across the UK;
- Taking a place-based approach by tailoring support to the research, development and innovation strengths of different places and developing policies in partnership with local government, businesses and research, development and innovation institutions; and
- Improving the evidence by strengthening our understanding of what works and making high quality data transparent and accessible.

The Place Advisory Group also advised that R&D interventions seeking to make the most of places' potential must be part of a wider strategy for that place, considering skills, infrastructure, business support and regeneration, tailored to each place's needs.

Making the most of R&D in places around the UK remains a key government priority. But we also recognise the importance of taking a joined-up approach to supporting places to realise their potential. We will bring together different departments and work closely with the devolved administrations to agree a more detailed strategy for R&D in places, as a key element of the wider Levelling Up white paper due in the autumn. This is an opportunity to ensure that we are taking a comprehensive place-based approach to economic growth, with R&D one of the vital measures we can take.

Taking a systemic approach: levelling up across government's Research and Innovation activity

To increase investment in the whole of the UK, we need both broader systemic and more targeted measures that can respond to the varying needs of different places across the UK. Our proposals, based on engagement with the Place Advisory Group and stakeholders across the UK, are outlined below. We will develop these further, in partnership with the devolved administrations, national and local government and local partners, as part of the forthcoming Levelling Up white paper.

At a systemic level, we have a target of increasing public and private sector R&D expenditure to 2.4% of GDP to support the UK being a science superpower with a world-class research and innovation system. As we move towards that target, we are reviewing how we can increase the proportion of total R&D investment, public and private, outside London, the South East, and East of England. The Levelling Up white paper will set out further details in the autumn, working closely with the devolved administrations.

We are also reviewing how policy can maximise the local societal and economic impacts of research and innovation investments and infrastructure, and foster greater collaboration between decision-makers at national, devolved and local levels.

Our proposed approach, which we will develop over the next few months, includes:

- reviewing how major R&D funding bodies' core organisational objectives might change to help deliver the UK government's levelling up ambitions as well as to fund excellence, starting with UKRI;

- reviewing how best to increase local engagement, and the regional presence, of major R&D funding bodies, and the influence that local, regional and national stakeholders have on UK-wide decision-making;
- reviewing ways in which we can deliver stronger levelling up outcomes from current and future research and innovation programmes;
- encouraging institutions such as PSREs, Catapults and universities and colleges to increase their local economic and societal impacts; and
- making levelling up a factor in investment decisions for new research and innovation infrastructure and facilities.

We will also improve the availability and quality of evidence on research and innovation ecosystems to inform decision-makers at all levels – from government Ministers to local councillors. This will include making high quality data accessible and strengthening our understanding of what works in place-based research and innovation interventions.

As a first step we will be publishing a new spatial R&D data tool. Co-developed by BEIS and NESTA, the tool provides indicators to compare the scale of sub-regional R&D systems in the UK, by measuring the factors needed for public R&D; private R&D; and business innovation from R&D collaborations. Anyone will be able to access the website, visualise and explore time trend data, and use this as a foundation for further analysis.

Case Study: The UK Innovation Districts Group – Belfast Innovation District

The UK Innovation Districts Group is a peer network of practitioners from across the country and different sectors. It is focused on shaping, stimulating and strengthening shared productivity and prosperity through place-based innovation. The Group aims to foster a unified voice for innovation districts into government, business and policy makers, and focuses on understanding and stimulating more inclusive innovation.

The Belfast Innovation District, led by Innovation City Belfast, is a flourishing world-class hub for research, innovation, and entrepreneurship. The District has been a key driver in establishing Belfast as the leading international investment location for US cyber and global fintech firms. Core to its success is a partnership led approach which includes Belfast City Council, Queen's University Belfast, Ulster University, Belfast Harbour, Catalyst, and Invest NI, supported by UKRI investments in the form of an Innovation & Knowledge Centre funded by EPSRC, Innovate UK and Invest NI. The Belfast Region City Deal digital and innovation investment of £350 million will further enhance the area through programmes, centres and initiatives – with the collective aim of inculcating digitally-enabled innovation to grow the regional knowledge economy to ten times its current size.

Titanic Belfast visitor centre and Harland & Wolff cranes located in the Belfast Innovation District



Targeted measures: levelling up Research and Innovation activity

Our evidence shows that we need to tailor R&D interventions to the needs of different places, a point echoed by the Place Advisory Group. Evidence and experience demonstrate that it is very difficult to create a world-leading innovation cluster from scratch. However, there is more we can do to build on existing strengths in places around the UK, attract new investment and put local partners at the heart of the innovation decision making process.

We will work with places to deliver local growth, tailoring our relationships to reflect differing levels of innovation maturity; high potential international R&D clusters of the future; areas with emerging R&D strengths; and those that currently have limited R&D capacity, but a lot to gain from greater adoption and diffusion of innovation developed in other parts of the UK.

We will work with local partners and the science, research and innovation sector to develop proposals for a new cross-government approach that enables places outside the Greater South East of England with demonstrable potential to become world-leading research and innovation clusters. We will work closely with devolved administrations, local governments, businesses and universities, and learn from good practice from across the UK.

We will also work with local places to develop proposals for a cross-government approach to supporting the adoption and diffusion of innovation amongst local businesses, in places with less developed Research and Innovation capacity.

It is also vital to enable places with emerging research and innovation strengths to deliver greater local economic benefits, linking this to local sector strengths as appropriate. We will develop proposals about how best to do this, learning from the success of the Strength in Places Fund (SIPF) which focuses on growing R&D capacity and capability across the public and private sector to strengthen innovation and support local growth. SIPF is the first major R&D fund to focus explicitly on place-based outcomes. It has pioneered bringing together consortia of research organisations, businesses and local leadership to target local strengths, and has demonstrated the valuable role R&D can play in levelling up.

Through the second wave of UKRI's SIPF **we are investing £127 million, backed by a further £110 million from private firms and research organisations, in 5 major projects that will develop R&D capacity and support local growth.** The projects span diverse

sectors, including manufacturing, agri-tech and the creative economy, and will deliver benefits to local economies across the UK. This brings total UK government investment in SIPF to over £300 million.

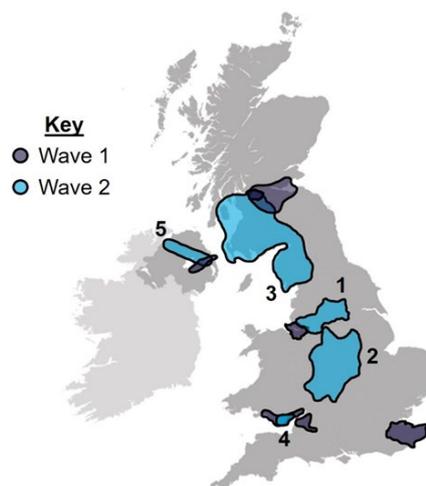
Overview of SIPF projects across Waves 1 and 2

Led by UKRI, Strength in Places Fund (SIPF) projects focus on a self-defined area anywhere in the UK, not limited by nations or regions. Government is investing over £300 million in 12 major projects in nations and regions across the UK, attracting an additional £340 million of investment from private firms and research organisations. In Wave 1, businesses and universities in Glasgow, Edinburgh, Belfast, Cardiff, Bristol, Liverpool and Kent are benefitting from project investments.

Wave 2 investments are being made:

- Across the North of England, £22.6 million to the Advanced Machinery & Productivity Initiative to drive innovation for the UK's advanced machinery manufacturers needed by emerging technologies. (1)
- Across the Midlands, £18.3 million to the Midlands Industrial Ceramics Group to improve manufacturing processes in advanced ceramics making them more energy-efficient, faster and cheaper. (2)
- In Scotland & Cumbria, £21.3 million to the Digital Dairy Value-Chain project will create a dairy industry that is more efficient and sustainable by combining digital communications and advanced manufacturing. (3)
- In Wales, £22.2 million to the media.cymru project to bring together UK broadcasters, small local businesses and freelancers to research and develop new products and services for global markets. (4)
- In Northern Ireland, £42.4 million to the Smart Nano NI project to speed up the development of new nano-scale optical components to power our future digital devices. (5)

Figure 6: Map of the seven UKRI Strength in Places



Wave 1 and five Wave 2 Fund projects across the UK

National programmes responding to local need

All UK regions have innovative firms that have increased their productivity by using R&D. However, these improvements vary by region and depend on the type of innovation and the type of firms in the region. We want to respond to this by collaborating with specific places and building national programmes that are better tailored to local needs.

We already have a varied and effective programme of work to support innovation activity across the country, including UKRI's SIPF, Innovate UK's regional engagement team, Innovate UK EDGE, the Catapult Network, the Knowledge Transfer Network and the £100 million Connecting Capability Fund (CCF), which is leading to a number of regional commercialisation initiatives.

We want to build on the success of CCF now and in the future. **This year we will be allocating an additional £25 million funding to extend some CCF projects.** This will help drive further economic growth through university-business innovation and continue the CCF's aims to share good practice and capacity internally across the higher education sector, and to forge external technological, industrial and regional partnerships.

Case Study: Environmental Satellite Data Deliver Multi-Million-Pound Boost for East Midlands

Over 130 firms have secured benefits worth millions of pounds thanks to University of Leicester environmental research, harnessing satellite data to tackle real-world challenges. The companies, also based in the region, have leveraged the University's Earth Observation Science group skill-set, underpinned by NERC long-term funding and support from other organisations.

The partnership helped Earthsense, for example, to produce unique high-resolution air pollution maps from country-scale right down to street corners and forecasts, helping local governments to address air pollution hotspots and providing air quality information for property sales.

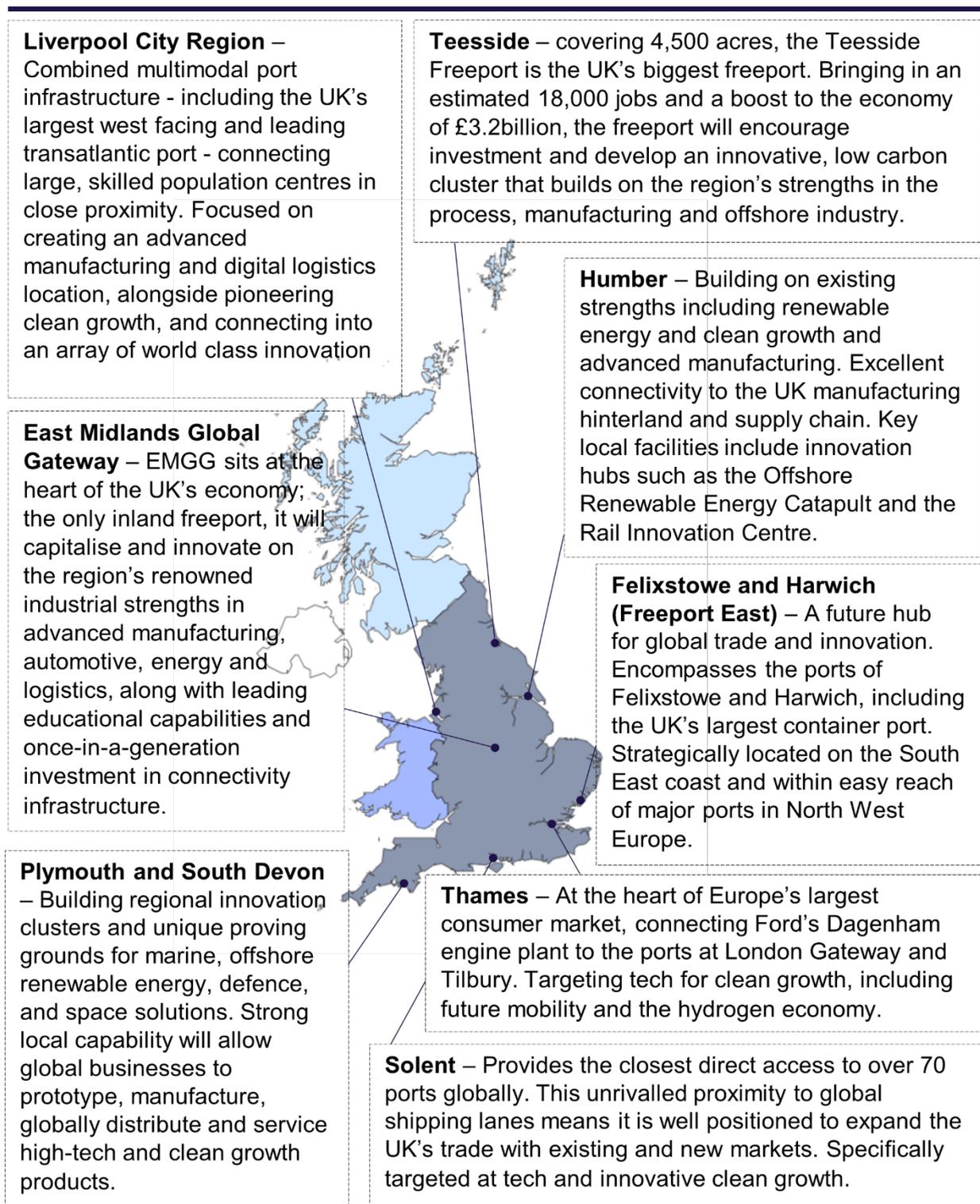
The success of these collaborations shaped East Midland's development plans, highlighting the potential of both space technology and research-business partnership as an engine for regional growth. The resulting £100 million investment in Space Park Leicester is aimed at creating a global hub, where industry and academia can collaboratively develop and exploit space-based technologies benefiting economy and society.

Freeports

Freeports will offer tax reliefs, simplified customs procedures and wider government support to create jobs and growth and regenerate communities. They will create national hubs for international trade, innovation and commerce – regenerating communities across the UK, attracting new businesses, and spreading jobs, investment and opportunity to towns and cities.

In the Budget 2021, we announced the development of eight Freeports across England. We remain committed to establishing at least one Freeport in each of Northern Ireland, Scotland, and Wales as soon as possible. The first Freeports are planned to open for business in late 2021 and will be able to access some UK government funding, subject to the successful completion of their business case. The innovation activity in Freeports will build on the government’s 2025 UK Border Strategy, published in December 2020, which set out a Technology and Innovation roadmap to drive forward innovation at the UK border.

Figure 7: What are the opportunities at each of the 8 English Freeports



The UK Shared Prosperity Fund (UKSPF) will support people and communities, opening up new opportunities and spurring regeneration and innovation. A portion of the UKSPF will target places most in need across the UK. The UK government will publish a UK-wide investment framework later this year for UKSPF and confirm its funding profile at the next Spending Review.

Attracting Foreign Direct Investment (FDI) to more areas of the UK

The Department for International Trade (DIT) undertakes R&D FDI promotion activities to ensure a coherent and effectively targeted approach to attracting key companies and investors. The second round of DIT's High Potential Opportunities Programme will showcase 24 new opportunities to overseas investors in emerging technologies and innovative sub-sectors, across the nations and regions of the UK. Working with businesses and investors on the ground, it helps innovative businesses to trade internationally, and drives investment into key sectors. The Office for Investment (OfI) was established to target mobile investments which support the objective of securing long-term strategic advantage for the UK, including in the priority technologies identified in this Strategy. DIT also supports the retention of mobile R&D investment in the UK through its Strategic Relationship Management programme and other activities, and will work closely with Innovate UK and others to do so.

We will develop a targeted, long-term, national approach complementing a more tailored, local approach. This will drive up FDI into innovation across the UK. OfI, DIT, BEIS, UKRI and other key departments will continue to support the development of strong R&D clusters across the UK, including by attracting high potential overseas spinouts and scale-ups to the UK, and presenting an attractive and coordinated offer of government support. We plan to:

- Help more places to develop effective investment strategies and an R&D prospectus, aligned to local and regional opportunities and national priorities.
- Promote regional excellence in R&D using major set-piece events to potential partners and investors.
- Improve our approach to identifying and promoting strategic UK R&D opportunities that would benefit from inward investment.
- Provide stronger support for places in the development of their local investment priorities by strengthening the collaboration between regional teams in the DIT, Innovate UK and UKRI; and, other national R&D bodies.

In parallel, we will be proactive in our approach to retaining high potential homegrown spinouts and scale-ups in the UK, including retaining investment in places where they can have a significant local economic benefit. We will undertake targeted engagement to better understand and tackle the specific issues faced by these businesses, which may lead them to consider relocation overseas. We will particularly target businesses that are likely to be critical to UK strategic advantage and long-term resilience in high priority technology areas.

Pillar 4: Missions & Technologies – We will stimulate innovation to tackle major challenges faced by the UK and the world and drive capability in key technologies.

Today, as in the past, particular areas of innovation merit emphasis from government. This can be for different reasons. Sometimes, a specific technology promises radical changes in a broad range of capabilities, such as the revolutionary impact of computing in the mid-20th Century. Other times, a challenge is so pressing that we must engage in highly focused missions – driven by government in partnership with innovators across the economy – such as rapidly developing, procuring, and manufacturing a vaccine for COVID-19. The UK was a pioneer of this approach, using the Longitude Act of 1714 to inspire and incentivise innovators to invent a practical and reliable method for determining longitude to aid navigation at sea.

We want to build on this pioneering, problem-solving spirit, bringing government together with innovators across the economy. This Pillar sets out how the UK government will take a leading role, directing innovation through a suite of Innovation Missions focused on some of this government's foremost policy priorities. Separately, it also identifies the key technology 'families' where the UK can develop strategic advantage, and which promise transformational benefits for our economy and society.

- *Innovation Missions* will bring the public and private sector together to respond directly to pressing national, and global, challenges.
- *Innovation in technology* will make fundamental contributions to these missions and will shape our lives, the economy and society in the decades ahead. The pandemic has taught us that we can and should be more strategic about emerging technologies, including backing potentially transformative technologies at an early stage.

Innovation Missions and technologies are separate but complementary. Missions are about a clear and measurable outcome, such as vaccinating the UK against COVID-19, for which we need to draw on multiple technologies and research disciplines, work with different industries and supply chains and tackle innovation, manufacturing, and logistical challenges. Technologies, such as AI or genomics, will be vital for tackling these challenges but we may not know from the outset precisely how they will help. Both complement each other, technologies can help tackle some of the biggest challenges confronting our nation; and missions, in turn, will help bring profile and significance to technological innovation, as well as supporting diffusion of new technologies.

Our approach to supporting these missions and technologies will require us to be agile and responsive. Just as in response to the pandemic, we will move quickly to seize opportunities as they arise, investing at risk in portfolios of projects. Our funding programmes will be less bureaucratic and quicker to provide support to innovators who come to us with great ideas. As well as spending programmes, we will use a wide range of other levers to drive progress, including regulation and public procurement.

This Pillar sets out several of the key issues that will confront the UK and how we will address them through a set of new goals. It then develops the Integrated Review's call for a "more

active approach” to building advantage through science and technology, describing the technology families in which the UK has an industrial and R&D edge, and how we can embed and develop best practice to promote these technologies, helping to meet our mission goals.

Directing innovation towards our top priority societal missions

The pandemic has highlighted the challenge faced by governments globally in responding to an array of systemic problems that threaten the wellbeing, prosperity and security of people, communities, and businesses. Issues like the climate and biodiversity crises, demographic change, and pandemics pose complex, interconnected challenges. Innovation Missions translate these challenges into tangible problems, and mobilise the energies, insight and resources of government, industry, civil society, and academia behind a shared endeavour to tackle them.

Case Study: Nissan undertakes a globally significant 230-mile automated drive to Sunderland

The UK market for connected and self-driving vehicles could be worth £41.7 billion by 2035, making journeys greener, safer, easier, and more productive. Since 2015, the government’s Centre for Connected and Autonomous Vehicles has helped establish a world class automated vehicle ecosystem in the UK, investing around £400 million in partnership with industry to support 90 cutting-edge projects made up of over 200 organisations.

In November 2019, the £13.5 million, Nissan-led HumanDrive project completed its fully automated 230-mile Grand Drive from the Nissan European Technical Centre in the Midlands to the Nissan plant in Sunderland.

The project explored how new technologies can make automated vehicle systems feel more human-like, including novel Hitachi-led workstream on the use of machine learning to improve user experience. This partnership with government validated Nissan’s 2017 decision to base its European self-driving testing in the UK and enhanced the UK’s global reputation as a leader in these technologies.

By specifying a ‘mission’, UK government can bring urgency and pace to addressing real-world problems. This generates public value while simultaneously driving transformative spill-over benefits for industry and the wider economy by strengthening the innovation cycle from research through to commercialisation and adoption. The outstanding success of the UK’s vaccines programme is a model example of how government leadership in marshalling industry, academia, and others behind a clear and urgent mission, can deliver real progress against the thorniest of problems, while opening the way for future innovation and growth.

We will establish a new Innovation Missions Programme to tackle some of the most significant issues confronting the UK in the coming years. The programme will build on the successes of the Vaccine Taskforce mission and historic UK leadership in mission-driven innovation. It will set out a suite of bold new goals responsive to our current priorities, behind which we will rally and focus the talents of the UK's world-leading innovation community to enhance prosperity and security for people, communities, and businesses across the country. The Innovation Missions Programme will support our Global Britain ambition, complementing wider efforts to drive new trade, investment, and scientific partnerships, and helping to harness the transformative power of UK-backed science and innovation to tackle shared challenges.

Case Study: Digital Pathology and Imaging AI Centres of Excellence

The Digital Pathology & Imaging AI Centre of Excellence Programme is a pioneering example of how a strong collaboration between the industry and NHS can drive innovation and support the transformation of patient care.

Supported by £50 million of Industrial Strategy Challenge Funding, and £33 million industry investment, the Centres – based in London, Leeds, Oxford, Coventry and Glasgow – are curating data from hundreds of thousands of diagnostic images a year to make new AI systems for analysis of medical imaging. Since their launch, the Government has invested further £50 million alongside £17 million industry investment to scale-up the work of the centres in Leeds, London and Coventry. This additional funding will help to further modernise diagnostic services, strengthen the Centres' partnerships with the NHS, support research to improve diagnosis and deliver precision treatments. Together, the centres are boosting our diagnostic capabilities, improving outcomes for millions of patients, and freeing up NHS staff time.

The Prime Minister has recently set out some of the key challenges facing the UK.⁷⁹ They include, the need to urgently accelerate the solutions that will help us tackle climate change and wider environmental challenges set out in our Ten Point Plan for a Green Industrial Revolution. They include how, in the wake of COVID-19, we will build on the UK's capabilities in medicine and the life sciences to tackle public health challenges such as dementia or using new gene therapies to cure diseases that have to date been incurable. They include how we will leverage technology to grip new threats and opportunities in cyber, space and AI, and a range of other issues fundamental to the future health, wellbeing, prosperity and security of people, the economy, and our environment – in the UK and globally.

⁷⁹ Prime Minister's Office (2021) 'We're restoring Britain's place as a scientific superpower'. Available from: <https://www.gov.uk/government/speeches/prime-ministers-article-in-the-daily-telegraph-21-june-2021>

Case Study: 'ReFLEX Orkney' creating a virtual Energy System

'ReFLEX (Responsive Flexibility) Orkney is a £28.5 million project led by European Marine Energy Centre, project that is advancing the creation of an integrated, affordable, low-carbon energy system for the future.

Working with partners across business, academia and government, the project was funded through the Industrial Strategy Challenge Fund to create an integrated energy system interlinking local electricity, transport and heat networks into one controllable, overarching system, digitally connecting distributed and variable renewable generation to flexible demand. Aiming to demonstrate flexibility using technologies such as battery storage, electric vehicles and smart meters, once proven in Orkney this model can be replicated across the UK and internationally providing long-term export opportunity and contributing to the creation of a more flexible and renewable-based energy systems across the globe.

Source of 'ReFLEX Orkney' case study.⁸⁰

Our approach to Missions

A suite of bold, specific, measurable, and timed innovation missions will be at the heart of our approach; bringing UK brilliance in science and innovation to tackle some of the toughest problems core to these priorities.

Innovation Missions will galvanise innovators across diverse UK sectors and disciplines, combining the insight, expertise, energies and resources of government, industry, civil society, and academia. They will consolidate and harness our strengths across UK high growth sectors and develop and leverage UK capabilities in transformative technologies set out below. But they should also invite broad participation from across the diverse range of UK sectors, and draw on insights generated by our world leading expertise in the sciences and technical disciplines, arts, and humanities.

We will employ a diverse range of funding and policy instruments to support our mission objectives and to make the most of the wider economic benefits missions offer. This will include, for instance, competitive research and innovation 'Challenge' funding that builds on the lessons of the Industrial Strategy Challenge Fund, to incentivise broad and diverse participation across UK sectors and disciplines and ensure an agile approach in gripping new challenges and opportunities.

To complement challenge funding, missions will leverage the full machinery of government. Supported by a strong team, they will coordinate policy across areas such as skills, regulation, and procurement to provide a whole-system approach to delivering on our goals and for gripping the full range of benefits on offer. They will draw on the lessons learned from the Vaccines Taskforce including, for instance, making the most of government's convening power, embedding flexibility and tolerance for risk, and championing empowered, accountable, expert mission leadership.

⁸⁰ ReFLEX Orkney 'What is ReFLEX?'. Available: <https://www.reflexorkney.co.uk/about-reflex>

Missions will also help boost the standing of the UK and UK businesses on the world stage. The biggest challenges are often global in nature, requiring international collaboration to really make a difference. Missions offer a compelling platform for deepening international scientific and commercial collaboration to benefit peoples' lives around the world and for strengthening our standing as a science superpower. We will strive to work with our partners to accelerate progress on missions – and related shared commitments on EU Horizon missions and the UN Sustainable Development Goals – for benefitting the national and global good, create new international trade and investment opportunities and drive prosperity at home and overseas.

Following publication of this Strategy, we will identify a suite of ambitious and inspiring missions determined by the new National Science and Technology Council. These will be specific and time-bound, they will deliver on UK government priorities set out in 'Build Back Better: our plan for growth' and 'The Integrated Review of Security, Defence, Development and Foreign Policy', take advantage of our existing or potential competitive advantage, and generate a wealth of societal and economic benefits.

Strategic technologies: Supporting transformational deep tech in the UK

Technological innovation can drive not just incremental but exponential change. Emerging technologies will be essential to addressing our Missions and will shape the future of our economy and society. The Integrated Review highlighted the importance of technology for our security, empowering UK government to “take a more active approach to building and sustaining strategic advantage through Science and Technology”. This section sets out how government can work with industry to deliver this 'more active approach' to driving technological innovation.

In the post-war period, two major technological revolutions transformed our world, and continue to do so. These were:

- The development and deployment of ubiquitous computing technology
- The birth of molecular biology

The roots of these technologies stretch back centuries, but the circumstances that allowed for their innovation and dramatic acceleration came together in the post-war period. Their most transformational effects are likely still to come. Their impact has been global, but their economic benefit is still strongly tied to where they flourished, in Silicon Valley and our own Cambridge. This demonstrates the importance of making bold early moves.

So, as well as setting Missions to tackle big, complex societal challenges, we must back the emerging technologies that can make fundamental contributions to those missions and will shape our lives in the decades ahead. Getting this right requires parallel efforts. Firstly, it requires the cultivation of an ecosystem where R&D excellence is paired with a willingness to take risks. Secondly, it requires prioritising our finite capacity on specific innovations that emerge from that system and acting swiftly and decisively to back them. In the language of the Integrated Review we must take judicious decisions on whether to 'own', 'collaborate on' or 'access' the technologies that are vital to our security and prosperity.

To help deliver this agenda we have identified seven technology families where the UK has globally competitive R&D and industrial strength.⁸¹ There is considerable diversity and complexity within these families. In some cases, like that of AI, the potential of these technologies is already being realised. In others, like quantum, the transformative potential of many of its applications may not be felt until the 2030s. Just as backing molecular biology in the post-war period placed us at the centre of modern medicine, prioritising within these families and making the right interventions now can ensure that UK researchers, innovators, and firms transform the world.

The purpose of these technology families is to focus domestic and international attention on the potential of UK tech. Domestically, facilitating collaboration between industry, researchers and government will strengthen the broader technological ecosystem, not least as government is a crucial customer for transformative technology. The families are intended to complement not supersede the ongoing efforts to promote such collaboration, for example through the AI Council or the Robotics Growth Partnership. Internationally we should not hesitate to remind the world that the UK is a technological powerhouse that offers enormous value to collaborators and investors. The UAE sovereign wealth fund's recent investment in UK life sciences is testament to this.

The families provide a starting point for prioritisation. Attempting to lead in every technology within each family will likely prevent us attaining a world-leading edge in any one area. We will need to prioritise investments at a granular level, considering factors like UK comparative advantage, transformative potential, and security and societal need. Learning from the success of vaccine development we must be decisive in backing these priorities and be agile in reviewing those we back where circumstances change. The new National Science and Technology Council, chaired by the Prime Minister, will steer this crucial prioritisation process.

The seven technology families of UK strength and opportunity:

- Advanced Materials and Manufacturing
- AI, Digital and Advanced Computing
- Bioinformatics and Genomics
- Engineering Biology
- Electronics, Photonics and Quantum
- Energy and Environment Technologies
- Robotics and Smart Machines

⁸¹ The families are derived from an analytical synthesis drawing on work from BEIS, UK Research and Innovation including Innovate UK, and the Intellectual Property Office. The methodology considered UK R&D strength, industrial capacity, and global opportunity. Further details will be published in the forthcoming analytical publication. The technology family concept owes a debt to the Eight Great Technologies, which have had an enduring influence since their launch in 2012/13.

The seven technology families of UK strength and opportunity

Advanced Materials & Manufacturing

We need materials that can survive in the harshest conditions, allowing us to dig at the bottom of the ocean and to transport the fuels of tomorrow. Learning to manufacture these materials at scale and incorporating safety and sustainability into their design and innovation, is as important as their discovery and development. This effort is essential to unlocking innovation across all major industrial sectors.

This is a truly revolutionary time in advanced materials development. Materials are being manipulated at an atomic level to elicit new properties and vastly improved performance. The UK has a world leading advanced materials science base. The 2010 Nobel prize was awarded to scientists at the University of Manchester for advances in Graphene, an ultra-thin, ultra-strong material.

Opportunities are many and include:

- **Metamaterials:** Artificially structured composite materials with unique, tuneable electromagnetic properties. World-leading UK research in this field will transform the communications industry by enabling compact, lightweight 5G antennas that are easier to manufacture, ship and install.
- **2D materials,** which can be only a single layer of atoms thick can contribute to more efficient batteries for electric vehicles, strengthen traditional materials, and have novel electrical, optoelectrical and superconducting applications.
- **Self-healing and animate materials:** systems that change shape or structure over time, self-repairing in response to degradation, for example self-healing roads that fix their own potholes.
- **Composite structures** that create stronger, more lightweight, and more durable structures and the coating technologies that enhance materials with properties like corrosion resistance.

Manufacturing these advanced materials at scale requires new technologies and processes. The UK industry is at the forefront of developing these as it evolves from supplying distinct materials such as metals, polymers, and ceramics, to supplying finished components and systems for medical, energy, and aerospace sectors. Collaboration between academics and industry have been crucial to this, including at the Advanced Manufacturing Research Centre in Sheffield, Warwick Manufacturing Group in the Midlands and the Royce Institute in Manchester. The process of 'additive manufacturing' is an example of one such new process, which involves manufacturing bespoke structures and products that can be adapted to their environment over time using 3D and 4D printing. The UK should show global leadership in safe and sustainable design across the full materials life cycle. This innovation will drive growth in the UK's advanced manufacturing sector creating high quality jobs throughout the UK.

AI, Digital & Advanced Computing

AI, Digital, and Advanced Computing are the software and data driven technologies used across next generation products and services. Combined, they have transformative potential. They include the AI and machine learning that optimises the data economy, the blockchain solutions that builds trust in digital services, and the cyber security innovations that keep systems secure and safe. High-performance computing enables the vast data analysis and manipulation that these technologies perform and applications like digital twinning open new frontiers in data-driven decision-making and problem solving.

Artificial Intelligence is a general-purpose technology that is already having a transformative effect. Wherever traditional computing executes instructions in code AI can 'think for itself', adapting and operating autonomously. Everyday uses of AI are on the rise, including in mobile phones' speech and facial recognition and in banks' automated fraud detection. AI is increasingly used in more complex tasks, such as medical diagnosis, drug discovery, and predictive maintenance. It has even been used to create new art and music. Despite these leaps, we are only in the early days of AI deployment.

The UK has a global lead in AI due to its strengths in frontier computer science exemplified by the Turing Institute. Remaining among the global leaders will not be easy, with Germany and France making investments that compare to, or exceed, the UK's 2017 AI Sector Deal, and the US and China making enormous investments. To maintain the UK's position of leadership we are developing a forward-looking National AI Strategy, led by the Office for AI, to set the UK up for the next ten years of progress in AI.

Augmented and Virtual Reality (AR and VR) technologies are used extensively across the UK's creative industries sector. VR is the UK's fastest-growing entertainment and media sector, growing 34% annually to reach £1.2 billion by 2022. The UK is currently Europe's largest market for VR and AR, supported by over 1,000 immersive specialist companies. AR and VR's potential goes beyond entertainment. Rolls Royce and McLaren use VR in their design processes and researchers have studied VR's potential for use in the rehabilitation of conditions like Multiple Sclerosis.

As our dependence on technologies, digital services and networks grow, **cyber security** ensures resilience to cyber threats. The UK is a leader in cyber security with Cambridge-founded Darktrace amongst the most innovative cyber defence company globally. UK government's Digital Security by Design Challenge funds solutions to cyber security problems from industry and academia, like 'CHERI', a cutting-edge microprocessor technology developed by Cambridge University, applied to ARM's processors, and endorsed by Microsoft's Security Response Center.

Developing UK **High Performance Computing** power is crucial in unlocking innovation across the families' other technologies. We need to stay at the forefront as the frontier moves from petascale to exascale systems and shifts beyond digital to new paradigms like quantum computing.

Source for 'AI, Digital & Advanced Computing'.⁸²

CMAC programme manager Dr Andrea Johnston interacts with a digital twin.



Credit: UKRI

⁸² PWC (2018) 'Global Entertainment & Media (E&M) Outlook 2018-2022'. Available from: <https://www.pwc.co.uk/press-room/press-releases/UK-entertainment-and-media-sector-to-grow-by-8bn-over-the-next-four-years-PwC-forecasts.html>; Innovate UK (2018) 'The Immersive Economy in the UK'; University of Cambridge Trust and Technology Initiative 'Digital Security by Design: Toward compute systems that are more trustworthy'. Available from: <https://www.trusttech.cam.ac.uk/perspectives/foundations-trustworthy-design/digital-security-design-toward-computer-systems-are-more>

Bioinformatics & Genomics

UK science was pivotal to an historic achievement of the 20th century: learning to read the genetic code. Unlocking the potential of this discovery in the 21st century will address global challenges such as improving human health, caring for our environment, and sustainably feeding global populations.

Genomics is the study of an organism's DNA. The UK has a world-class genomics capability that was recently deployed in the COVID-19 response. Most genomes are many millions of times more complex than a virus however. To understand the secrets of DNA a suite of 'omics' technologies characterise the dynamic relationships between the genes, proteins and metabolites that are the basic building blocks of all life. This large-scale genomics is combined with sophisticated **bioinformatics**, which uses computer programming and software tools to understand large and complex biological data sets, deriving in-depth information about the genomes of a wide variety of species.

Examples of the potential of bioinformatics and genomics include:

- Game changing vaccines and treatments for cancer that could be available on the NHS by the early 2030s.
- New varieties of crops bred to incorporate natural innovations from wild species, which will increase yields, reduce environmental impact, and have greater resilience to pathogens and climatic variation.
- The vast 'dark matter' of microbial genomes contains a potential treasure trove of new antibiotics that will allow us to keep pace with the serious threat of antimicrobial resistance in our hospitals.
- Novel enzymes and bioprocessing techniques will be harnessed to recycle our waste and drive a more sustainable circular economy.
- Tracking the emergence and spread of pathogens with resistance to existing treatments and targeting interventions to contain outbreaks by matching treatments to specific variants.

The UK is recognised as the third largest bio cluster in the world. Our genomics sector accounts for 10% of the global market, and our life-sciences sector contributes £14.5 billion per annum to UK GDP. The broader bioeconomy is currently worth £220 billion GVA and contributes over 5 million UK jobs.

Capitalising on the next phase of the genomics revolution will lead to a wide range of new products and services. It will also enrich our society through knowledge of the basic blueprint that links humans and all other life on the planet.

Source for 'Bioinformatics & Genomics'.⁸³

⁸³ PWC (2017) 'The economic contribution of the UK life sciences industry'; HMG (2018) 'Growing the Bioeconomy'

Engineering Biology

This century is one of biology. In the past few years alone, we have produced a completely new range of biological tools that have allowed us to develop new types of vaccines and engage in precise genome editing.

Engineering biology exploits the recent convergence of physical sciences and engineering with biology. This has led to the application of engineering technologies and principles to the design and fabrication of biological components and systems, enabling innovations like plastic-free packaging, improved silk fibres for sports clothing, and life-saving therapies.

As well as enabling cheaper and greener products, engineering biology can dramatically transform the manufacturing processes that underpin existing industries. This will help lessen our dependence on fossil fuels and simplify global supply chains, shifting us from an oil-based economy towards a bio-based economy. Where fossil-derived fuels or plastics are required, biomanufacturing will deliver biobased and waste-derived alternatives in 80% of the cases by 2035.

The UK is a world-leader in engineering biology following government investment. The UK has made many of the critical discoveries and developments of the modern age including DNA, genetic engineering, cloning, and monoclonal antibodies. Advances in the coming decades are likely to come from exploiting new tools, such as CRISPR and mRNA platforms, software for biology, and microfluidics. These will create a new 'bioeconomy' that moves beyond the current focus on the therapeutics ecosystem. The potential economic benefits are significant, with estimates that biological applications could unlock an estimated \$2-4 trillion in annual direct global economic impact by 2030 to 2040.

With the development of powerful new technologies however, comes the need to ensure that they are used responsibly. Ensuring the UK remains at the forefront of their development will help shape their ethical frameworks. Continued investment alongside the creation of an appropriate regulatory framework will harness the potential of engineering biology to create jobs and growth and tackle societal challenges.

Source for 'Engineering Biology'.⁸⁴

⁸⁴ McKinsey Global Institute (2020) 'The Bio Revolution'

Electronics, Photonics & Quantum

Electronics, photonics, and quantum technologies are the hardware and embedded software that allow products and processes to sense, communicate, have power, have intelligence, and be controlled or automated.

Electronics hardware enables everything we do digitally. The UK is a leader in *power electronics* that allow us to connect and construct systems. Without it we could not connect renewable energy systems to our existing grid or shift between electric and petrol sources in our hybrid vehicles. *Microelectronic chips* are used in every digital device. The UK is already a leader in the design of semiconductors, and with sufficient support it has the potential to become a leading designer and manufacturer of compound semiconductor chips and technologies. This would allow the UK to capitalise on increased global demand for semiconductor chips and support domestic production in critical sectors like health, telecoms and automotive. By the mid-2030s UK companies – including those based at established clusters in Wales, Bristol and Cambridge – could play an increasingly central role in a supply chain of acute geopolitical importance.

Photonics manipulates light to create new devices and systems that more efficiently sense or transmit information, amongst other emerging applications. Sensing and photonics will unlock new innovations in medical diagnostics, autonomous vehicles, and navigation systems. The UK is a global leader in photonics, exporting over 30% of Europe's photonics supplies and contributing £14.5 billion to the UK economy in 2020.

Applying *quantum* science will achieve a technological paradigm shift across a range of applications. This includes more accurate sensing for non-invasive brain imaging; new communications techniques to secure the transmission of data; and more precise timekeeping for the financial markets. Quantum enables exponentially more powerful computers that can address previously intractable problems, for example accelerating drug development by predicting which drugs will be effective against diseases. Quantum computing poses an existential challenge to existing cryptographic systems and work is ongoing to ensure the UK can deploy quantum safe cryptography.

Public and private investment in the UK's National Quantum Technologies Programme (NQTP) is due to pass £1 billion by 2024, ensuring the UK stay in the vanguard of these crucial technologies. The efforts of industry and the NQTP could see the UK could have one of the world's first general purpose quantum computers by the 2030s.

Sources for 'Electronics, Photonics & Quantum'.⁸⁵

⁸⁵ Innovate UK (2019) 'Electech Roadmap'; Photonics Leadership Group (2021) 'Photonics grows to a £14.5 billion UK industry'. Available from: <https://photonicsuk.org/photonics-grows-to-a-14-5-billion-uk-industry>

Energy & Environment Technologies

Energy and Environment Technologies will be critical to achieving net zero and protecting our natural environment. These technologies can unlock:

- Cleaner ways to produce, store, and distribute energy;
- Sustainable ways to manage and optimise our resource consumption;
- Solutions to enhance our land and restore biodiversity; and,
- Large scale solutions to capture, store, and make use of greenhouse gases alongside negative emission technologies.

Realising these technologies is a global challenge, to which the UK can make fundamental contributions and drive progress through international collaboration. The UK is home to some of the world's leading scientists and engineers who are tackling these challenges, building on the UK's history of technological development in this field. The lithium-ion battery, which is enabling the transition to electric propulsion across the automotive sector, was discovered in the UK in the 1980s. More recently the most efficient solar cells in the world, based on advanced perovskite technology, were discovered in Oxford and are being commercialised by Oxford Photovoltaics.

In the last decade, low carbon energy generation, particularly in the form of wind and solar, has seen spectacular reductions in cost and improvements in efficiency. The latest turbines can power a house for 24 hours with a single turn of their blades. UK synthetic biologists are developing purpose grown energy crops as part of a bioenergy strategy, and marine energy technologies could be a lucrative export market for the UK. Hydrogen represents a clean source of fuel useful in contexts that are less compatible with electrification. We are pioneering hydrogen heating trials, starting with a Hydrogen Neighbourhood and scaling up to a potential Hydrogen Town before the end of this decade. The UK already generates more electricity from offshore wind than any other country and is well placed to lead the world through a green industrial revolution. Alongside technological innovation our international offer includes expertise in planning, regulation and finance, which can enable a 'just and inclusive' energy transition through collaboration with our international partners.

Energy storage and management solutions are also key. Long-duration storage technologies will accommodate increasing electricity demand in the context of more variable supply from renewables. Demand reduction technologies are needed to reduce UK energy demand by 40% by 2050 through applied data science that drives behaviour change and regulation. Geoengineering and carbon negative technologies will also enable the cooling of the environment and the removal of greenhouse gases from the air.

The UK is a leader in advanced modular reactors and fusion energy technologies that are expected to complement renewable sources in the future. Scientists at the UK Atomic Energy Authority (UKAEA) recently made a world-first breakthrough in exhaust technology that cools 'tokamak' fusion reactors. UK companies Tokamak Energy and First Light Fusion are at the forefront of commercialising innovative fusion reactor technologies. The UK's expertise is recognised around the world: the Canadian fusion company General Fusion recently announced it would build its fusion demonstration plant in the UK.

Robotics & Smart Machines

The use of robotics is no longer confined to specific uses in factory environments. In the near future we will see increasingly autonomous, reconfigurable and scalable smart machines, which will be able to operate safely alongside people and as part of complex interconnected systems.

Robots and smart machines have wide-ranging applications across many sectors of our economy helping to automate dangerous or repetitive tasks and contribute to economic productivity and growth. This includes applications in transport (self-driving cars and unmanned aerial vehicles), nuclear decommissioning (including robot submarines and aerial drones that map radiation), infrastructure maintenance (such as inspecting and repairing hard-to-reach infrastructure like off-shore wind turbines and narrow underground pipes), agriculture (including autonomously weeding crop fields), healthcare (for example, disinfecting robots and minimally invasive surgery) and automated warehouse logistics.

The UK leads the world in developing many of these applications. Research in the UK and in collaboration with institutions internationally is accelerating the development of these robotic capabilities and reducing costs. The UK has existing strengths in many of the capabilities underpinning robotics and smart machines, including AI, sensing technologies and haptics (touch), design engineering, and system integration. We have a strong reputation for industry-led innovation, design, and implementation. Emerging fields such as modularity and reconfigurability, autonomy, human-machine interfaces and the use of soft robotics are also increasingly seeing breakthroughs.

Overall, the total UK market for Robotics & Autonomous Systems (RAS) is forecast to grow at a compound annual growth rate of more than 40% per annum between 2020 and 2030, reaching an estimated market size of almost £3.5 billion by 2030. Based on current adoption trends, the total economic impact of RAS uptake across all selected sectors is estimated to be £6.4 billion by 2035, but there is significant headroom to do better than this if we increase our current adoption rate. Our challenge is to build on and focus the UK's technical and entrepreneurial strengths into the areas with greatest societal and economic opportunity, to boost productivity, supply chain resilience, worker safety and resource efficiency.

Source for 'Energy & Environment Technologies'.⁸⁶ Source for 'Robotics & Smart Machines'.⁸⁷

The greatest benefits will often be at the intersection of these technology families. 'Cyber-physical infrastructure' will enable this interoperability, weaving together AI, connected smart machines, data, digital twins, and other technologies. For example: agricultural machines managed by AI will nurture crops using orbital sensors that allow real-time environment analysis, resulting in sustainable and affordable food. Supporting technologies at their interfaces will accelerate innovation and multiply the potential of any individual technology.

⁸⁶ GE Renewable Energy (2020) Statement about Haliade-X 13 MW; BEIS and Prime Minister's Office (2020) 'Ten Point Plan for a Green Industrial Revolution'; UK FIRES (2019) 'Absolute Zero Report'

⁸⁷ BEIS (2021 – forthcoming) 'The Economic Impact of RAS across UK sectors'

Government's role in enabling these technologies

The case for government to promote innovation in deep and transformative technology is strong.⁸⁸ Prospective investors and customers of deep tech may be unwilling to take chances on new and unproven technology or may not fully understand its potential. The journey of tech-based innovation to market can be long, complex, and often non-linear. The UK excels at certain stages of this process but is weaker at others. For instance, a start-up or spin-out is created by a UK university roughly every two hours.⁸⁹ These spinouts have developed into AI pioneers and biopharmaceutical innovators, but as these companies grow they often have to look abroad for the investment required to scale. Foreign investment in UK companies is a welcome vote of confidence, but weaknesses in the UK scale-up ecosystem could be preventing our R&D intensive companies reaching 'national champion' scale.

We should pursue these signals of weakness and address the underlying issues. Vaccine development and the ventilator challenge has shown the power government has to procure technological solutions by convening participants and helping to manage the risks associated with industry activity. The UK government can build on that model, identifying barriers to innovation that are felt acutely in deep and transformative tech, and articulating how government can empower industry to overcome them. Managing risks – or so-called 'de-risking' – does not mean creating a zero-risk environment. Without risk there is no innovation, but in some cases governments are better placed to bear some of the risks of technological innovation, such as in the early stages of the development of the internet or space technologies like GPS.

We will manage the risks associated with:

- *building research and innovation capability.*

Deep tech development requires access to specific skills and knowledge that are rare and sought after. Tech innovators often need access to expensive and specialist equipment to develop their products, such as supercomputing capacity or science infrastructure. The UK Government can better facilitate industry's access to these resources.

- *incubation and development of technological innovation.*

By comparison to software, hardware and biologically-based innovations have a prolonged and expensive process of development, including prototyping, testing and verification. Novel technologies present challenges to regulators. We must ensure that innovators are not stymied but enabled by a responsive regulatory environment and robust ethics regimes.

- *investment in deep and transformative tech.*

⁸⁸ Historically HMG has taken this more active role in promoting technology in the field of security. See for example the Tech Families highlighted in the Defence Technology Framework (MOD, 2019). The Integrated Review invites us to expand this approach beyond the core security and defence realm.

⁸⁹ HESA 'Intellectual property, start-ups and spin-offs'. Available from: <https://www.hesa.ac.uk/data-and-analysis/business-community/ip-and-startups>

The UK ranks third in the world for deep tech investment and has the highest rate of growth globally.⁹⁰ However, there are clear signals that the UK finance environment has more potential to support UK deep tech firms, especially where they specialise in less well-known technologies or wish to raise larger investment rounds. Between 2018 and 2020 UK R&D-intensive companies received investment equal to 0.17% of GDP, substantially lower than US R&D-intensive companies which received investment equal to 0.32% of GDP.⁹¹

- *adoption and industrialisation of deep and transformative tech.*

Deep and transformative tech products are novel by definition. Potential customers may be unaware of what they can achieve and be averse to the risk of adopting something new. Consequently, deep tech innovators must build their own industries and markets alongside their products. This can manifest in a struggle to embed themselves in domestic supply chains, which can lead to offshoring of production and missed opportunities for fostering new advanced manufacturing industries in the UK.

To address these barriers, we will:

- *Convene* business and academia to solve problems through technology. **UK Government will launch eight new Prosperity Partnerships.** These will establish business-led research projects to develop transformational new technologies, such as the development of the world's first AI system to control airspace. The Engineering and Physical Sciences Research Council (EPSRC) has initiated new projects with £59 million of industry, university and government investment.⁹²
- *Invest* alongside business to manage the risks associated with the development of deep technologies in the UK. Including projects such as:
 - **Hartree National Centre for Digital Innovation in the Northwest of England, where UKRI and IBM have co-invested £210 million to stimulate high performance computing enabled innovation in industry.**
 - **The National Quantum Computing Centre in Harwell near Oxford; where £93 million has been committed to scale emerging quantum computing technologies in the UK.**
 - **The Clean Maritime Demonstration Competition, which will invest £20 million to support innovators in zero emission shipping to bring new solutions to market.**
- *Prioritise*, realising the potential of the seven technology families requires fostering and sustaining the ecosystem from which technologies emerge, and prioritising among those that emerge to generate strategic advantage. We will use the tech families to guide prioritisation and assess what technology-specific interventions are needed to meet our

⁹⁰ Tech Nation (2021) 'Tech Nation Report'

⁹¹ British Business Bank (2021) 'Small Business Equity Tracker 2021'

⁹² This takes the overall investment in Prosperity Partnerships to £335m since 2017 of which £167m has been leveraged from the businesses involved.

ambitions. The forthcoming Spending Review is an important moment to agree some of those priorities.

- **Establish a new National Science and Technology Council chaired by the Prime Minister** and supported by a new Office for Science and Technology. It will provide strategic direction on the use of science and technology as the tools to tackle great societal challenges, level up across the country and boost the UK's place in the world. The Prime Minister is tasking the whole of UK government, working with the new Council, to take the success of the UK's approach to vaccines and apply it to other priorities, setting bold visions, acting with speed, and taking risks. This will bring high rewards and benefits to the UK, including in developing technology to reach net zero, curing cancer and not only treating it, and keeping our citizens safe at home and abroad.

A number of proposals set out in this strategy and Build Back Better: our plan for growth also address these barriers and enable risk management, including:

- *Skills*: Internationally the UK will attract and retain global talent through its visa system, and enable business and academia to partner abroad to undertake R&D and share talent, for example through the work of the Science and Innovation Network (SIN).
- Domestically, initiatives like the Turing AI Fellowships show the value of promoting specific deep tech skills in the workforce. To inform this effort, Innovate UK are investing in their ability to identify skills required by the innovation economy.
- *Regulation*: The pro-innovation principles of the Regulatory Horizons Council and the Regulators' Pioneer Fund, and the flexible approach to standards in emerging sectors taken by the British Standards Institution (BSI), make the domestic and global regulatory landscape more suited to deep tech innovations.
- *Finance*: To make the public funding landscape more easily navigable Innovate UK will develop an online Innovation Hub to complement the British Business Bank's Finance Hub. This will allow easier access to the range of public funding interventions designed to support technology companies from Innovation Loans and British Patient Capital to the new Future Fund: Breakthrough, which is focussed on the later funding rounds of R&D intensive companies.
- To unlock investment, we are consulting on reform of regulations that deter certain pension schemes from investing in a broader range of assets, including UK technology firms. The Lord Hill-chaired UK Listings Review will strengthen the UK's position as a global financial centre, including by focusing on deep tech firms' needs.
- UK Finance will collaborate with Innovate UK and the British Business Bank to improve lenders' and investors' understanding of innovative businesses through training.
- *Procurement*: UK Government can use its procurement power to drive innovation by acting as 'venture customer' for UK deep tech. This will help demonstrate market applications to potential customers and investors. The Office for AI have issued

guidance on how to procure AI in government that could be replicated for other emerging technologies.⁹³

- *Trade*: UK trade policy can open new global markets for UK technology firms, the UK is breaking new ground by seeking to promote emerging technologies through trade agreements. Trade promotion activity such as that led by the Digital Trade Network can help companies make the most of global markets.

We will enable international collaboration and give industry and academia more confidence to commit to long-term international innovation collaborations. We will achieve this by forging new global collaborations, and by supporting engagement in multilateral organisations R&D frameworks, including Eureka and the World Trade Organisation (WTO). We will use the Integrated Review's 'Own-Collaborate-Access' framework to guide our approach: prioritising international partnerships that support UK objectives without undermining UK security interests. We will build on best practice such as the UK-US Statement of Intent to Cooperate in AI R&D,⁹⁴ which was the first international MoU on AI R&D cooperation for both countries, brokered by the Science & Innovation Network (SIN).⁹⁵ This year the UK's Foreign, Commonwealth and Development Office will focus £251 million of R&D investment on global challenges like climate change and biosecurity.

Specific interventions will be needed for different technologies at different stages of development, some of which will be addressed by these forthcoming strategies and guidance:

- AI strategy – to be published in the autumn, will set out how we will grow our AI ecosystem in the UK, including helping businesses and the public sector to responsibly adopt AI.
- Space Strategy – will detail the role the burgeoning UK space sector plays in using, and driving the development of emerging technology.
- Semiconductors - have become an area of intense geopolitical interest. We will evaluate the nature of the support the government already gives the sector to support UK capabilities.
- Cyber-physical infrastructure – UK government will launch a consultation on options for a future national capability in 'cyber-physical infrastructure'. This will promote interoperability of technological tools and platforms.
- Robotics Growth Partnership – to set out its vision for Robotics and Smart Machines, and the supporting cyber-physical infrastructure that will help realise this, by the end of the year.

⁹³ Office for AI (2020) 'Guidelines for AI Procurement'

⁹⁴ DCMS, OAI, BEIS (2020) 'Declaration of the US and UK on Cooperation in AI R&D'. Available from: <https://www.gov.uk/government/publications/declaration-of-the-united-states-of-america-and-the-united-kingdom-of-great-britain-and-northern-ireland-on-cooperation-in-ai-research-and-development>

⁹⁵ See also the New Atlantic Charter's commitment for the US and UK to strengthen ties in science and technology, available from: https://www.gov.uk/government/publications/new-atlantic-charter-and-joint-statement-agreed-by-the-pm-and-president-biden?utm_medium=email&utm_campaign=govuk-notifications&utm_source=dd7765e8-50e2-4796-a5d9-d6371a954ea2&utm_content=immediately

What does good look like?

There are many successful examples of industry, researchers, and government collaborating to enable technological development. We can learn from and embed this best practice.

UK government can convene industry and academia to co-design, develop and drive the adoption of transformative tech. Initiatives like Innovation and Knowledge Centres connect ground-breaking research with potential users in industry. Networks like the Hydrogen Economy Innovation Network improve understanding of what emerging technologies can do.⁹⁶ Programmes like the Made Smarter Innovation Challenge – a £300 million partnership between government, industry, catapults and academia - accelerate advanced digital manufacturing innovation in the UK, such as Artificial Intelligence, Robotics, 3D printing, through a national network of research, innovation hubs and collaborative programmes.

Test beds, sandboxes, and living labs are invaluable in making deep tech innovations market ready. The £200 million Connected and Automated Mobility (CAM) Test bed provides a successful precedent for providing life-like and real-world environments in which innovation can be tested safely.⁹⁷

Demonstrators and pilot lines help deep tech firms industrialise their products by giving innovators access to infrastructure they could not afford alone. Incubators and accelerators similarly provide access to expertise and investment that helps technological advances become products.⁹⁸ Building on the recent Catapult Review,⁹⁹ and complementing security initiatives such as co-creation spaces,¹⁰⁰ the UK government can repeat the success of initiatives like the Cell and Gene Therapies Manufacturing Centre.

⁹⁶ EPSRC 'Innovation and Knowledge Centres':

<https://epsrc.ukri.org/innovation/business/opportunities/impactschemes/ikcs/>; KTN 'Innovation Networks': <https://epsrc.ukri.org/innovation/business/opportunities/impactschemes/ikcs/>

⁹⁷ Funded by the UK government's Centre for Connected and Autonomous Vehicles and delivered by Zenic, CAM Testbed UK consists of six facilities that brings together automotive, infrastructure, testing, academic and local government organisations. It provides a comprehensive set of capabilities for developing new transport technologies from concept to commercialisation, across virtual, controlled, and public testing environments.

⁹⁸ BEIS (2019) 'The Impact of Business Accelerators and Incubators in the UK'

⁹⁹ BEIS (2021) 'Catapult Network Review 2021: how the UK's Catapults can strengthen research and development capacity'

¹⁰⁰ See work of the National Security Technology and Innovation Exchange (NSTIx) detailed in [Defence and Security Industrial Strategy HMG \(2021\)](#)

Case Study: Electronics, Photonics & Quantum: South Wales Semiconductor Cluster Sets Sights on Global Role

Launched in 2015, CSconnected is the world's first compound semiconductor (CS) cluster bringing together leading university researchers, high-tech companies and future-focused businesses, and linking to diverse sectors including healthcare, digital communications and energy.

To date, the cluster contributes a GVA of £172 million per annum to the regional economy from half-a-billion pound turnover, and supports around 2,100 full time equivalent jobs.

A range of organisations have helped unlock industry innovation by bridging the gap between academia and industry and addressing skills and training needs. The success of this ground-breaking initiative has been built through sustained, long term investment and partnership between EPSRC and UKRI, the Compound Semiconductor Applications Catapult, the Welsh Government, the Higher Education Funding Council for Wales and the Cardiff City Regional Deal.

Case Study: Bioinformatics & Genomics: Government investment unlocking growth in Cell and Gene Therapies

Far-sighted investment from Government in the emerging field of cell and gene therapies has seen the UK become host to the largest cluster of cell and gene therapies companies outside the US.

HMG recognised that the capital investment required to develop therapies was inhibiting innovation and growth in the sector. A £70 million investment from government led to the opening of the Cell and Gene Therapy Catapult Manufacturing Centre in Stevenage in 2012 offering a unique operating model and innovative processes to allow companies to grow with reduced infrastructure investment risk. Since then, companies based at the Centre and Stevenage Bioscience Catalyst, have raised over £1 billion in investment, part of a UK-wide £2.5 billion investment received by UK cell and gene therapy companies since 2012.

By 2035 the UK is predicted to command a 15% share of the market in advanced therapy medicinal products. Placing the UK in the vanguard of developing the emerging technology has not only created jobs and growth in the UK, but it means that UK companies will lead the world in overcoming some of the greatest medical problems of our age.

Case Study: Energy and Environment Technologies: Government de-risking and empowering fusion innovation

Fusion energy has the potential to transform the global energy mix, helping nations sustain net zero in the decades ahead. To realise the scientific and economic potential of fusion energy, the UK's Fusion programme has two primary goals:

- Develop a prototype fusion power plant in the UK by 2040 to demonstrate the commercial viability of fusion.
- Establish a world-leading UK fusion industry which can export fusion technology around the world in subsequent decades.

Central to these goals is the UK's STEP (Spherical Tokamak for Energy Production) programme, which aims to harness the UK's existing leadership in fusion R&D and build – by 2040 – a collaboration with industry, driving investment and innovation in the supply chain to enable UK businesses to commercialise this transformative clean energy technology.

In just the last five years around £500 million of new public investment has been committed to support fusion facilities, infrastructure and globally unique R&D programmes. This programme of funding aims to de-risk the commercialisation of fusion energy by boosting the capability of the private sector and signalling to the market that fusion innovation is a credible investment.

Source for 'Bioinformatics & Genomics'¹⁰¹ and for 'Electronics, Photonics & Quantum' case studies.¹⁰²

¹⁰¹ CGT Catapult (2020) 'Annual Review 2020'

¹⁰² CS Connected (2021) 'New report highlights resilience of Compound Semiconductor Cluster': Available from:

Part 4: Achieving our ambitions – implementation and next steps

Achieving our vision will require co-ordinated activity between the private and public sector over many years. We need to understand what this step-change will look like, be able to monitor progress and have clear understanding of success. This chapter sets out some of the key steps we will take to achieve our objectives and build on this Strategy.

As outlined in Part 2, we will be leveraging quantitative analysis and qualitative intelligence to monitor progress throughout the implementation of this Strategy.

Following publication of the R&D Roadmap in July 2020, we created the Innovation Expert Group (IEG) to provide advice to government. The Group has been instrumental in shaping our innovation policy and developing this Innovation Strategy. As we move into the implementation phase, to make sure we hear the voice of business loud and clear **we will establish a new Business Innovation Forum**. The Forum will galvanise action towards our objectives from the business community, support implementation of the Strategy, and hold government to account on the actions contained within the Strategy. Dr Hayaatun Sillem has agreed to act as chair of the Forum. We are very grateful to members of the IEG who have supported the development of the Innovation Strategy over the last year.

We will also draw on the expertise and networks of departmental Chief Scientific Advisers (CSAs) to ensure a joined-up approach to our Innovation Missions programme, investment in key technologies, and broader innovation commitments, and to strengthen the interface between government, industry and universities.

As this Strategy has highlighted, science and technology have never been more important to the success of the UK, our economy, the wellbeing of our people, and the security of our nation. This is why the Integrated Review recommended establishing “new S&T horizon-scanning, assessment and policy capabilities within government, to anticipate and assess priorities as we pursue strategic advantage”. In response, **UK Government has established a new Office for Science and Technology Strategy**.

The Office for Science and Technology Strategy will support the National Science and Technology Council and the National Technology Adviser to drive forward Whitehall’s science and technology priorities from the centre. This will put science and technology at the heart of policy and public services. The Office will also identify the science and technology capability required in the UK and in the government to deliver the Prime Minister’s global science superpower ambitions.

The Office for Science and Technology Strategy will work with BEIS as the leading funder of R&D, alongside other government departments, who will continue to maintain their respective R&D responsibilities.

The government’s future innovation work programme

This Strategy is broad and cross-economy in its focus: it does not detail all the measures that will be taken to promote innovation in the coming years. Building on this Strategy, we will bring forward further actions to realise our vision and deliver the UK government’s plan for growth.

‘Build Back Better: our plan for growth’ set out that, in addition to the Innovation Strategy, the UK government will come forward with visions for sectors and sub-sectors with high-growth potential, where we are well-placed to capture and develop a meaningful share of the global market and be genuinely world leading. We are prioritising high-growth sectors that demonstrate, for example:

- current competitive advantage
- future growth potential
- support for our strategic objectives of Net Zero, Global Britain and Levelling Up
- where government action can help overcome barriers such as market/coordination failures

In addition to Sector Visions, we will continue to work with and support innovation in specific sectors, including to help them recover from the pandemic.

In the coming months, the UK government will bring forward a range of further work to make progress towards achieving our vision for innovation.

<p>In the next three months...</p>	<ul style="list-style-type: none"> • The National Space Strategy will outline the UK government’s vision for the space sector and the core benefits we intend to secure from space for the UK’s economy, security, research and public services over the next decade. • The joint Action Plan on Standards for the Fourth Industrial Revolution will champion an agile approach to standardisation to respond to fast-paced technological change and foster synergies between standardisations, policy making and strategic research work that are needed to underpin innovation across sectors.
<p>In the next six months...</p>	<ul style="list-style-type: none"> • We will publish a comprehensive Net Zero Strategy ahead of COP26, setting out the UK government’s vision for transitioning to a net zero economy. This will raise ambition as we outline our path to meet net zero by 2050, our Carbon Budgets and Nationally Determined Contribution. • We will publish a Levelling Up white paper later this year, articulating how bold new policy interventions will improve opportunity and boost livelihoods across the country as we recover from the pandemic. • We will publish a bold new Export Strategy. The strategy help will ensure our domestic policies create the best possible business

	<p>environment for exporters, easing trade and championing regulatory reform.</p> <ul style="list-style-type: none"> • We will publish a National AI Strategy in the Autumn, coordinated by the Office for AI. Following on from the nearly £1 billion partnership between government, industry and academia, the National AI Strategy will set out how we intend to build on our early lead in Artificial Intelligence while also supporting businesses and the public sector to responsibly adopt AI. • We will publish a Digital Strategy later this year, setting out a detailed vision for harnessing new appetite for digital transformation, accelerating growth, and building a more inclusive, competitive and innovative digital economy for the future.
<p>In the next twelve months...</p>	<ul style="list-style-type: none"> • We will publish the Food Strategy white paper in the next twelve months which will support the development of a food system that is sustainable, resilient and affordable, that will support people to live healthy lives, and that will protect animal health and welfare. It will cover the entire food chain from field to fork, building on work already underway in the Agriculture Act, the Fisheries Act, the Environmental Bill and the Childhood Obesity plan. • We will publish Sector Visions in the coming months. In developing these visions, we will consider the role of government in supporting high-growth sectors that have the potential to build a globally competitive advantage, as well as how these sectors can also support wider government objectives, for example levelling up or enabling our transition to net-zero. • We will publish a National Cyber Strategy which will build on the Integrated Review, emphasising the UK’s strength in cyber as an opportunity for ensuring long term prosperity and security. It will include measures to foster growth and innovation in the UK’s cyber security sector, develop more secure digital infrastructure, ensure security is built into the future technologies that will transform our economy and society, and protect cutting edge research and IP in the sectors critical to our strategic advantage.

Source for Sector Visions in footnote:¹⁰³

¹⁰³ UK Parliament (2021) ‘Plan for Growth Sector Visions’. Available from: <https://hansard.parliament.uk/commons/2021-06-22/debates/B2F0BDA4-5199-4737-8AFA-851709CE14CF/PlanForGrowthSectorVisions>

Our full list of actions:

Pillar 1: Unleashing business

Finance

- Increase annual public investment in R&D to a record £22 billion.
- Devise training to upskill the next generation of lenders, supporting them in their ability to assess risk when lending to innovative businesses.
- Government will engage closely with pension funds and the investment industry to understand the scope for industry-led initiatives that take advantage of innovation investment opportunities.
- Establish £10 million innovation seed fund to provide early-stage patient capital for high-potential businesses.
- Reduce complexity for innovative companies by developing an online finance and innovation hub between Innovate UK and the British Business Bank within the next 12 months.

Infrastructure

- Provide a £50 million package for innovation infrastructure projects.
- Launch a consultation on the potential value of and options for a national capability in 'cyber-physical infrastructure'.

World-class regulation

- Consult on how regulation can ensure that the UK is well-placed to extract the best value from innovation.
- Commission the Regulatory Horizons Council to consider how best to support innovation through regulation, including looking whether there are a set of high-level guiding principles for regulation that may apply broadly to any sector of innovation.
- Extend the reach of the 'Agile Nations' network to make it easier for businesses to introduce and scale innovations across international markets.
- Publish a joint Action Plan on Standards for the Fourth Industrial Revolution and publish the UK Measurement Strategy that will provide the measurement infrastructure that the UK needs to innovate.

Pro-innovation competition regime

- Consult on reforms to ensure that the competition framework is effective for an innovative modern economy and on setting up a new, pro-competition regime for digital markets
- Publish the National AI Strategy to support businesses and the public sector to responsibly adopt AI.

Safeguarding intellectual property

- Expand IP education programme for researchers and launch International IP Services to bolster innovative companies' and researchers' ability to confidently collaborate, export and invest overseas.
- Consult on the protection of inventions and creations made by AI with minimal human input.

International trade

- Develop innovation chapters in Free Trade Agreements and work across government to develop an innovation to export pathway.

Public procurement

- Ensure government procurement is proactive and supportive, providing a route to market for innovative new products and services.

Getting technologies to market

- Establish a UKRI-wide Commercialisation Funding Framework to simplify support, minimise bureaucracy and embed best practice so the best ideas can be commercialised.
- Innovate UK will continue to strengthen its provision of support for commercialisation capability.
- Launch Help To Grow: Digital to support 100,000 small businesses to adopt digital technologies that will save them time and money, helping them recover from the pandemic.
- Expand Innovate UK EDGE, working alongside Growth Hubs in England, and programmes delivered by Scottish Enterprise, Invest Northern Ireland, and the Welsh Government to accelerate growth in the UK's most innovative businesses.

Driving adoption

- Allocate £8 million announced in February 2021 to continue Made Smarter Adoption in the North West of England and to begin scaling-up support in the West Midlands, North East of England and Yorkshire & the Humber for the adoption of advanced industrial digital technology amongst manufacturing SMEs.
- Innovate UK will include the adoption and diffusion of cutting-edge innovation in its objectives.

Public sector innovation

- Set up the Government Office for Technology Transfer to support public sector organisations in identifying wider uses for their innovations.

Pillar 2: People

- Launch the second project of the Emerging Skills Programme to explore further how the Skills Value Chain could be adopted by the innovation ecosystem.
- The Gatsby Foundation will support centres of innovation to work with industry and training providers to expand industry's capacity to forecast its emerging skills needs.
- UKRI, through Innovate UK, will develop a leadership role in identifying critical innovation emerging skills gaps and will be recognised as an authoritative voice on future skills implications for businesses.
- Design a pilot to help researchers acquire skills and knowledge beyond their own discipline, as set out in the R&D People and Culture Strategy.
- Provide support for flexible, cross-sector training programmes to encourage more movement and collaboration between academia, industry and the third sector.
- Help to Grow: Management will support 30,000 senior managers of small and medium sized businesses to boost their business's performance, resilience, and long-term growth.
- Introduce new High Potential Individual and Scale-up visa routes, and revitalise the Innovator route to attract and retain high-skilled, globally mobile innovation talent.

Pillar 3: Institutions & Places

- Develop a simpler way for businesses to understand and interact with the UKRI institutional structure.
- Undertake an independent review, led by Nobel Laureate Professor Sir Paul Nurse, Director of the Francis Crick Institute, looking across the landscape of UK organisations undertaking all forms of research, development and innovation.
- Create the UK Advanced Research and Invention Agency (ARIA) to bring the ARPA model of R&D to the United Kingdom.
- Allocate £127 million through the Strength in Places Fund to 5 projects that will develop R&D capacity and support local growth across the UK.
- Invest a further £25 million of funding through the Connecting Capability Fund to help drive further economic growth through university-business innovation.
- Undertake R&D FDI promotion activities to ensure a coherent and effectively targeted approach to attracting key companies and investors.

Pillar 4: Missions & Technologies

- Establish a new Innovation Missions programme to tackle some of the most significant issues confronting the UK in the coming years.
- Identify the key seven technology families that will transform our economy in the future.

- Launch eight new Prosperity Partnerships to establish business-led research projects to develop transformational new technologies, with £59 million of industry, university and government investment.
- UKRI and IBM co-investment of £210 million to stimulate high performance computing enabled innovation in industry.
- Invest £93 million in the National Quantum Computing Centre in Harwell near Oxford to scale emerging quantum computing technologies in the UK.
- Establish a new National Science and Technology Council, chaired by the Prime Minister, and supported by a new Office for Science and Technology.

Implementation

- Form a new Business Innovation Forum to drive Implementation of this Strategy.

Annexes

Annex A: Innovation Institutions

Universities and research organisations

The UK has a priceless asset in the strength of its research base, which is consistently ranked as world-leading in a wide range of areas. We have four of the top 10 global universities and 18 in the top 100.¹⁰⁴ With less than one per cent of the world's population, the UK accounts for 4 per cent of researchers, 7 per cent of the world's academic publications, and 14 per cent of the world's most highly-cited academic publications.¹⁰⁵ We also have strength in our research organisations which include independent and non-profit organisations as well as Research Council Institutes.

Funding Bodies

There are both UK Government and public sector bodies in England, Scotland, Wales and Northern Ireland that provide funding for innovation in the UK through a range of mechanisms. The key funding bodies include:

UK Research and Innovation (UKRI) brings together the seven research councils, **Research England** and **Innovate UK**, to direct research and innovation funding. UKRI plays an important role in convening, catalysing, incentivising, and investing in research and innovation, supporting the wider science base and bridging the gap between research and innovation in the UK. In 2021-22 UKRI was allocated £7.9 billion to support research and innovation. Much of this research will be critical to supporting real-world innovations in the coming years. While all the UKRI councils work with researchers and businesses, **Innovate UK**, holds a unique position within UKRI; as a business-facing agency it reaches across all sectors to support business-led innovation. It deploys a wide range of levers to boost innovation, including grants, loans, advice, and training programmes to support businesses of all sizes. It also manages other key innovation focused institutions such as Catapults and Agri-Tech centres.

The **Advanced Research and Invention Agency (ARIA)** will be a new agency that will support high-risk, high pay-off research. ARIA will exclusively focus on projects with potential to produce transformative technological change, or a paradigm-shift in an area of science. This new and important part of the funding landscape will complement the work of UKRI and other funders to support research that will lead to the world-changing breakthroughs of the future.

The **British Business Bank** works to ensure that financial markets work effectively for UK firms who want to grow. They do so by providing finance through a wide range of delivery partners such as banks, venture capital funds and leasing businesses. Because financial

¹⁰⁴ QS (2020) 'World University Rankings'. Available from: <https://www.topuniversities.com/university-rankings/world-university-rankings/2020>

¹⁰⁵ BEIS (2019) 'International comparison of the UK research base, 2019'. Available from: <https://www.gov.uk/government/publications/international-comparison-of-the-uk-research-base-2019>; Elsevier (2017)

markets often do not work well for innovative businesses, as set out below, the British Business Bank plays a particularly important role in supporting these firms.

The **National Institute for Health Research (NIHR)** funds and supports translational, clinical and applied health research spanning the whole innovation pathway across multiple programmes. Its investment in research infrastructure enables collaboration with the life sciences sector to support the development of new innovations and technologies, enabling commercialisation and helping to establish and grow new companies across the UK. NIHR also funds the Invention for Innovation (i4i) Programme that supports development of innovative medical technologies by managing the risks of early-stage projects that have a strong potential for commercialisation and acceptance for use in the NHS.

The **Higher Education Funding Council for Wales (HEFCW)** provides university research programmes with the underpinning resources to enable it to compete for external research funding through quality-related research funding (QR). In 2019/20, HEFCW allocated £76 million to Welsh Universities. HEFCW also provides support for innovation and engagement activities through the **Research Wales Innovation Fund (RWIF)** designed to both incentivise and reward performance at Welsh institutions. Associated three-year strategies set out ambitious targets relating to commercialisation and income generation; business growth; skills support; and civic mission and public engagement. For business support services, **Business Wales** provides access to Welsh Government, and non-governmental funded business support programmes. The **Development Bank of Wales** provides business finance for companies in Wales.

The **Scottish Funding Council**, a Scottish Government body, provides funding for universities and colleges, including research. In addition, the **Scottish National Investment Bank**, wholly owned by Scottish Ministers on behalf of the people of Scotland, is a mission-led development investment bank for Scotland. Scotland has three economic development agencies. **Scottish Enterprise** provides Scotland-wide services and works in partnership with its two sister regional agencies: **Highlands and Islands Enterprise**, which focuses on the north and west of Scotland, and **South of Scotland Enterprise**, which assists companies in the south.

The Northern Ireland **Department for the Economy** is responsible with the UK Government for developing an innovative, sustainable and inclusive economy through investment in skills, higher and further education, economic infrastructure, research and innovation, and business development. **Invest Northern Ireland** is the region's economic development agency, responsible for promoting trade and investment opportunities. Their services help potential and existing investors flourish and connect trading partners with their suppliers.

Through the UK aid portfolio, the UK also finances innovation around the world to reduce poverty, stimulate growth, create opportunities for UK business and build trading partners of the future.

CDC Group, the UK's Development Finance Institution, invests in private sector firms in developing countries, bringing much needed capital and expertise, supporting innovation through local venture capital markets and providing a direct route to private sector growth.

CDC builds new markets and supports economic transformation. For example, in 2018 CDC invested \$100m of seed financing as the sole investor in the Ayana platform to develop renewable power solar and wind generation projects across India. This has now grown to provide 1.14GW of solar generation capacity in hard to reach areas of India.

Public Sector Research Establishments

Public Sector Research Establishments (PSREs) are world-class organisations. They are mission-driven public bodies that provide critical research capabilities, services, infrastructure and expertise.

The focus of many PSREs is development of new technologies working in collaboration with business to provide science services. Their wide geographical distribution means they often form the basis of innovation clusters across the country bringing significant benefit to their local economy, environment and community and an important role in fostering skills through apprenticeships and graduate roles. The UK government will develop and bring forward plans to build on our world-leading PSRE network.

Based on the Government Office for Science definition for PSREs,¹⁰⁶ there are around 50 PSREs across the UK, including those sponsored by the devolved administrations. They include:

- Defence Science and Technology Laboratory
- HSC Innovations
- Joint Nature Conservation Committee (JNCC)
- The Met Office
- National Engineering Laboratory
- National Nuclear Laboratory
- National Physical Laboratory
- Natural Resources Wales (Cyfoeth Naturiol Cymru)
- Scottish Health Innovations
- UK Atomic Energy Authority

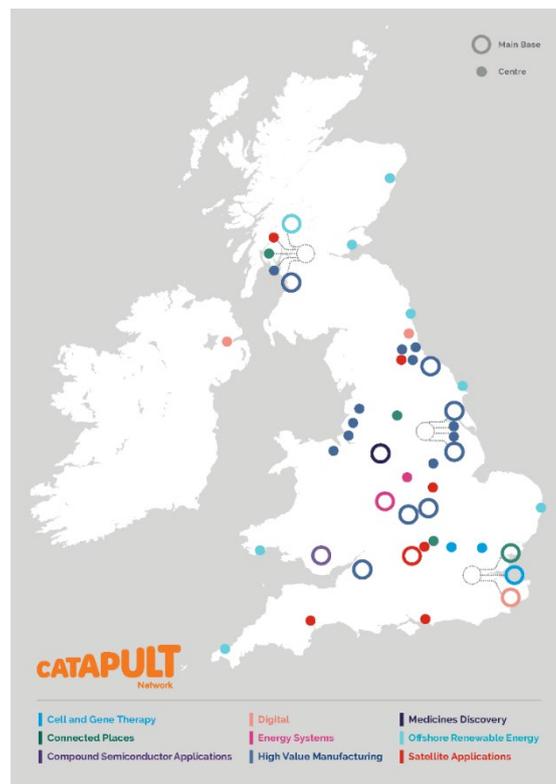
Catapults and Innovation Centres

Catapults bridge the gap between innovative businesses and the research communities, taking an active role in removing industry-wide barriers to innovation and commercialisation. They manage innovation risks through the provision of R&D infrastructure, specialist knowledge and expertise, partnership and collaboration building capabilities, and business support. There are nine Catapults with centres covering more than 40 locations across the UK.

¹⁰⁶ PSREs are public bodies carrying out research that supports a wide range of government objectives, including informing policy making, statutory and regulatory functions and providing a national strategic resource in key areas of scientific

The UK government's review of the Catapult Network was published in April 2021. It acknowledged the significant value that Catapults are adding in the innovation sector, and their potential to deliver more. Innovate UK will ensure that Catapults deliver on their full potential for business. This will include growing their capabilities to support skills development in the sectors they support, contributing to levelling up, driving research commercialisation, and enabling global innovation collaborations.

Figure 8: Map showing the locations of Catapult facilities



Scotland's Innovation Centre programme, launched in 2012 and funded in partnership by the Scottish Funding Council, Scottish Enterprise and Highlands and Islands Enterprise, forms a critical part of Scotland's knowledge exchange and innovation ecosystem. There are currently seven centres, in areas of biotechnology and the circular economy, digital health and care, precision medicine, construction, aquaculture, data and AI and sensors, imaging and 5G. They work with Scotland's colleges, universities and research institutes to address demand from, and the opportunities and challenges facing, the private, public and third sectors. They are strategic in focus, build transformational collaborations and exist to develop Scotland as a world-leading entrepreneurial and innovative nation with global impact.

Knowledge Transfer Network (KTN)

Knowledge Transfer Network (KTN) is a key delivery partner of UKRI, providing a unique capability in the UK to support innovation collaboration across business sectors and throughout the UK. KTN supports collaboration between innovative businesses seeking to connect with partners, customers, suppliers and the research base in order to grow. Since 2018 KTN's engagements with over 7,000 firms have resulted in more than 2,000 business to business and business to research collaborations, helping innovators to find new opportunities and achieve

their aims more quickly. A conservative estimate of the impact is that 60% of firms working with KTN increase their investment in R&D, while 40% achieve their innovation aims faster.

National Academies and Academies in Scotland, Wales and Northern Ireland

The National Academies (the Royal Society, the British Academy, the Royal Academy of Engineering and the Academy of Medical Sciences), the academies of Scotland, Wales and Northern Ireland (the Royal Society of Edinburgh, the Learned Society of Wales, the Royal Irish Academy respectively) and their Fellows represent the best of UK science, research, innovation and engineering. They play a major role in attracting, nurturing and retaining extraordinary research and innovation talent.

Business accelerators and incubators

Accelerators and incubators are organisations that provide support to start-ups through the early stages of growth. While incubators support start-ups at the start of the process of building up their business, accelerators support the advancement of the growth of an existing business which already has an idea and business model in place. These organisations help start-ups through various means including providing access to mentorship networks, seed investment funding, and attracting top venture capital firms to invest in the business.

Science and Innovation Parks/Innovation Districts

Science and innovation e-parks are dedicated clusters of offices, laboratories and workspaces for knowledge intensive businesses, while innovation districts are networks of organizations in major cities that produce and commercialise knowledge. Their aim is to facilitate growth for businesses, entrepreneurs and start-ups. They support innovation and commercialisation by facilitating knowledge sharing, collaboration, commercialisation of R&D outcomes, innovation promotion and business support. There are over 100 science and innovation parks and innovation districts located throughout the UK. Recent years has seen significant private sector investment in their development. They can have a significant impact. Cambridge is Europe's largest technology cluster. Around 61,000 people are employed by the more than 5,000 knowledge-intensive firms in the area, which have combined annual revenue of over £15.5 billion.

Research Infrastructure

Research Infrastructures (RIs) are facilities, resources and services used by the research community to conduct research and foster innovation. There are over 500 nationally and internationally significant RIs in the UK, 75% of which work with UK businesses, and many of which generate clusters of innovative private sector businesses, attracting talent and foreign direct investment to the UK. RIs are funded from a range of sources including the UK government and devolved administrations. The Harwell Campus alone (centred on the ISIS and Diamond Light Source facilities) is home to dozens of innovative SMEs working in advanced manufacturing, life sciences, satellite applications/space and other innovation-intensive fields. In addition to providing services and facilities access to industry, RIs are natural focus points for innovation: our Fusion Energy RIs have led to significant advances in

robotics and remote handling and the ISIS Neutron Source is testing advanced materials for jet engine turbines. Innovative UK companies often contribute to constructing or upgrading RIs using their in-house resources, rather than with cash. The benefits of investments in RIs are greatest if the RI is hosted in the UK.

Overseas Networks

The UK government's overseas networks play a vital role, working across organisations to connect innovative businesses in the UK with overseas opportunities, as well as promoting the UK's innovation excellence globally. The Science and Innovation Network (SIN) has approximately 100 officers in over 40 countries and territories around the world, helping to establish strategic innovation collaborative partnerships, supporting innovative businesses to make international connections and providing intelligence on overseas markets. SIN's successes in recent years have included developing UK-Japan collaboration on cutting-edge genomics research, facilitating the entry of UK companies into the Chinese space sector and securing investment from Canada into AI innovation in the UK. HM Trade Commissioners (HMTCs), the global network of over 1,500 overseas trade officials, and targeted initiatives such as the new Digital Trade Network (based in Asia Pacific) support UK businesses to break into export markets around the world and play a vital role in attracting investment into high-growth, innovative sectors of the UK economy. UKRI's international offices in China, India, North America and Europe provide essential expertise and support for the UK's innovation system to engage with key territories across the world.

Annex B: List of Stakeholders Consulted

24 Haymarket	Cisco	Graphcore	Money and Pension Service	Servicenow
2M Holdings	Civica	Graven Images	Mott MacDonald	SETsquared
Accenture	Clarendon Fund Managers	Greenhouse Intelligence	MSC R&D Limited	Severn Trent
Adarga	Cloud Gateway	Growthdeck	MSD	Shadow Robots
Advalus	Collingwood Solutions	GSK	Murphy Group	Siemens
Advanced Manufacturing Innovation Centre	Compound Semiconductor Applications Catapult	Halma	NASA	Silver Fleet Capital
Advanced Manufacturing Research Centre	Compound Semiconductor Centre	Harvey Nash	National Composites Centre	SilverLake
Advice Direct Scotland	Computacenter	HCL Technologies UK Limited	National Innovation Centre for Data	Six Degrees Group
Advice-Cloud	Connected Places Catapult	HDR UK	National Manufacturing Institute Scotland - Advanced Forming Research Centre	Soar
Aerospace Technology Institute	Convedo	Health Innovation Research Alliance NI	Natwest Group	Sopra Steria
Aerospace Wales Forum	Cornerstone Partners	Heathrow	NCUB	Spirent
Age Scotland	Corporate Governance Risk	Heriot-Watt University	Nesta	Spirit Aero Systems
Agri-Epi Centre	Costain	Highways England	Nesta Challenges	STFC
AirBus	CPI	HP	Network International	Strawhuts
AIRTO	Creative Industries Federation	HR Wallingford	Network Rail	Sumption Solutions
Albion Capital	Credera	HS2	Newable Ventures	Sunderland City Council
Alma Angela	Creo Medical	HSBC	Newcastle Helix	Sunderland Software City
Alzheimer's Society	Darktrace	HSSMI	Newcastle University	Sustainable Acoustics
Amaryllis Ventures Limited	Dassault Systems UK	Huawei	Next Wave Partners	Swansea Bay City Deal
Amazon	Data Performance Consultancy	i3p	NI BBB	Swansea University
Angel Academy	DataLab	land	NICA	Swoop
Angels Invest Wales	Deep Branch Biotechnology	IBM	Nile	Syncona
Apple	Dell	IDEO	NNL	Synova Capital
Arcinova	Deloitte	Impeller Ventures	North East Fund	Tanium UK Limited
Arista	Derry and Strabane District Council	Imperial College London	North East LEP	Tata Consultancy Services
Arm	Design For Social Change Limited	Inbest	North Invest	Taylor Vinters
Arqiva	Digiidnet	Industrial Strategy Council	North of Tyne Combined Authority	Tech Nation
ARUP	Digital Catapult	Industry Wales	North Star Ventures	Tech UK
Aspectus Group	Digital Catapult NI	Informed Solutions	Northern Powerhouse	Technology Connected
AstraZeneca	Digiterre	InSadly	NSSIF	Techstart Venture LLP
Atomico	Direct ID	Institute of Directors	Nuclear Advanced Manufacturing Research Centre	Tesco
Autolus	Direct Line	Institution of Engineering and Technology	Nude	Thales
Avieco	Domo	Institution of Mechanical Engineers	Ocado	Thomas Swan
Ayming	Dragados UK	International Collaboration Division, Israel Innovation Authority	Office for Investment	Through Technology
Balfour Beatty	Duke Street	InTrace	Offshore Renewable Energy Catapult	Trades Union Congress
BAM	Durham University	Invest NI	OGTC	Trilateral Resarch Ltd
Bangor University	DXC	ITECH Learning Technologies	OneWeb	TWI Bridgend
Becrypt Ltd	Dynamo	ITV	Open Banking Limited	UK Finance
Belfast City Council	Edf Energy	IUK	Open Cast Software	UK Innovation Districts Group

Belfast Met	Edinburgh Chambers of Commerce	Jaguar	OpenText UK	UK Space
Belfast Region City Deal	Edinburgh Innovations	JDR Cable Systems	OpTIC	UKAEA
Bellrock Technology	Education Partnership North East	John Lewis Partnership	Oracle	UKBAA
BenevolentAI	EMBL	Johnson Matthey	Outrun Ventures	UKRI
Bentley	Energy Systems Catapult	JRanger	Oxbotica	Ulster University
Beringea	ENGIE	JRC	Oxford Sciences	Unilever
Bessemer Society	Engineering UK	Kanios	P1vitol	Universities UK
BGF	Environment Agency	Kingspan	Palantir	University College London
BioIndustry Association	Ever Resource Ltd	KTN	Panasonic	University of Bath
BJSS	Evri Insight	Kubos Semiconductors	Paragraf	University of Cambridge
Black Pepper	Excelitas	L&G	Pearson	University of Edinburgh
Black Stones Advisors	Exizent	Laing O'Rourke	Penderyn	University of Glasgow
Blackberry	EY Incentives	Lakestar	Phoenix Instinct	University of Manchester
Blenheim Chalcot	Federation of Small Businesses	Land Rover	Pinsent Mason	University of Oxford
BMT Global	Financial Conduct Authority	Landsec	Port of Tyne	University of Sheffield
Boeing	FinTech Scotland	Larkspur International	Precision Decisions	University of Southampton
BP	FLINT	Law Society of Scotland	Prezzo	University of Strathclyde
BRE Group	Fnc	Leading Edge Forum	Proctor and Gamble	Valuechain
Bristol Private Equity Club	ForgeRock	Leeds City Council	Qinetiq	Vector Associates (UK) Ltd
British Academy	Forum for Private Business	Leonardo Company	QUBIS	Viasat
British Airways	Fraunhofer	Life Sciences Hub Wales	Queen Elizabeth Olympic Park	Victoria Ward Limited
British Chamber of Commerce	Fraunhofer CAP	LINC Scotland	Queen Mary University	Virtually Informed
Brunel University	Freshfields	Linx	Queens University Belfast	Visa
BSI Group	FSB	LSE	RACE	Visiba Care
BT	Fujitsu	M2 Lasers	Reckitt Benckiser	VMware UK Limited
BVCA	FundHer North	Mace Group	RedX Pharmaceuticals	Vodafone
Cambridge Angels	Gaist Solutions Limited	Made Smarter	Resolution Foundation	Warwick Manufacturing Group
Campaign for Science and Engineering	Galliford Try	Make UK	Rhea Group	Warwick University
Cardiff City Deal	Gatsby	Makerversity	Riversimple	Wellcome Collection
Cardiff University	Genomics England	Manufacturing Technology Centre	Roche	Welsh Automotive Forum
Catalyst Inc	Gillian Hall Consulting	Mastek	Roke	WIG
CBI	Glasgow Chambers of Commerce	Matrix	Rolls Royce	Winsland
CBI NI	Glasgow City Council	McKinsey	Royal Academy of Engineering	Wireless
CBI Scotland	Glasgow City Innovation District	McLaren Automotive	Royal Institution of Naval Architects	WMCA
CBI Wales	Glasgow Life	Medallia	Royal Society	WMG
Cell and Gene Therapy Catapult	Glasgow Riverside Innovation District	Medicines Discovery Catapult	Russell Group	Wood
Centre for Process Innovation	Glasgow School of Art	MediWales	Salesforce	WPP
Ceredigion County Council	Glass Futures	Mercia	Satellite Applications Catapult	WSO2 Inc.
CGI	GlobalData	Microsoft	Scale Up Institute	WSP
Cheltenham Borough Council	Google	Mirada Medical	Scottish Enterprise	Zaizi
Chipside	Goonhilly Earth Station Ltd	MIT	Scottish Funding Council	Zinc
Cinven	Government of Canada Graham	Mitrai	Sellafield Senergy	Zivver

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