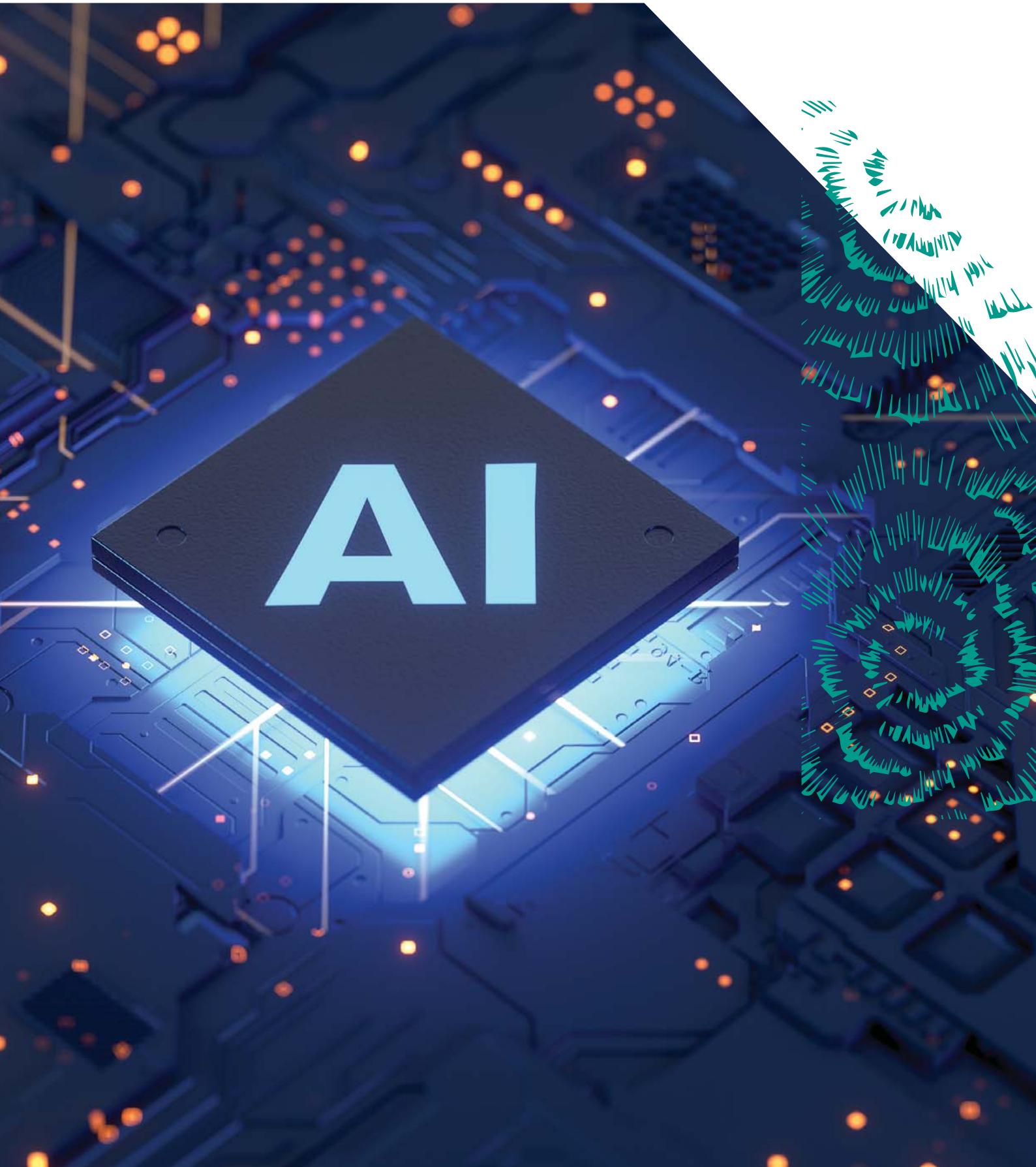


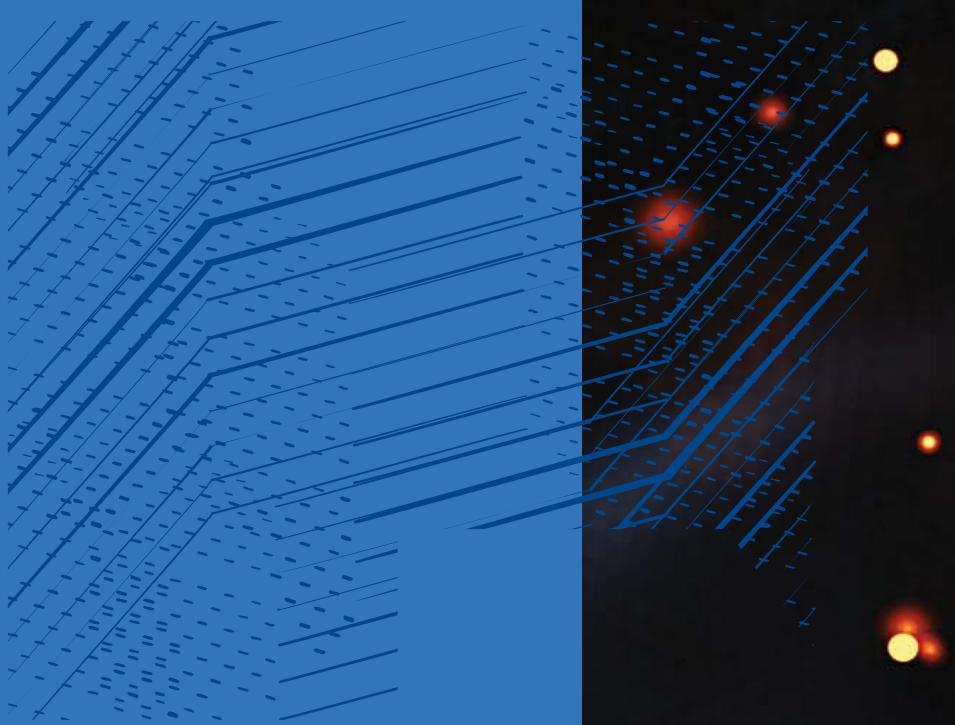


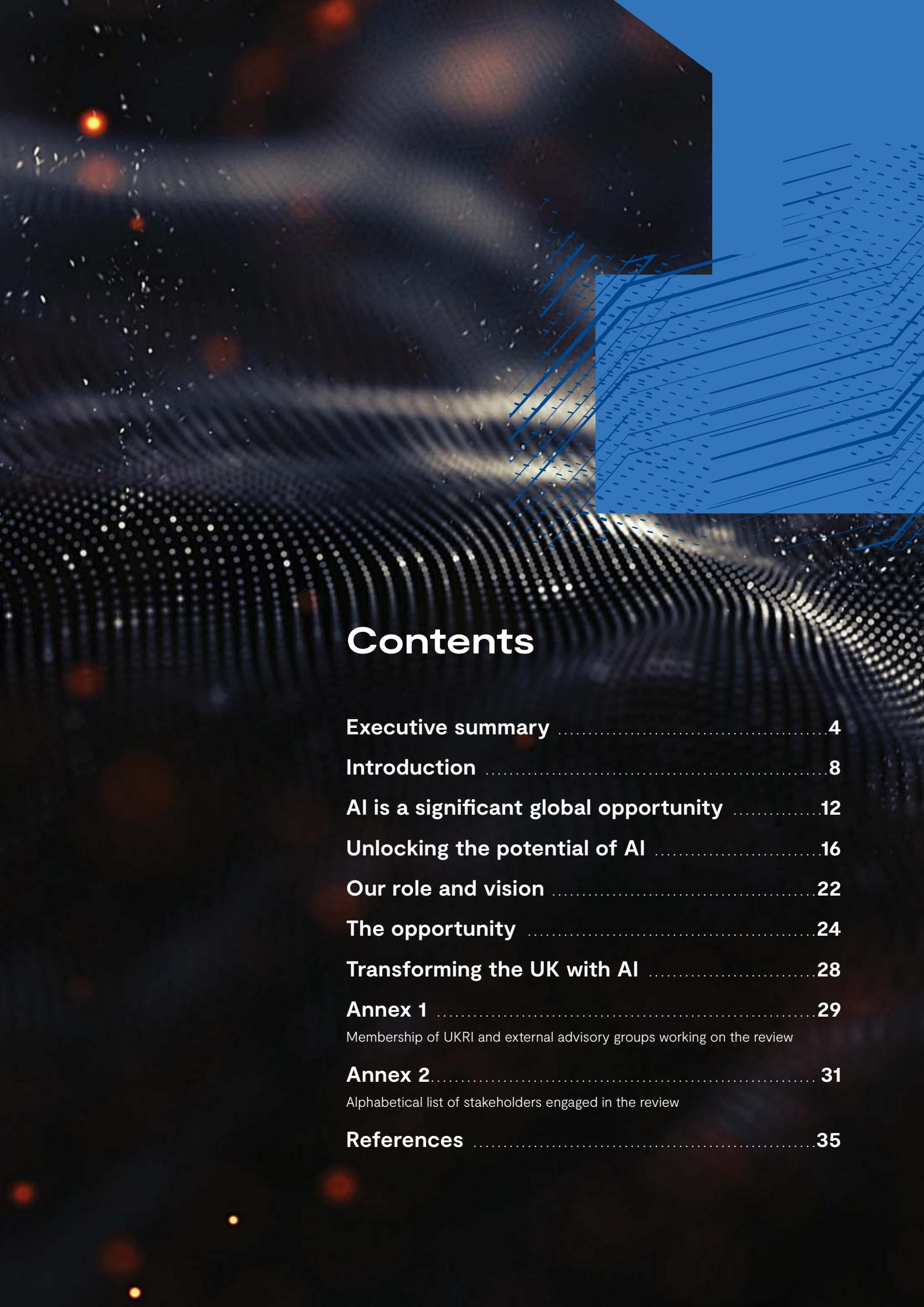
UK Research
and Innovation

Transforming our world with AI

UKRI's role in embracing the opportunity







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Executive summary



In order for the UK to seize the huge opportunity that AI represents, we need to support researchers and innovators to develop next generation AI technologies that are responsible and trustworthy and can have real impact on the societal, economic and environmental challenges facing the world today.

Artificial intelligence is already transforming our world. It is helping scientists to make important new discoveries more quickly – notably in dealing with the COVID-19 pandemic. It is transforming health services, including the prediction and prevention of disease. It is already helping us to meet challenges in fields such as energy, the environment, food and agriculture and business productivity.

Artificial intelligence, commonly known as AI, describes a suite of computational technologies and tools that aim to reproduce or surpass abilities of humans to undertake complex tasks like learning and problem solving. It enables us to use and make sense of data. Its use has grown with the increase in computing power, the rapid rise in the availability of data, and the need to process increasingly large and complex datasets.

AI is considered by economists to be a 'General Purpose Technology', with the potential to have profound impacts on the economy, and on addressing national and global challenges. This profound impact of AI on the economy has not yet been realised, and will rely on substantial research, development, innovation, and commercialisation efforts.

The full potential of AI is a long way from being realised. The use of AI has the potential to drive substantial economic growth across all regions and nations of the UK, and it will be vital to help companies rebuild, revitalise and become resilient. Its use can significantly improve health and wellbeing, it can revolutionise public services whether transport, welfare or justice and it can address inequality across communities and places. It can help us radically reduce our environmental impact, enabling us to meet our net zero greenhouse gas emissions targets and monitor environmental infringements. It can open up new avenues of scientific discovery and exploration.

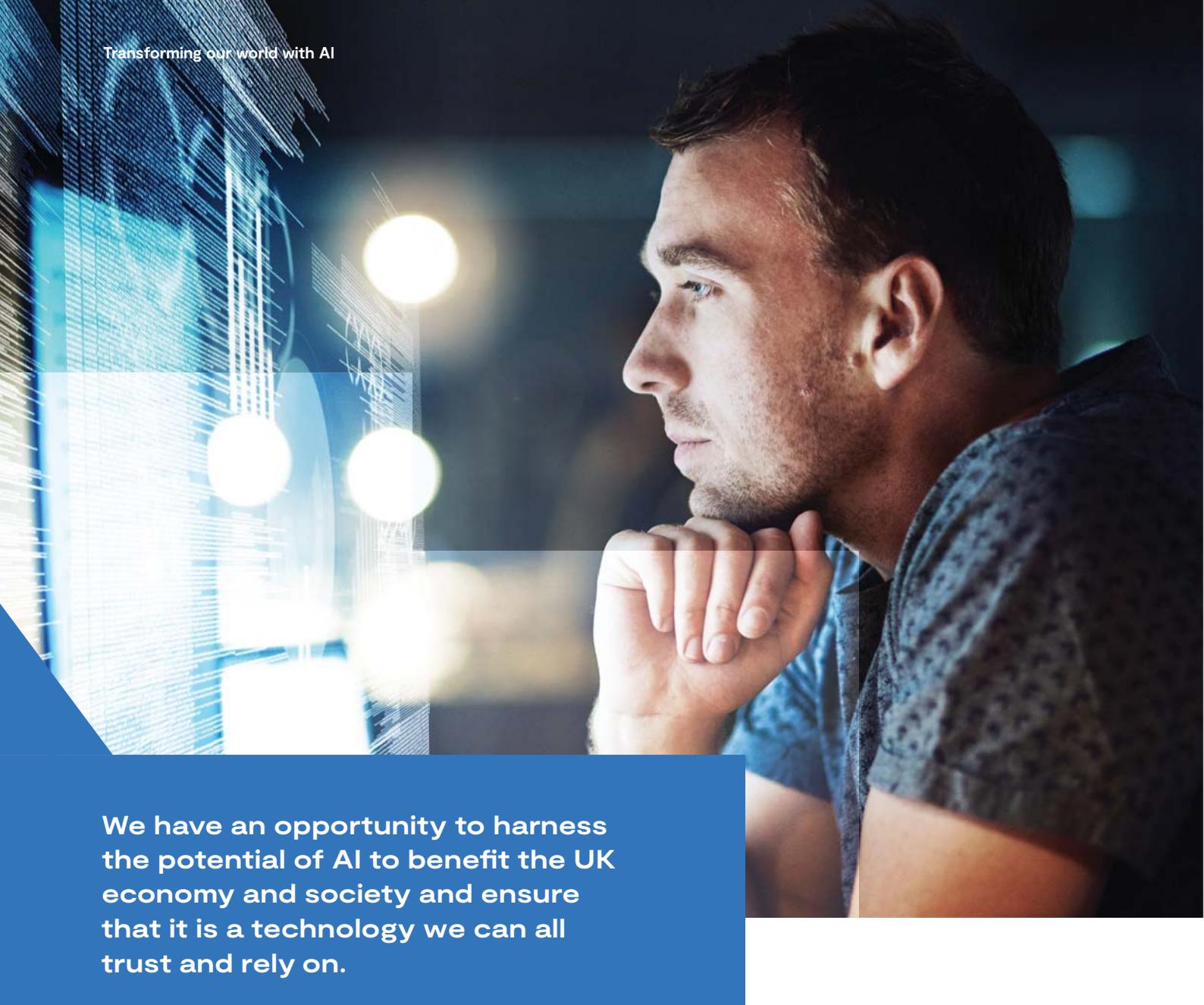
This document sets out the cross-disciplinary and cross-sector opportunities to support AI research and innovation in the UK, as developed through the UKRI AI Review. It also sets out UKRI's aspirations to play a key role in bringing researchers and innovators together, across disciplines and sectors, to develop better AI technologies that meet the demands of real-world challenges and train the workforce of the future, bringing the benefits of AI to bear on the UK's future economic prosperity, societal wellbeing and our contribution to net zero.

Unlocking the potential of AI

AI opportunities for the UK are enormous across all areas of science, the economy and government. It is estimated that leading countries could gain an extra 20% to 25% of economic growth and productivity through AI over the next decade. The UK is well placed to take advantage. We are ranked third in the world for our research and innovation in AI, remarkable for our size, but only 11th in terms of our ability to realise innovation and impact from AI, a real gap and opportunity. We have the high-performing universities able to advance research in AI and innovative businesses that are already attracting significant venture capital investment. We must also recognise that along with many benefits there are genuine public concerns about AI and its potential to automate many areas of life, from jobs to decision-making.

In order to realise the full benefits of AI, we will need to act to support the growth of the UK's AI research and innovation capabilities, building on strong foundations. This is likely to require substantial investment over a sustained period.





We have an opportunity to harness the potential of AI to benefit the UK economy and society and ensure that it is a technology we can all trust and rely on.

The UK needs better AI technologies to meet the demands of real-world applications. The nature of AI, which is often context specific, means that novel AI technologies are not only developed by world-leading mathematical and computational science specialists, they are often developed through tackling real world problems in application domains. The UK must also develop the new technologies that will ensure AI is trustworthy and adoptable, including countering bias and embedding human and societal values into AI.

Fundamental research in social sciences and humanities must be joined with technical development so that we better understand how AI is being deployed and its impact on society and the economy. The need for research and innovation activities across technical advances, societal understanding, and application

domains, are inextricably interlinked; we cannot invest in one part of the pipeline and expect to optimally realise trustworthy adoptable technologies for the socioeconomic benefit of the UK.

We must also create the right environment in which researchers and innovators can thrive. This means creating the right environment in which we can drive business adoption. It means raising skills at all career stages, building teams, and attracting talent across disciplines and across the UK. It means building a networked and collaborative sustainable UK research and innovation community. It also means ensuring a lack of computing power and poor access to data are not a barrier to research and that researchers and innovators can work across sectors and disciplines on both the national and international stage.

The opportunity

Currently, the UK has an opportunity to position itself as a leader in international AI research and innovation; UKRI has a key role to play in realising this opportunity.

Our vision is for advances in UK artificial intelligence to benefit society, provide skilled employment, and deliver significant economic growth.

We will aim to support world-leading AI research and innovation including:

- **creative discovery-led research that delivers the next generation of transformative AI technologies**
- **new capabilities and understanding that deliver responsible and trustworthy AI technologies designed with an understanding of the real world context in which they will be used, and drawing from public opinions and perceptions**
- **bringing researchers, innovators, and problem owners together for application-driven research and innovation in discovery science and in areas such as health, the environment, agriculture, security, and government policy**

We will seek to ensure that the UK has the right environment for world-leading researchers and innovators to thrive including by:

- **supporting the development of a networked and interconnected UK AI research and innovation community, convened by a central organisation building on the successes of The Alan Turing Institute**
- **facilitating businesses to develop and deploy cutting-edge AI to increase business productivity, resilience and competitiveness across the economy**
- **recruiting, developing, and retaining the best people with the broadest skills and approaches to develop and use the AI technologies of the future**
- **working to ensure that access to data and compute capacity is not a barrier to research and innovation**
- **promoting the interdisciplinarity and cross-sector working needed for successful advances in AI**

- **working internationally on excellent AI research and innovation and shared opportunities**
- **enabling public engagement with AI to be embedded in our research and innovation**

Transforming the UK with AI

AI will transform the UK over the next 20 years. We have an opportunity to ensure that this transformation brings the maximum benefits to the UK economy and society and that it results in new technologies that we can all trust and rely on.

This document sets out UKRI's view of the opportunities for research and innovation in AI in the UK, as determined through the UKRI AI Review. In it we set out our aspirations for supporting transformational activities, and for working with our partners to place the UK in a strong position to realise the vast potential benefits of AI.



Introduction

Artificial Intelligence will transform the way we live and work, from the way we diagnose and treat cancer to the security of online transactions. With AI, computers can analyse and learn from information at higher accuracy and speed than humans can and ultimately offer capabilities which complement those of humans.



Artificial intelligence is revolutionising our world. It is giving scientists the tools to make new discoveries and to make them more quickly. AI is already transforming health services, including the prediction, prevention and treatment of diseases such as cancer. It is helping towards our work to meet targets for net zero greenhouse gas emissions, giving us the tools we need to feed a growing world population, and improving online security. It is helping businesses boost productivity in internal processes and increasing competitiveness through the development of products and services better tailored to customer needs. It will play a key role in recovery from COVID-19 helping us to tackle the social and economic consequences of the pandemic, and help us avoid potential future pandemics.

Artificial intelligence, commonly known as AI, describes a suite of technologies and tools that aim to reproduce or surpass abilities (in computational systems) that would require 'intelligence' if humans were to perform them. This could include the ability to learn and adapt;

to sense, understand and interact; to reason and plan; to act autonomously; and even to create. AI will transform the way we undertake science, across and within all disciplines, how we develop products and services for the market, the way we live, and the environmental impact we have.

AI enables us to use and make sense of data. Its use has grown with the increase in computing power, the rapid rise in the availability of data, and the need to process increasingly large and complex datasets. AI is a general purpose technology that has the potential to transform the way we do things across many different sectors. It is already being used across industry, including in manufacturing, environmental monitoring, crop production, driver-assistance technology, toys and games, and financial trading. Notable recent advances in AI have covered a spectrum of topics, from AlphaFold and AI used for drug discovery, to GPT-3 and advances in reinforcement learning and facial recognition.

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UK Research and Innovation

UK Research and Innovation works in partnership with universities, research organisations, businesses, charities, and government to create the best possible environment for research and innovation to flourish. We aim to maximise the contribution of each of our component parts, working individually and collectively. We work with our many partners to benefit everyone through knowledge, talent, and ideas.

Operating across the whole of the UK with an annual budget of more than £7 billion, UK Research and Innovation brings together the seven research councils (Arts and Humanities Research Council, Biotechnology and Biological Sciences Research Council, Economic and Social Research Council, Engineering and Physical Sciences Research Council, Medical Research Council, Natural Environment Research Council, and Science and Technology Facilities Council), Innovate UK and Research England.

Using AI to understand COVID-19

Health records are commonly stored in multiple incompatible formats, with much of the useful data held as text. This means that the information can be hard to access and utilise. Scientists at the national institute for health data science, Health Data Research UK (HDR UK), are developing novel Natural Language Processing methods to extract information from these unstructured data sources. With these powerful data mining techniques, we can search through medical records quickly and efficiently, helping to understand diseases and develop more effective treatments.

The team analysed medical notes of COVID-19 patients and their preliminary data suggests that patients taking medicines known as ACE-inhibitors to manage high blood pressure and diabetes are no more susceptible to a severe form of COVID-19 infection. ACE-inhibitors were initially thought to exacerbate COVID-19 symptoms; these findings indicate COVID-19 patients can continue receiving treatment to manage their underlying conditions without further detrimental effects to their health.

HDR UK was set up by the Medical Research Council (MRC) in partnership with National Institute of Health Research (England), Chief Scientist Office (Scotland), Health and Care Research Wales, Health & Social Care R&D Northern Ireland, the Engineering and Physical Sciences Research Council (EPSRC), the Economic and Social Research Council (ESRC), the British Heart Foundation, and Wellcome Trust.



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Science and
Technology
Facilities Council



Arts and
Humanities
Research Council



Engineering and
Physical Sciences
Research Council



Biotechnology and
Biological Sciences
Research Council



Economic
and Social
Research Council



Research
England



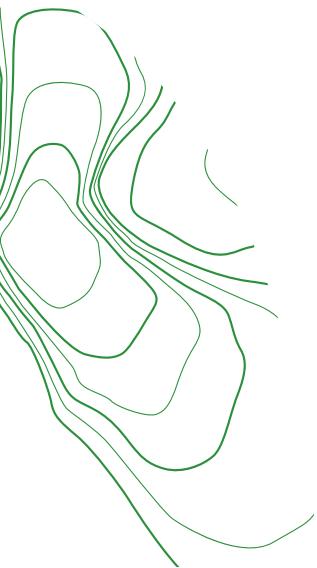
Natural
Environment
Research Council



Innovate
UK



Medical
Research
Council



AI will open up new opportunities in UK businesses; from the creation of new businesses, to the transformation of business models across sectors. It is also an increasingly important tool for the work of government, operation of public services, charities, and other third-sector organisations. However, its full potential is a long way from being realised. The Made Smarter Review suggests that AI in manufacturing alone could be worth an extra £198.7 billion to the UK economy by 2027^[1].

AI has a clear role to play in the response to COVID-19, as well as rebuilding and recovery from the pandemic, and planning for preparedness for future pandemics and other perturbations.

The growing use of AI in all aspects of our lives, and the potential for it to become a transformative General Purpose Technology, raises genuine public concern about machines replacing people's jobs, automated decisions about us based on biased or misused information, increased surveillance, and manipulation of news feeds and information to influence us. UKRI has a unique potential to explore these issues and to enable informed decisions to be made about how AI should be deployed, by bringing together technical research and development with understanding of the applications and implications of new technology and public engagement and dialogue.

AI is far from being a mature technology, and many of its anticipated transformative capabilities are not yet a reality. The UK must invest in the development of new AI technologies and in skills across academia and industry if it is to fully realise the benefits that will positively transform society and the economy and maintain our competitiveness on the global stage. A key area for accelerating the pace of acceptance and adoption of AI is the development of new technologies and capabilities that are needed to make AI technologies of the future trustworthy. However at the other end of the innovation spectrum the level of UK private investment in AI technologies does not currently meet our levelling up aspirations; research and innovation has a role to play in attracting and enabling this investment, and in de-risking business engagement. An effective combination of UK public and private investment, to both develop new technologies and demonstrate their value across sectors and applications, will be crucial to realising the potential for AI in the UK.

UK has world-class strengths in AI

According to the venture capital firm MMC, Europe was home to 1,600 AI startups in 2019. Almost 500 of them were in the UK^[2]. Between 2015 and 2019, four UK AI companies achieved unicorn status, a privately held startup company valued at more than \$1 billion, compared with only one other company in the rest of the EU^[3]. The UK has world-class strengths across relevant academic disciplines including mathematical sciences, natural language processing, computer vision, applied ethics, law and regulation. We also have legal excellence, a well-developed regulatory system, and world-class industry strengths in fintech, biotech, digital marketing and advertising, and security. Strong clusters of AI and digital activity have already formed around the UK including in Belfast, Edinburgh and Manchester. We can build on these strengths, and the successes of The Alan Turing Institute, to deliver a true national effort in AI research and innovation. A rich UK AI research and innovation ecosystem will include a variety of research structures, and enable interconnectivity and collaboration between academia and the private and third sectors.

Much is happening already. The government is committed to increasing UK investment in R&D to 2.4% of GDP by 2027 and public funding for R&D to £22 billion a year by 2024/25. Its Research and Development Roadmap^[4] aims to build on support for traditionally R&D-intensive sectors while also putting the UK at the forefront of transformational new technologies such as AI. The government's Industrial Strategy also identifies AI and data as one of four grand challenges where the UK can lead the world for years to come^[5]. The AI Sector Deal, announced as part of the Industrial Strategy, is a £1 billion package of funding from government, academia, and business to support the adoption of AI^[6]. Publication of the government's National Data Strategy, aimed at building a world-leading data economy, is expected in 2020^[7]. UK Research and Innovation (UKRI) is already making strategic investments in AI and will continue to do so.

Increased investment in research and innovation and in the skills to deliver it are vital if the UK is to reap the full benefits of AI. UKRI brings together the UK's research and innovation communities in a way that no other organisation does. We work across academia and business. We can use that power to build on our strengths

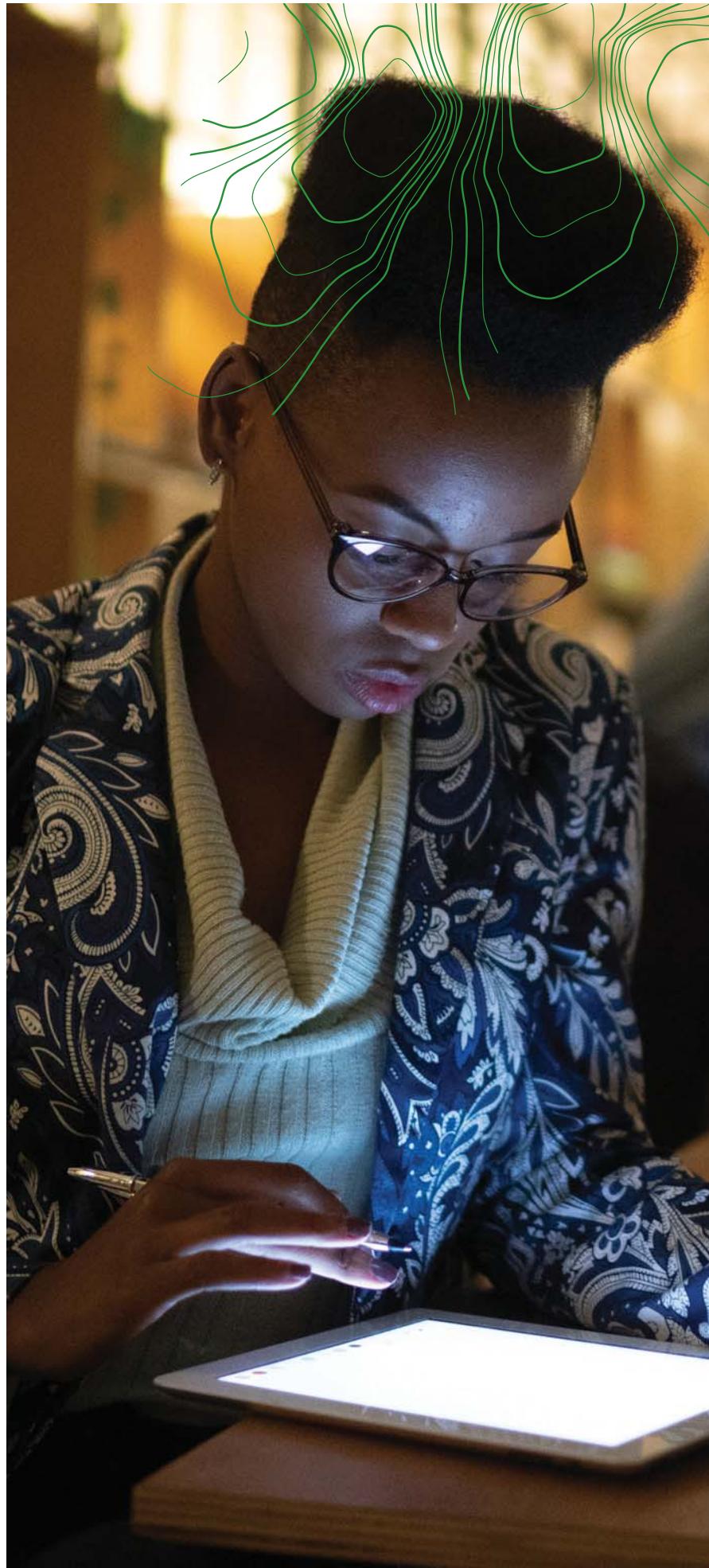
and on the UK's position as a world leader in AI. We can drive the discovery of ground-breaking science, help to solve some of the greatest challenges of our age, and support industry to maximise the commercial benefits by bringing together research experts, innovators, those across all sectors applying AI to their work, and ethical and business expertise. And we can help create and maintain an environment in the UK, in which a highly skilled workforce has the tools it needs to carry out the research and innovation that will transform our world.

The UKRI AI Review

This document draws upon the output of the UKRI AI Review, a wide-ranging exercise to understand UKRI's current and future role in supporting AI research and innovation in the UK. Our investments in research and innovation ensure that the UK has the capability to meet the societal, environmental, and economic challenges facing us.

This document sets out both the highly cross-disciplinary and cross-sector findings of the UKRI AI Review and, building on these, UKRI's aspirations for AI research and innovation in the UK. It recognises that AI is vital to the UK's future economic prosperity, environmental impact and societal wellbeing, and that UKRI's investment in research and innovation and its power to bring researchers and innovators together is critical to the work needed across sectors and disciplines to bring the greatest benefits to the UK.

The review was carried out by representatives from across all Councils of UKRI working with an external advisory group representing research, industry, and government from across the UK, particularly DCMS, the Office for AI and the AI Council. See Annex 1 for a list of members. We also consulted representatives of more than 300 outside organisations, including universities, research institutes, businesses, industry bodies, charities, and government. The full list is attached as Annex 2. Whilst the input of colleagues from these organisations has been used by UKRI to develop our ambitions for AI research and innovation in the UK and consider our role in its delivery, the individuals and organisations consulted have not specifically endorsed this position statement.



AI is a significant global opportunity

The UK is a world leader in AI research and innovation, in the mathematical and computational sciences, and in areas where AI will be transformative including environmental, medical, biological, and social sciences. We also have a vibrant technology innovation sector; we are in a strong position to realise the societal and economic impacts of AI.

AI is a significant global opportunity to increase economic wealth and transform society. The global consultancy business McKinsey & Company estimates that leading countries could gain an extra 20% to 25% of economic growth and productivity gains through AI over the next decade^[8]. This potential is recognised in the 30 national strategies for AI published between 2017 and 2019^[9]. China, the USA, and Europe are generally regarded as the leading researchers and innovators in AI.

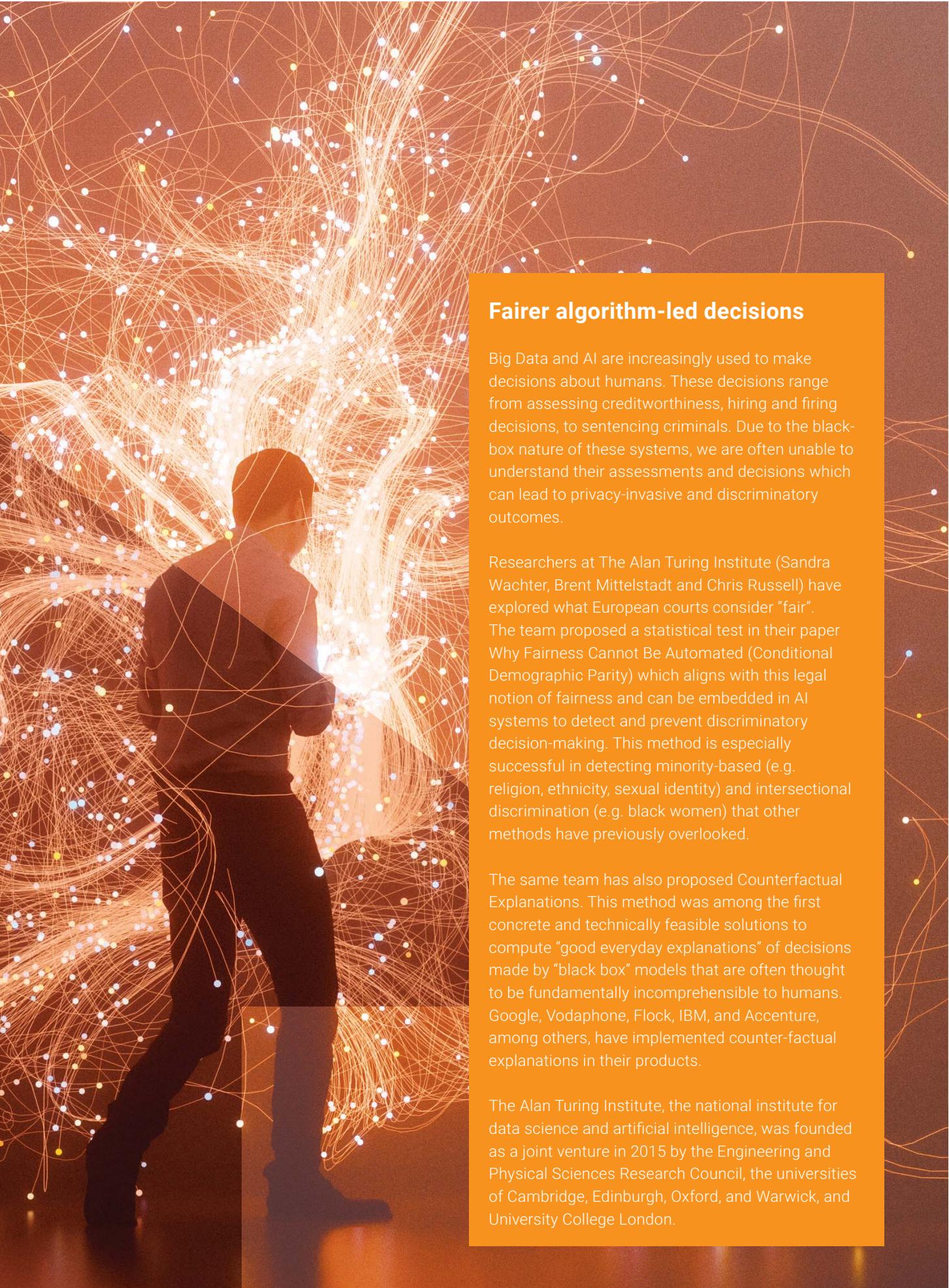
The UK is a world leader in AI and well placed to benefit. We are home to a third of Europe's AI startups^[2] but whilst we are ranked number three in the world in the first global AI index for research, our international ranking for innovation and impact is much lower, demonstrating real potential^[10]. UK AI businesses attracted £6.8 billion in venture capital investment between 2013 and 2018 – more than double the amount raised by French and German companies combined^[11].

The UK ranks third in the world for most highly cited research publications^[12]. We have the ecosystem for rapid advances in AI, with

key players and research structures including businesses of all sizes, influential government bodies such as the Centre for Data Ethics and Innovation (CDEI), and a strong regulatory reputation, sitting alongside the high-performing universities needed to advance research and innovation in AI. This AI ecosystem is complex and interconnected, and collaboration between key players is a real strength of the UK, which has underpinned the UK's leading position. Examples include successful AI startups such as Deepmind having a key role in research and innovation alongside traditional research structures, university spin-outs such as Nozzle.ai working with high profile retailers, and notable businesses such as Darktrace originating from academic endeavour.

The UK government's AI sector deal, announced in 2018, includes £1 billion of public and private investment in new technologies. However, other countries are investing more: Germany is investing £3.1 billion^[13], to be matched by the private sector; France £1.4 billion^[14]; China £1.7 billion^[15]. Furthermore, public investment in the USA is expected to reach £5.4 billion in 2020.

The UK has a strong ecosystem to support rapid advances in AI, key to maintaining our international standing in a highly competitive environment.



Fairer algorithm-led decisions

Big Data and AI are increasingly used to make decisions about humans. These decisions range from assessing creditworthiness, hiring and firing decisions, to sentencing criminals. Due to the black-box nature of these systems, we are often unable to understand their assessments and decisions which can lead to privacy-invasive and discriminatory outcomes.

Researchers at The Alan Turing Institute (Sandra Wachter, Brent Mittelstadt and Chris Russell) have explored what European courts consider “fair”. The team proposed a statistical test in their paper *Why Fairness Cannot Be Automated (Conditional Demographic Parity)* which aligns with this legal notion of fairness and can be embedded in AI systems to detect and prevent discriminatory decision-making. This method is especially successful in detecting minority-based (e.g. religion, ethnicity, sexual identity) and intersectional discrimination (e.g. black women) that other methods have previously overlooked.

The same team has also proposed Counterfactual Explanations. This method was among the first concrete and technically feasible solutions to compute “good everyday explanations” of decisions made by “black box” models that are often thought to be fundamentally incomprehensible to humans. Google, Vodafone, Flock, IBM, and Accenture, among others, have implemented counter-factual explanations in their products.

The Alan Turing Institute, the national institute for data science and artificial intelligence, was founded as a joint venture in 2015 by the Engineering and Physical Sciences Research Council, the universities of Cambridge, Edinburgh, Oxford, and Warwick, and University College London.

The UK must grow support for AI research and innovation and in high-level skills to maintain and build on its strong position. Public investment in the right areas will unleash innovation and attract and unlock inward and private investment to the UK. The Tech Nation 2020 report identified the UK as attracting the third highest level of international investment in AI (£1.3 billion) in 2019^[16]. Failure to support AI research and innovation could lead to a fall in UK competitiveness and the country missing out on societal benefits, key sovereign capabilities, and the opportunity to influence the agenda on responsible and ethical research and innovation.

Opportunities exist across business and research

AI will allow us to maximise use of complex data and help us to address global challenges, including feeding a growing global population; tackling disease; keeping an ageing population fit and healthy; and dealing with climate change.

AI-enabled forecasts can now predict impacts of El Niño up to 18 months ahead. The software tool RootNav has increased the accuracy with which scientists can extract the features of plant roots, has transformed their ability to identify crop improvement traits and speed up crop breeding programmes.

AI is opening new avenues for researchers to analyse data and make groundbreaking discoveries, including new drugs and

treatments for diseases such as cancer and the development of new sustainable chemicals. It will deliver productivity and economic growth through new products, services and processes in manufacturing and service sectors, as well as driving new business models across all sectors. The impact of COVID-19 requires businesses to pivot what they do; AI has a significant role to play in helping them achieve this.

Our review has identified significant opportunities across business and science to promote the design, development, and deployment of AI technologies, including in health, environment and energy, sustainable agriculture and food, defence and security, ICT, construction, earth observation from space, and creative industries.

Government can use AI to improve services

Government also has a strong interest in supporting research and innovation in new AI technologies that could transform public services in areas such as education, public infrastructure management, transport, justice, immigration, welfare, taxation, and addressing inequality across communities and places. Government departments are already demonstrating how AI can help them to deliver services. New and better AI technologies could ultimately change our approach to policy making and the management and analysis of public sector data and radically improve the efficiency and effectiveness of public services.

AI will revolutionise the way we live, work, communicate, learn, and discover, impacting every part of our lives.





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Unlocking the potential of AI

Despite the promise of AI, and the UK's existing strengths, the full potential of AI is a long way from being realised. The UK needs better AI technologies with new capabilities to meet the demands of real-world applications, and this will require research and innovation.

To realise the vast potential socioeconomic impact of AI, and for the UK to remain a global power in the field, we must support the UK's capabilities in the development and application of new AI technologies. We should seek to support the creation of the right environment in which researchers and innovators can thrive. That means raising skills across disciplines and across the UK, building a networked and collaborative sustainable UK research and innovation community, ensuring a computing power and access to data are not a barrier to research and innovation, and that researchers and innovators can work across sectors and disciplines on both the national and international stage.

We need better AI technologies

Next generation AI technologies

The UK needs to develop new or better AI technologies with a range of capabilities to meet the demands of real-world applications. The UK already has world-leading AI and computing research and researchers; realising the full potential of AI will not be possible unless we build on this strength to develop new or improved capabilities that do not already exist. These include:

- smarter and better working with data with a range of properties, sources and characteristics; learning from 'small data' as well as 'big data' for example to predict rare events or conditions; integrating data from many sources, for example video, image and text, and new ways of finding structure and causal relationships in data

- richer interactions that allow genuine partnerships between humans and AI systems through user modelling, consideration of human-AI understanding and interaction, and design and development of AI in line with our understanding of human communication, behaviour, and values. This will also need technological development to embed an understanding of societal and institutional structures and cultures to harness human preference, taste, and judgement
- making AI technologies and their outcomes applicable and transferrable more broadly across all domains rather than task specific so we can transfer learning from one domain to another
- developing low power consumption computing approaches to manage increasing energy demands of AI technologies that threaten to limit adoption or pose environmental risks
- greater understanding of the mathematical and computational concepts that underpin AI, for example understanding the mathematics of uncertainty quantification and the theory of decision making in deep learning algorithms

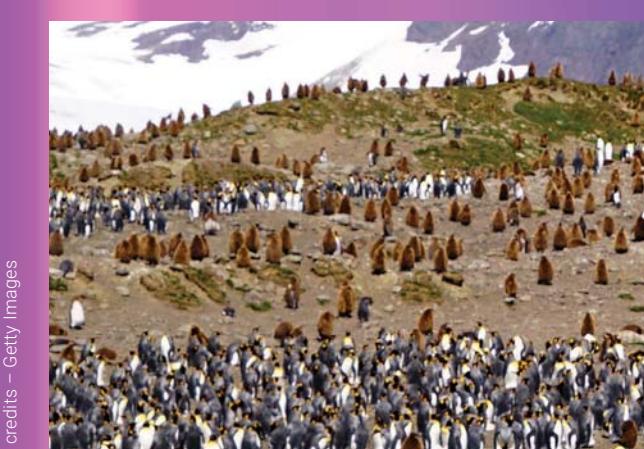


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Unlocking applications using next generation computing and artificial intelligence

The Visual Geometry Group at the University of Oxford, led by Professor Andrew Zisserman and Professor Andrea Vedaldi and supported by the Engineering and Physical Sciences Research Council, are developing next generation computer vision algorithms that can analyse, describe and search image and video content with human-like capabilities.

Artificial Neural Networks developed by the Group have had a transformative impact on the field of computer vision, because they enable large image datasets and video content to be searched with ever greater degrees of accuracy. VGG 16 and two-stream architectures —two types of neural network models developed by the Group—have been used in wide ranging real-world applications.

The Visual Geometry Group has contributed to many high-impact projects in natural sciences, material science, bibliography, zoology, conservation and beyond. An example is Penguin Watch, an automated penguin counter which analyses hundreds of thousands of time lapse images taken by remote cameras. This has significantly reduced the time taken to analyse data, and enabled zoologists to report breeding success from hundreds of colonies each year. Another example is Chimpanzee Face Recognition, where software can analyse decades' worth of video recordings of wildlife in its natural habitat automatically, identifying individuals and social structures with ease.

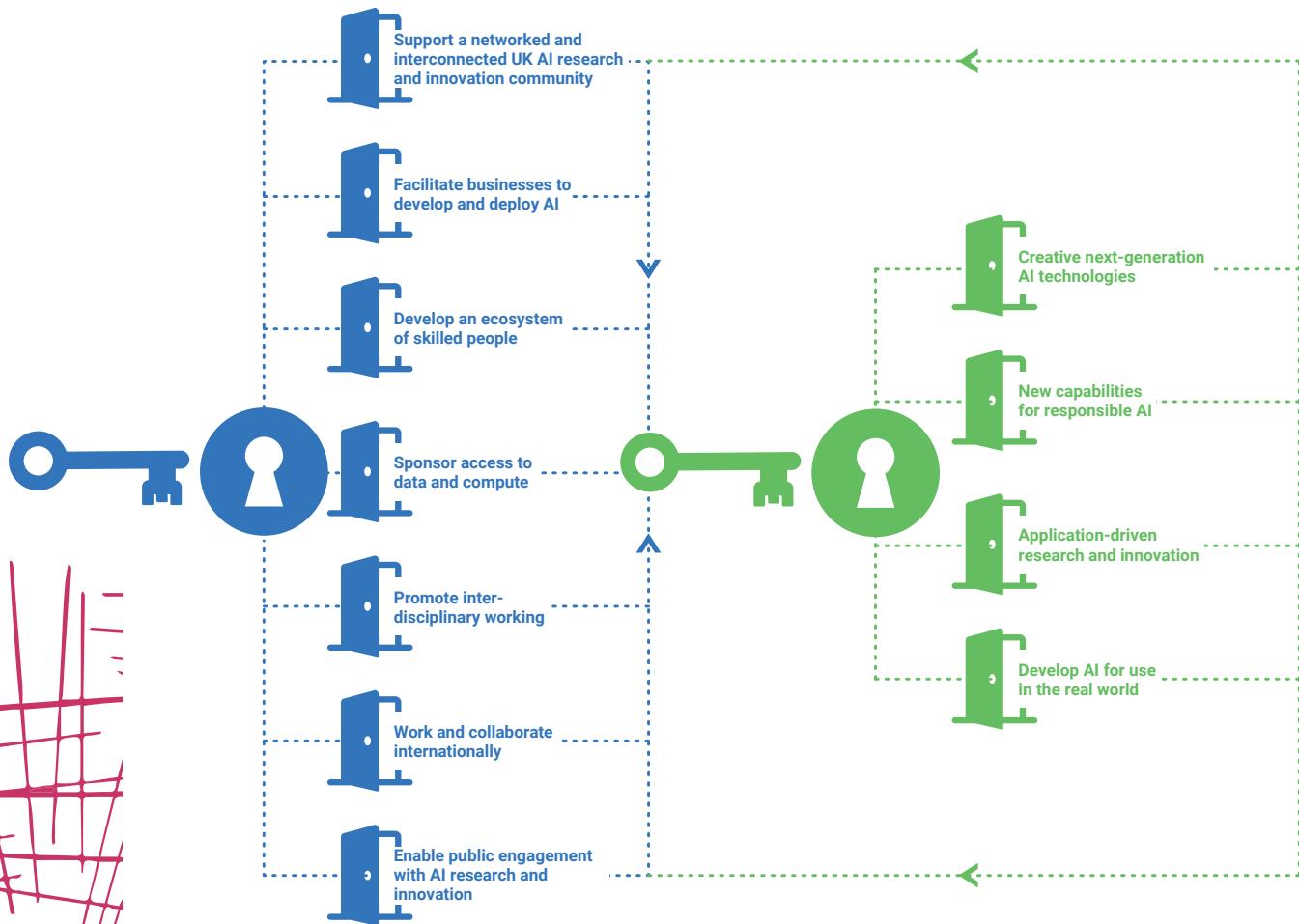
The Group have also made significant contributions to the field of visual speech recognition. They developed new lip-reading neural network models, which were trained using datasets comprised of videos from the BBC. The best of these network models set a new record for accuracy on real time lip-reading of continuous speech and has the potential to transform the quality and accuracy of live video subtitles.

The Visual Geometry Group has also contributed major open source software libraries, such as VLFeat, MatConvNet and annotation software, which have been used by many thousands of academic and industry researchers over the years.

Datasets are crucial to the development of AI technologies, because they are used to train neural networks. The Visual Geometry Group continue to publish new datasets under a free Creative Commons License, thereby providing an accessible resource for researchers across the UK and around the world.

Key areas to support for a strong UK AI research and innovation ecosystem

Creating the environment for AI research and innovation



Developing responsible AI

The UK needs to drive responsible approaches to AI that are secure, safe, and reliable and operate in a way we can all understand and that we can investigate if they fail; we have a real opportunity to show international leadership in this space through a broad and interdisciplinary approach. The technologies and approaches do not yet exist to properly counter bias and embed human and societal values into AI, and this cannot simply be rectified after a system has been developed. Significant gaps include technologies that:

- reflect and support human and societal values such as fairness and ethics, and aims such as improving outcomes for people, public services and communities
- are designed for user privacy, transparency, and to limit unjust or irrational bias
- are transparent, and appropriately explained to and understood by those they impact
- are reliable, robust, safe, and secure

Developing some of the capabilities of truly responsible trustworthy AI, which is acceptable and adoptable may require significant consideration of performance trade-offs, for example between the complexity or accuracy of an AI system and its security or explainability.

Addressing key applications and challenges

UK AI research and innovation in both academia and industry is world class. The nature of AI means that investment in new applications and ways of tackling challenges is a significant way to drive the development of novel and general purpose technologies. Greater investment in basic research such as in health will drive the discovery and development of new AI technologies. We must also ensure we continue to drive adoption of AI by business and government. We have yet to see the full benefits of AI as it is not being deployed at scale in many places.

Areas of opportunity for the UK:

- **AI for increasing business** productivity, resilience and increased competitiveness across the economy
- **science and research** where AI could allow us to do research differently, radically accelerating the discovery process and enabling new breakthroughs
- **health** where new capabilities for the management, use and interpretation of health data could help to predict and better manage disease, and deliver new treatments
- **environment and energy** where better use of data could help to manage smart energy networks, tackle climate change and deliver net zero CO₂ targets
- **sustainable agriculture and food** where more needs to be done to exploit the benefits of a data-driven approach and help small and medium-sized businesses to adopt them
- **defence and security** where demonstrating AI technologies at scale is challenging
- **creative industries**, from understanding and addressing copyright to virtual production and the need to improve data infrastructure
- **application of AI to government policy and public services**, to improve the effectiveness and efficiency of services for the public, and how policy is informed by data to prioritise what works, why and for whom

Using AI in the real world

Technical development of AI must be joined with research and innovation in social sciences and humanities so that we better understand how AI is being developed, how it is being deployed in the real world, and its impact on the economy, people and society. This needs to include public engagement and genuine public dialogue that directly informs research. This joined up approach is also key to the UK maintaining a strong role in the development of standards and regulation around the technology. We should seek to gather robust and reliable evidence to underpin development of new legal, regulatory and policy frameworks and work with international regulatory partners on standardisation of AI. A strong reputation for responsible AI could be a big competitive advantage for the UK.

Maintaining the right environment for research and innovation

The UK must develop AI skills across academia and industry if we are to stay at the forefront of research and innovation. AI research and innovation is undertaken across a wide variety of research structures, including business of all sizes, independent bodies, institutes, and universities. The ecosystem is complex, and the UK's environment for AI research and innovation must build upon ways of working from all of these structures, and particularly enable working across research structures for an open and creative UK research and innovation environment.

Researchers and innovators must also be able to easily access and use data and have enough computing power to make best use of it. We need an environment that networks the UK community, recognises the importance of multidisciplinary and interdisciplinary working, diversity and inclusion, and international collaboration to AI development.

People and skills

LinkedIn's 2020 Emerging Jobs Report found that 'artificial intelligence specialist' was the number one emerging job in the UK^[17]. Skilled people are highly mobile and demand for them far outstrips supply, according to global



developer of AI-powered solutions and services Element AI^[18]. A small number of employers can attract and retain them with high salaries^[19].

The UK needs a healthy talent pipeline, it needs to attract, retain and develop talented, diverse people and teams with AI skills to work in academia, government, and the private sector. We need skills in computer science, mathematics, human factors, social science, and in all the areas in which AI may be applied or used. Collaboration across disciplines, and inclusive team approaches to science and research, will be key to developing the next generation of usable AI technologies. We need to develop the broader skills of entrepreneurship, scale-up, business knowledge, and data engineering to make the most of commercial opportunities. People must be able to work across disciplines and across sectors and have sufficient in-depth knowledge, as well as broader awareness of the key issues and considerations across adoption.

The development and application of AI relies on diversity and inclusion. We must bring together diverse people with a mix of knowledge from different disciplines across academia, business, and end users. Research and innovation advances will not only rely on leading individuals, we need team approaches, particularly featuring technical professionals with the right skills to enable UK researchers and businesses to handle data and software professionally.

Disciplines must work together

The UK will not reap the benefits of AI unless a large range of disciplines bring their different perspectives to the work. Working alone, or in a single discipline is not enough for success; we need to do much more to promote interdisciplinary working. For example: doctors must be involved with technical researchers in the design of medical technology to ensure it is something they will use. Those working in the ethics of technology must be working with technical researchers otherwise they cannot understand the way the technology is being designed or influence it. This multi and interdisciplinary collaborative working must be central to the design of technologies that will be used by people in real-world situations.

Convening and networking

The UK has huge distributed strengths in a breadth of areas of AI research and innovation. In order to create a sustainable and inclusive UK AI ecosystem which brings together the UK's diverse strengths and identifies and delivers new opportunities for the UK, we need to bring our rich research and innovation communities together to enable collaboration and cross-fertilisation of ideas.

LabGenius - autonomizing the discovery of protein therapeutics with AI

LabGenius evolves novel therapeutic proteins using EVA, a next-generation protein engineering platform which integrates several bleeding-edge technologies from the fields of synthetic biology, robotics and machine learning.

Dr James Field and a group of fellow Imperial College PhD students founded LabGenius in 2012 to commercialise their protein engineering technology; the company has gone on to raise >\$13 million in private investment. An Engineering and Physical Sciences Research Council (EPSRC -funded PhD and funding from the Biotechnology and Biological Sciences Research Council BBSRC) and Innovate UK helped establish LabGenius.

James was named BBSRC Innovator of the Year in 2017 and has been listed in the Forbes 30 Under 30 Europe list of the most impressive young entrepreneurs that are reshaping Europe for the better. James is also a fellow of the prestigious Synthetic Biology Leadership Excellence Accelerator Program (LEAP).



Fostering business innovation

AI has the potential to create and underpin new advantage industries, and to transform the business models of existing organisations across all sectors of the economy. We must ensure that the environment is right for business to adopt AI and maximise the benefits of its use. This includes ensuring businesses can make the case to invest in AI, have access to data and the skills to make best use it, and that they are able to work with researchers and innovators on new products and services. To realise the potential business impacts, industry and entrepreneurs will work collaboratively with researchers and innovators across traditional research structures to develop new products, services, and business models for the UK.

Access to data assets

The UK has rich data assets but they are not always easy to access and use; this can be a significant barrier to AI researchers and innovators. Many researchers and innovators estimate that up to 80% of time on AI activities is actually spent on activities to pre-manage data. Issues faced by users include data discovery, quality, access, interoperability, portability, sharing, curation, governance, storage, and security. These issues have been explored by others, including the Open Research Data Task Force, the Open Data Institute^[20], The Alan Turing Institute^[21], HDRUK (Health Data Research UK)^[22] and ADR UK (Administrative Data Research UK)^[23] but there is more that needs to be done.

Computing power

Easy and open access to computing power for everyone is essential to the development of AI technologies. We need sustained investment in a range of facilities from cloud, laboratory and department scale through to supercomputing to ensure this is not a barrier to research and innovation. Without this investment in a range of facilities, compute capacity has a potential to become a barrier to AI research and innovation in the near future.

Collaborating internationally

The UK can only lead the world in AI if it is working on the international stage; all of our activities must enable collaboration, and we should seek international leadership opportunities for important and emerging areas. We must work with international partners in emerging areas of research and innovation where we have strengths, where we have common interests and where we have complementary strengths and resources, so that we can maximise the benefits from worldwide advances.

Engaging the public

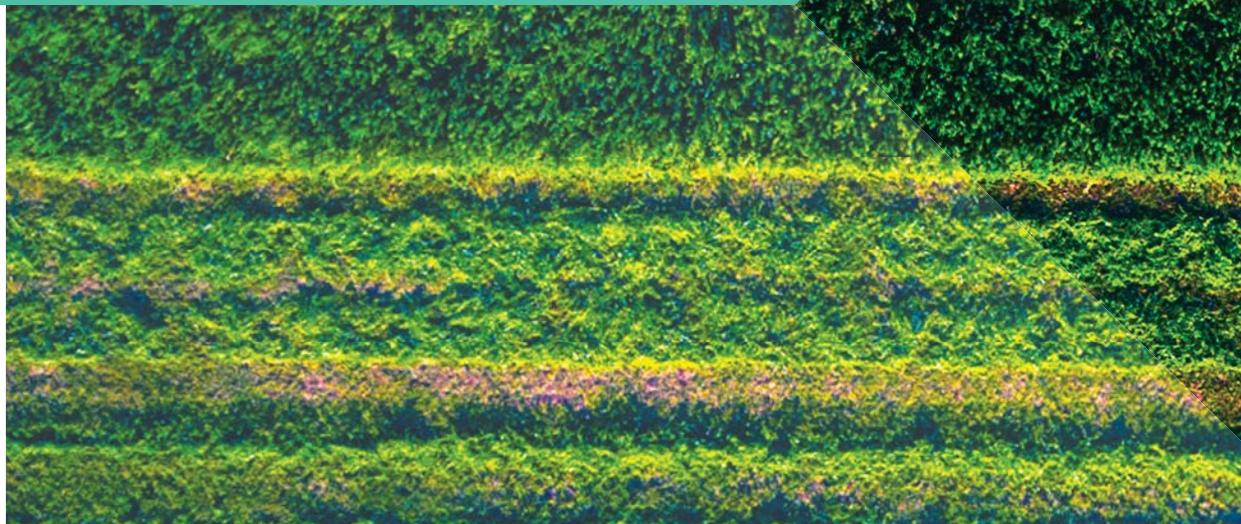
AI will impact all of society in some way. AI is creating new opportunities in every sector but it also raises genuine public concern. There is a pressing need for us to understand the impact AI will have on society and how the public perceive these impacts. AI researchers and innovators need to engage the public directly on AI, from public dialogues to explore directly public opinions and expectations on AI to communicating the benefits and impact of research and innovation being conducted to wider society. This engagement needs to be embedded into the AI research agenda and research process itself.



AI is already transforming our world, and it has the potential to drive substantial economic and social benefits for the UK across a wide range of sectors.

Our role and vision

In 20 years we expect AI's potential as a General Purpose Technology to have been realised. It will be pervasive, affecting the business, the economy, society, the environment, and the way we all live our lives. UKRI aims to support the UK to have the world leading AI research and innovation capability needed to realise the potential of AI in the UK.



UKRI operates in a complex landscape. Many of our investments in AI research and innovation have been made alongside other actors in this field, including government departments, health authorities, and other institutes and centres.

We have a unique role to play in developing and maintaining an environment in which the UK can maximise the benefits of AI. We must increase our investment in:

- developing new AI technologies and unleashing business innovation
- building the right environment for AI research and innovation to thrive

UKRI will work in partnership with a broad range of stakeholders to ensure we maintain the UK's leading position and realise the vast potential benefits of AI.

Our vision for AI

We aim to support the UK in remaining world leading in research and innovation for the next generation of AI technologies. The global marketplace is increasingly competitive. We want the UK to become more attractive for researchers and industry to research, innovate, develop, and deploy AI, and for cooperative action and collaboration to enhance the UK's strengths.

In 20 years, we expect AI to be pervasive – a part of the everyday products and services we use as we go about our daily lives. The public and private sectors will be using the power of AI to better understand UK data assets and make better decisions. It will be driving economic growth, and our workforce – academic, government and industry – will have the skills to reap the benefits across all sectors.

We will be harnessing the opportunities to maximise the societal benefits of AI across the UK and for diverse communities. There will be widespread public confidence that AI is being used in an ethical and responsible way for societal benefit.



UK Research and Innovation has a current investment portfolio of more than £1 billion supporting research and innovation activities related to AI. This breaks down as:



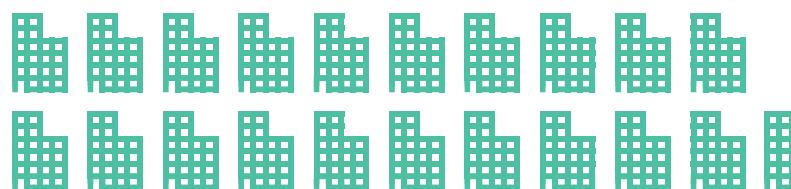
People and skills

including £100 million in AI centres for doctoral training



In research and innovation

including £129 million for novel AI algorithms, tools, and techniques, and £401 million in the applications and implications of AI



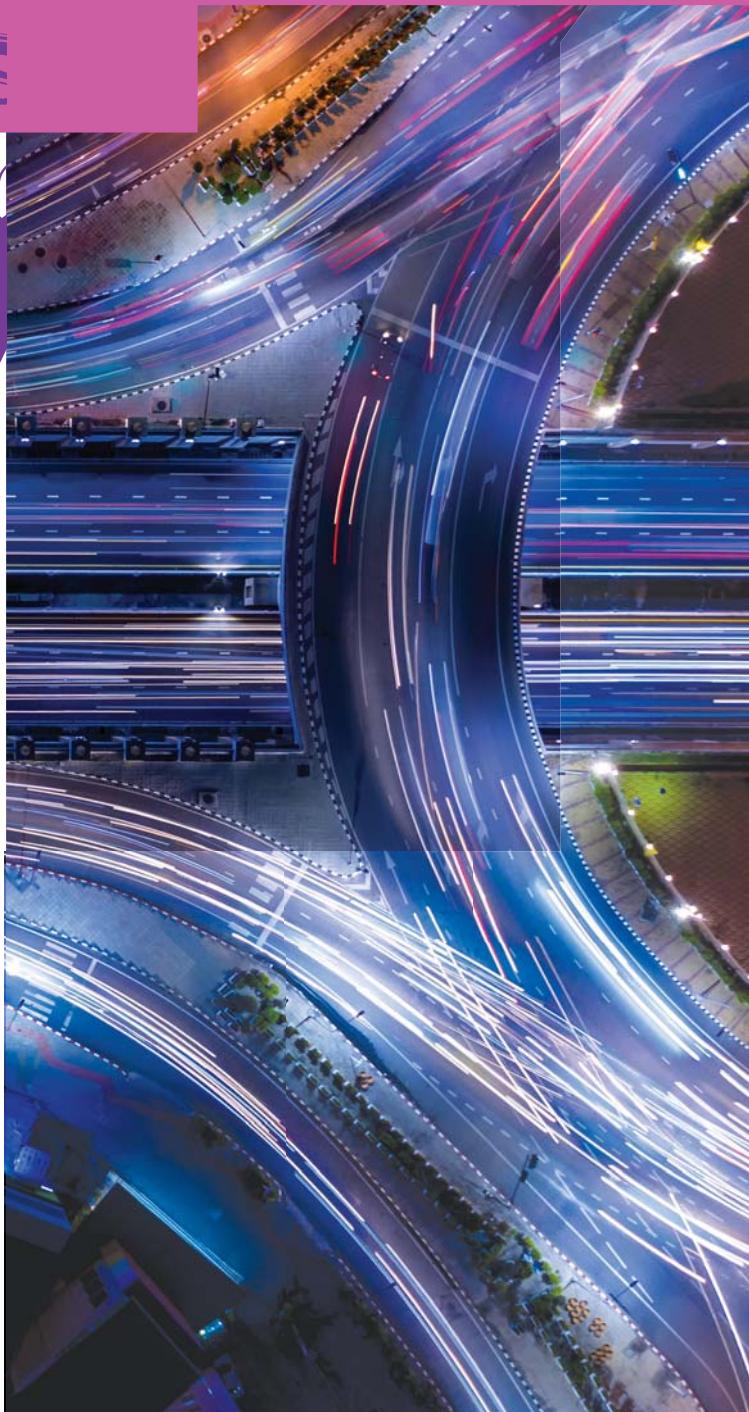
In key strategic investments using or supporting the development of AI

including supporting The Alan Turing Institute, the Hartree Centre^[24], Health Data Research UK^[22], and AI-relevant investments made through the Industrial Strategy Challenge Fund and Strategic Priorities Fund

Businesses have matched Innovate UK and EPSRC support with investments of at least £265 million in cash and in-kind contributions. The Catapult network of technology centres, supported by us and by third parties, also play a role in investing in AI and bringing in further private investment. The data above represents a snapshot of the UKRI portfolio of investments relevant to AI Research and Innovation in April 2019.

The opportunity

At this juncture the UK has a key opportunity to maintain and build its international position in AI, and to realise the significant potential impacts of AI on society, the economy, and the environment. Taking this opportunity will require world-leading research and innovation.



UKRI aims to support the world-leading research and innovation activity needed to build on the country's globally leading capabilities, and to build a strong and supportive UK ecosystem for AI research and innovation.

UKRI will seek to support:

- creative discovery-led research that delivers the next generation of transformative AI technologies
- new capabilities and understanding that deliver responsible and trustworthy AI technologies designed with an understanding of the real-world context in which they will be used, and drawing from public opinions and perceptions
- bringing researchers, innovators, and problem owners together for application-driven research and innovation in discovery science and in areas such as health, the environment, agriculture, and security, and government policy

We will ensure that the UK has the right environment for world-leading researchers and innovators to thrive including by:

- supporting the development of a networked and interconnected UK AI research and innovation community, convened by a central body building on the successes of The Alan Turing Institute
- facilitating businesses to develop and deploy cutting-edge AI to increase business productivity, resilience and competitiveness across the economy
- recruiting, developing, and retaining the best people with the broadest skills and approaches to develop and use the AI technologies of the future
- working to ensure that access to data and compute capacity is not a barrier to research and innovation
- promoting the interdisciplinarity and cross-sector working needed for successful advances in AI
- working internationally on excellent AI research and innovation and shared opportunities
- enabling public engagement with AI to be embedded in our research and innovation

Promoting discovery-led research

Support for novel AI technologies will be at the heart of our work. We must build on our strengths in mathematical and computational

sciences to develop capability and capacity in AI across all disciplines and sectors. We must invest in the blue-skies creative research needed to ensure the UK remains at the forefront of global AI research and development.

Delivering responsible AI

We will work to develop new capabilities and understandings that ensure AI technologies are responsible and trustworthy and designed with an understanding of the real-world context in which they will be used. We will work with partners to deliver public dialogues on AI, its use, its future, its implications and embed public engagement in AI research and innovation. We will seek to bring together technical researchers, humanities and social sciences researchers, and users of AI to design technologies that:

- reflect and support human and societal values
- are designed for user privacy and to limit unjust bias
- are transparent and explainable to those they impact
- are reliable, robust, safe, and secure

Enabling application-driven research and innovation

We will promote the development of AI to meet specific applications and high-priority challenges, such as the net zero greenhouse gas emissions target by 2050, pandemic response, feeding a growing world population sustainably and keeping an ageing population active and healthy. This will involve helping researchers and innovators to collaborate with those in the public, private, and third sectors looking for solutions to those challenges. We will also play our part in ensuring that researchers and innovators across UK universities, institutes, businesses, Catapults and public sector research organisations are working to their strengths individually and together as part of a single network.

Developing AI for use in the real world

We will sponsor research to understand the contexts in which AI is being deployed and in the potential societal and economic impacts

of its use. A key aspect of this will be bringing together researchers in social sciences and the humanities with technical researchers to create the right environment for responsible research and innovation. We will seek to connect the research and innovation community with key regulatory and governmental bodies and ensure that the UK takes a lead internationally in the standardisation of AI.

Supporting business innovation

We will develop business innovation support to facilitate the uptake of cutting-edge AI across businesses of all sizes to generate value and jobs in the UK. We will support startups and small businesses working in AI to accelerate their growth. We will seek to:

- help businesses to understand the impact of AI and how to act on their interest
- encourage the development of cutting-edge products and services by supporting knowledge transfer between academics and businesses, for example through Knowledge Transfer Partnerships and collaborative research and development
- encourage greater private investment including by supporting efforts to increase productivity in data engineering and lower the costs to business
- drive adoption of AI across companies of all sizes and sectors by supporting business-led feasibility studies and demonstrators that allow businesses to take their first steps in developing and deploying AI and understanding the return on investment
- support researchers and innovators to bring in social science and creative/design expertise to ensure that user-friendly AI will be adopted

Developing diverse talent across the UK

We will support the development of skills and talent across research and innovation from early career researchers to world-leading researchers and innovators. This will include seeking to attract, retain, and develop, diverse people and teams; creating a healthy talent pipeline and building our capacity by upskilling UK researchers and innovators and bringing in international talent. We will enable inclusive



team-based approaches to AI research and innovation, with forward-thinking research cultures. We will facilitate the creation of flexible ways for academics and businesses to work together. We will work with other stakeholders across the public and private sectors to build and support a strong UK digital skills ecosystem, with support across the career pipeline built around the opportunities and inspiration AI presents.

Feasibility study funding launched a multi-million pound tech business

A business that started life after winning a £15,000 Innovate UK award to test out the feasibility of an idea went on to install its predictive keyboard on hundreds of millions of smart devices and to join Microsoft in a deal worth a reported \$250 million.

SwiftKey was founded by Cambridge graduates Jon Reynolds and Ben Medlock who had the idea to use natural language processing and machine learning to predict how individuals use language and their devices to make typing on mobile phones and tablets much simpler.

Following the initial Innovate UK award in 2008 that allowed the pair to give up their day jobs, a subsequent award of £50,000 allowed them to prototype the app. SwiftKey was downloaded by more than 100,000 people in the first week of its launch in 2010. The company grew quickly to employ 150 people and was eventually acquired by Microsoft in 2017. At that point, its technology was installed on 300 million devices.

We will seek to increase the number of technical professionals, such as research software engineers and professional data scientists, so UK researchers and businesses from any discipline or sector have the skills and knowledge to help them access data and develop and use AI technologies. We will work with partners in the field to support the broader level-up of digital skills across the UK.

Promoting interdisciplinary working

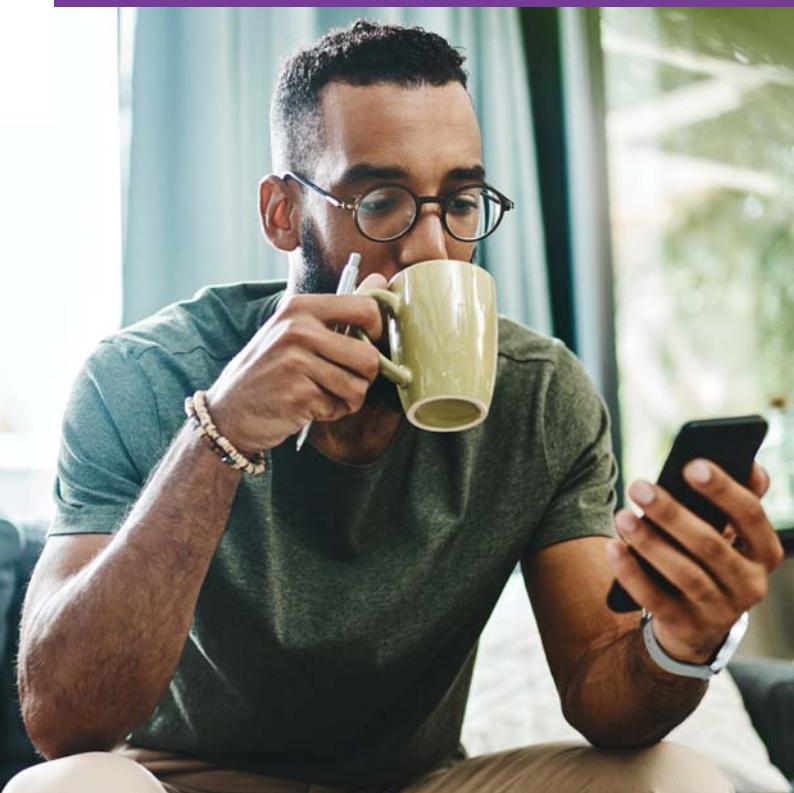
We will support researchers and innovators in developing their ability to work with other disciplines and experts and in applying their skills in areas of expertise that are not their own. We will help to create the space and time for communities to come together, promote the diversity and inclusion required for successful research and innovation in AI, and improve the way we design and run multidisciplinary research programmes.

Harnessing the power of the UK community

Networking and convening the research community across the UK will allow us to harness the currently distributed strengths of the UK research base. We will seek to build on the successes of The Alan Turing Institute to enable a truly national institute which will act as a convenor and broker between researchers, innovators, policy makers, businesses, and other stakeholders, building critical connections across the the UK AI research and innovation landscape and enabling cooperative action.

Use of data assets and computer capacity

The ability to access and use data for research and innovation is essential for both researchers of discovery science and those applying AI. Integrating technological innovations within AI with UKRI's wider ambitions on open research data could transform open research, allowing research data to be openly available in a way that is legal, ethical and economic. We will consider taking a prominent role in the development of the open research data agenda.



This is likely to include:

- undertaking a review of open research data and practice across UKRI to ensure that UK research is findable, accessible, interoperable and re-usable (Go FAIR)^[25] and as open as possible
- ensuring, where possible, that data generated through our investments is accessible and usable
- supporting provision and creation of data resources
- exploring how key data sets, for example standardised and anonymised health data, can be provided for research and innovation
- supporting innovative new approaches to data storage, sharing, and access
- seeking to make the case for a long-term approach to growing computing and network capacity.

Fostering international collaboration

We will support UK researchers and innovators to work with international leaders in areas where we are strong and that are in line with the strategic priorities of the UK. We will ensure international collaborations are driven both by research and innovation excellence and our expectations around responsible AI.

Public engagement

We will aim to enable UK researchers and innovators to undertake public engagement as part of their research and innovation activities, so that they can request the training, tools and time required to ensure their research is informed by public opinion. We will enable UK AI researchers and innovators to communicate the benefits and impacts of their research. We will work in partnership with other stakeholders to draw our researchers and innovators into a wider public engagement landscape and explore complex aspects of AI via public dialogues.

British band uses UK-developed AI to rewrite chart-topping album

In 2019, UKRI-funded researchers turned their music-generating AI platform loose on global music phenomenon Massive Attack's album Mezzanine. The creative AI project, MIMIC (Musically Intelligent Machines Interacting Creatively), uses artificial neural networks that can be trained more quickly than has been possible in the past and results in higher quality audio outputs. The MIMIC platform is usable by artists, not just computer scientists. The system can learn from and build upon what the researchers describe as the "texture" of an artist's sound and aims to enable people to understand and apply machine learning to their own creative work.

In this case, the MIMIC platform remixed Mezzanine – a number one album on the British charts in 1998 – in collaboration with the band, leading to a 5-year touring exhibition produced by the Barbican and the Tokyo Science Museum. One journalist described the remix as "a singular piece that is continuously being updated and extended, like a band who doesn't know when to stop riffing on the last track of a live set." Massive Attack has also used MIMIC to create new digital instruments for their 20th anniversary tour to celebrate Mezzanine.

The MIMIC platform has been designed to make machine learning software more accessible for artists and musicians, and is being used to deliver new online courses in collaboration with UK MOOC provider, FutureLearn. These cover a wide variety of topics in machine learning and creativity, and have attracted over 35,000 users in the first three months of launching.

MIMIC is now in its third year of funding from AHRC and has been developed by researchers at Goldsmith's College, University of the Arts London, Durham University, and the University of Sussex. More information is available at <https://www.mimicproject.com/>.



Transforming the UK with AI

In this document we set out the opportunity for the UK to enable the development of better AI technologies that meet the demands of real-world challenges, and contribute to economic prosperity, societal wellbeing and a net zero environment. We have also set out the crucial role that support for research and innovation will play in realising this opportunity.

AI will transform the UK over the next 20 years. We have an opportunity to ensure that this transformation brings the maximum benefits to the UK economy and society and that it results in new technologies that we can all trust and rely on.

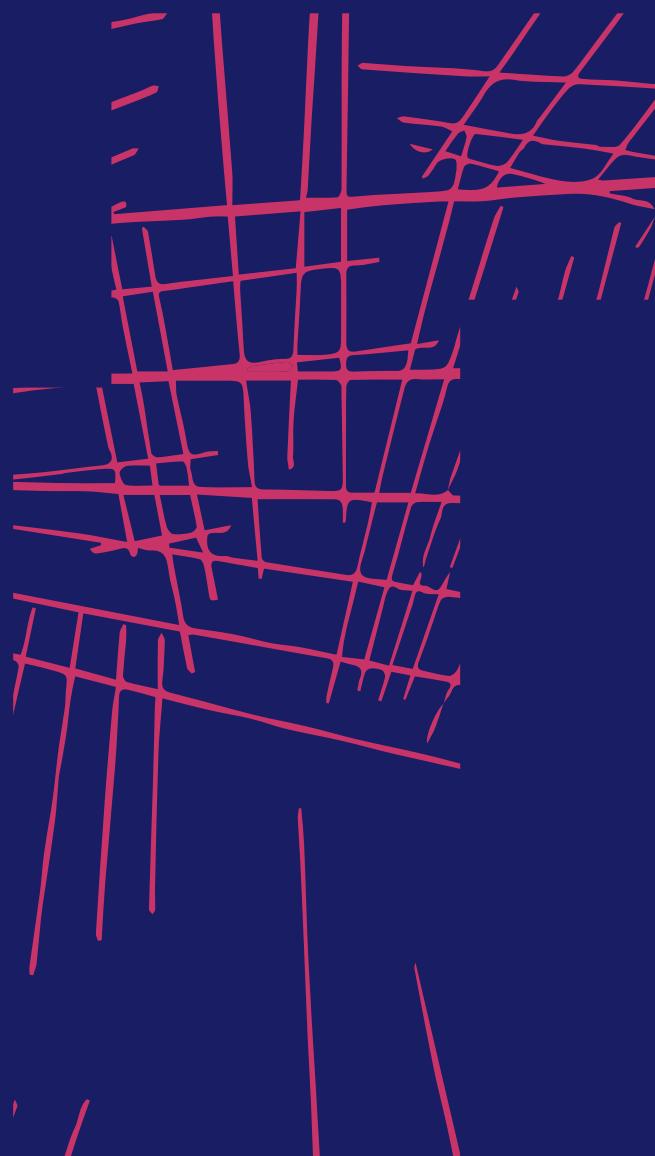
This document sets out UKRI's view of the opportunities for research and innovation in AI in the UK, as determined through the UKRI AI Review. In it we set out our aspirations for supporting transformational activities, and for working with our partners to place the UK in a strong position to realise the vast potential benefits of AI.

Our vision for AI in the UK is ambitious; realising it in full will require substantial new and sustained public investment in AI technologies. The benefits of making that investment could be substantial to our future wealth, health, and wellbeing.



Annex 1

Membership of UKRI and external advisory groups working on the review

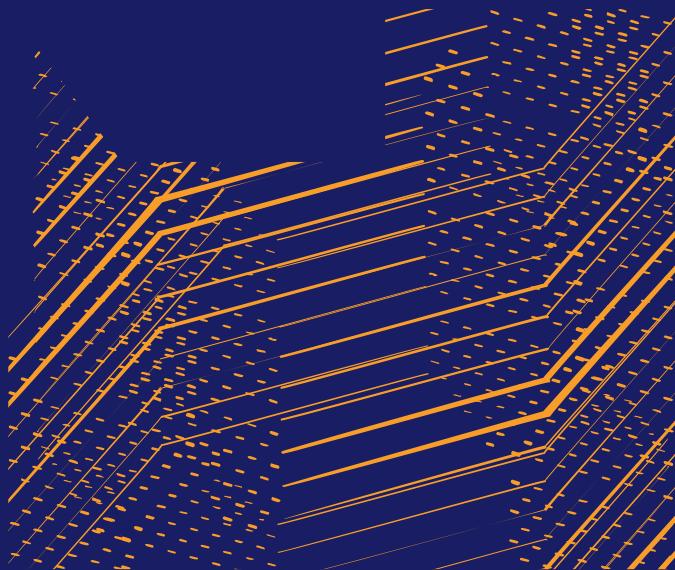


External Advisory Group	Steering Group	Project Group
Tom Rodden, CSA DCMS	Kathryn Magnay (EPSRC)	Renée van de Locht (EPSRC)
Mustafa Suleyman, Deep Mind	Anna Angus-Smyth (EPSRC)	Sara El-Hanfy (Innovate UK)
Wendy Hall, University of Southampton	Zoe Webster (Innovate UK)	Luke Moody (ESRC)
Mike Short, CSA for DIT	Edward Harcourt (AHRC)	Barbara Camanzi (STFC)
Natasha McCarthy, Royal Society	Paul Nightingale (ESRC)	Dawn Greenberg (AHRC)
Nick Jennings, Imperial College London	Alison Kennedy (STFC)	Daniela Hensen (BBSRC)
Adrian Smith, Alan Turing Institute	Barbara Camanzi (STFC)	Ekaterini Blaveri (MRC)
Adrian Johnston, Digital Catapult	Claire Newland (MRC)	Sarah Campbell (NERC)
Shefaly Yogendra, Ditto AI	Simon Gardner (NERC)	Laura Cadman (EPSRC)
Tony McEnery, Lancaster University	Steven Hill (RE)	Victoria Mico Egea (EPSRC)
Luke Readman, NHS	Amanda Collis (BBSRC)	Nina Cox (EPSRC)
David Smith, Scottish Enterprise	Peter Burlinson (BBSRC)	Ruqaiyah Patel (EPSRC)
Moritz Gerstung, EBI	Emily Swaine (UKRI Strategy Directorate)	Eleanor Lech (BBSRC)
	Sam McGregor (AHRC)	Deborah Kroll (AHRC)
	James Hetherington (UKRI)	Sasha Leigh (ESRC)
	Freya Pascall (Office for AI)	Laura Totterdell (EPSRC)



Annex 2

Alphabetical list of stakeholders engaged in the review



Input was sought from representatives of the following organisation as part of the UKRI AI Review. This document does not represent the specific views of any of the organisations named below.

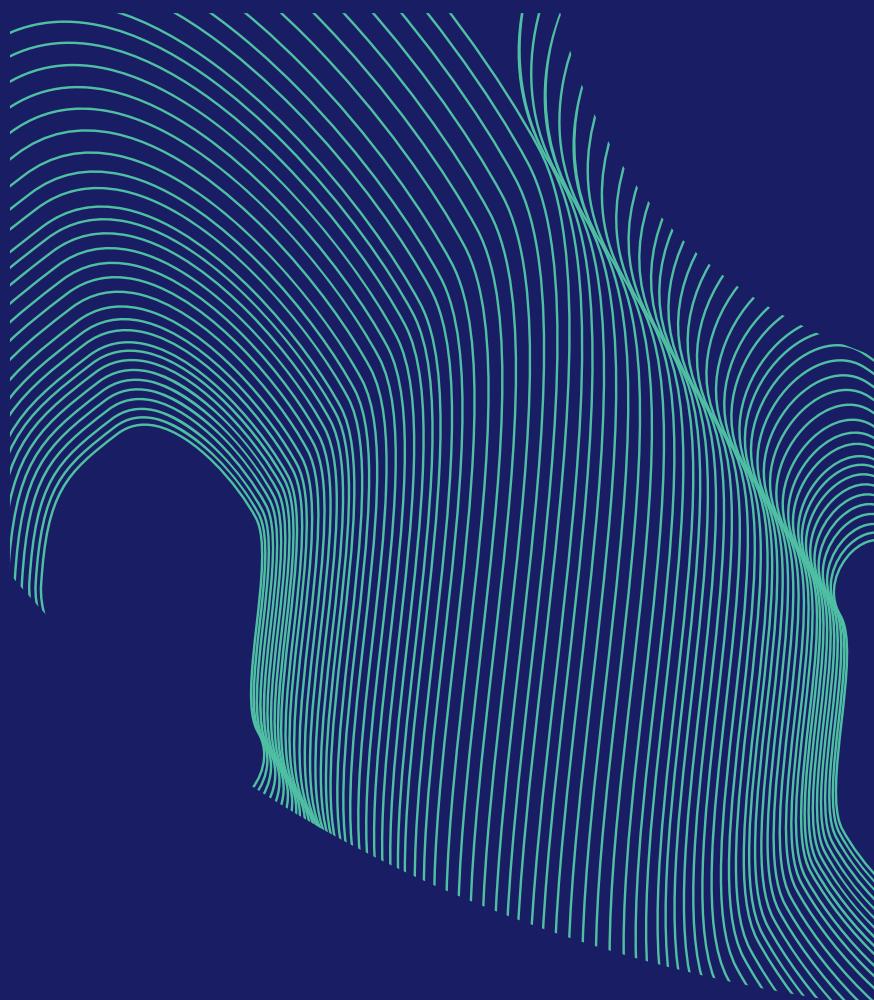
A L Tozer Ltd	C.W Fetcher	Digital Catapult
AB Agri	Cambrium LLP	Ditto.AI
AbacusBio International Limited	Cardiff University	Doteveryone
Aberystwyth University	Cell and Gene Therapy Catapult	Double Negative Visual Effects Ltd
Ada Lovelace Institute	Censis	Driveworks Ltd
ADAS	Centre for Crop Health and Protection	Durham University
Additive Automations	Centre for Data Ethics and Innovation	E4 Structures
Agricultural Engineering Precision Innovation Centre	Centre for Ecology and Hydrology	Earlham Institute
Agrimetrics	Centre for Environmental Data Analysis	Ecometrica
AI Labs	Centre for Innovation Excellence in Livestock	Edinburgh Napier University
Airbus	Centre for Interdisciplinary Methodologies	Edinburgh Parallel Computing Centre
AirSensa	Charisma AI	Effective Space Solutions Ltd
Allstate Northern Ireland	Chief Scientist Office (Scotland)	Electron
Almac Diagnostic Services	Circadian	Elemendar
Amazon	City University	Emu Analytics
Amey	ClearSky Medical Diagnosis	Encirc Ltd
Ampliphae	Clogworks Technologies Limited	Energy Systems Catapult
Analytics Engine	Codeplay	Environment Agency
Anglezarke Life Sciences	Committee on Standards in Public Life	Environmental Information Data Centre
Anomalous	Compound and Semiconductor Applications Catapult	European Bioinformatics Institute
Archangel Imaging	Computational & Systems Biology, Manchester	European Organization for Nuclear Research
Arm Limited	Computer Science, Newcastle	Facebook
Arup	Congenica	Falmouth University
AstraZeneca	Connected Places Catapult	FERA (previously the Food and Environment Research Agency)
Atkins	CorrosionRADAR Ltd	FiveAI
Atos	Coventry University	Food and Drink Sector Council
Autocraft Solutions Group	Craft Prospect	Forged Innovation Limited
Axial 3D	Cranfield University	Francis Crick Institute
BAE Systems	Crossword Cybersecurity plc	Fresh4cast Ltd
Barfoots	Darktrace	FTI Consulting
BBC	De Montfort University	Future Screens NI
BBC Northern Ireland	Deep Mind	GE Healthcare Ltd
Belfast Harbour	Defence Science and Technology Laboratory	General Electric
BenevolentAI	DEFT153	GeoLang Limited
Bibby Hydromap	Deimos Space UK	Geospatial Commission
BioExtraction Ltd	DEMOS	Get Living It Ltd
Blacklaws Consulting	Department for Business, Energy & Industrial Strategy	GlaxoSmithKline
BLP Insurance	Department for Digital, Culture Media & Sport	Global Open Data for Agriculture and Nutrition
BOC	Department for Environment, Food & Rural Affairs	Google Brain
BPS Birmingham	Department for International Trade	Graham Oakes Ltd
BrainWaveBank Ltd	Department of Health and Social Care England)	Graphcore
Bristol, North Somerset and South Gloucestershire Clinical Commissioning Group		Grid Smarter Cities
British Antarctic Survey		G's Growers
British Board of Film Classification		Gyana
British Broadcasting Corporation		Harper Adams University
British Geological Survey		Health and Care Research Wales
British Oceanographic Data Centre		Health and Social Care R&D Northern Ireland
British Standards Institution		
BT Research		

Health Data Research UK	National Centre for Earth Observation	Science and Technology Facilities
Health Research Authority	National Centre for Food Manufacturing (Lincoln)	Council Particle Physics
Heriot-Watt University	National Grid	Department
Hexit Lab Ltd	National Institute for Health Research	SCISYS
HiETA Technologies	National Oceanography Centre	Scotland's Rural College
High Value Manufacturing Catapult	National Physics Laboratory	Scottish Enterprise
Hosokawa Micron	Nesta	Seagate
Hudson Procurement Group	Network Rail	Sellafield Ltd
Humain	Newcastle University	Shadow Robot Company
ICAEW	NHSX	Sheffield Hallam University
Immense Simulations	Nissan Motor Manufacturing UK (NMUK)	Shell
Imperial College London	Northern Ireland Screen	Sidaway Technologies Ltd
Industrial Biotechnology Innovation Centre	Northumbria University	Siemens
Informatic Lab	Nottingham University Hospitals NHS Trust	Simmons Wavelength
Information Catalyst for Enterprise	NquiringMinds	Sirius
InnoTecUK	NVIDIA Limited	Software Sustainability Institute
Innvoteck Ltd	Observatory for Responsible Research and Innovation in ICT	Sonrai Analytics
International Business Machines Corporation	Office for AI	Space 4 Climate
Invest NI	Offshore Renewable Energy Catapult	Space Syntax
IRIS Software	Open Climate Fix	Swansea Academy of Advanced Computing
Italic Pig Ltd	Open Data Institute	Swansea University
ITS Ltd	Operational Research, Cardiff	Tata Steel
Jellybooks Ltd	Optibrium	Teesside University
John Innes Centre	Orchestra	Telefonica O2 UK
Kainos	Ordnance Survey	Tesco
Keele University	Oxford Biomedica	Thales
King's College London	Oxford Internet Institute	Tharsus
Knowledge Transfer Network	Pfizer	The Alan Turing Institute
KX First Derivatives	Philips Research	The Data Lab
Laing O'Rourke	Pilkington (NSG Group)	The Floow Ltd
Lancaster University	Pirbright	The Francis Crick Institute
Leeds Institute of Molecular Medicine	PricewaterhouseCoopers International Limited	The Manufacturing Technology Centre
Leeds Teaching Hospitals NHS Trust	Process Systems Enterprise Ltd	The National Farmers Union Mutual Insurance Society Limited
Leonardo MW Ltd	Queen Mary University of London	The Oil & Gas Innovation Centre
Liberty IT	Queen's University Belfast	The Roslin Institute
Lionshead Law	Randox	The University of Manchester
Lloyd's register Group	Reform UK	The University of Sheffield Advanced Manufacturing Research Centre (AMRC)
London College of Fashion	Renishaw plc	Tinsley Bridge
Loughborough University	Rock Solid Reserve Limited	To Play For
Lycra	Rolls Royce	Toshiba
Managing Partners' Forum	Rothamsted Research	UK Research and Innovation
Manufacturing Tech Centre	Rovco	Ulster University
Map of Ag	Royal Academy of Engineering	University College London
Matrix	Royal Holloway	University of Aberdeen
Medicines Discovery Catapult	Royal Mail	University of Bath
Merralls Consulting Ltd	Royal Shakespeare Company	University of Birmingham
Met office	Royal Society	University of Bristol
Microsoft	RPPtv Ltd	University of Cambridge
Mines Paris Tech	Rutherford Appleton Laboratory	University of Cranfield
Mondelez	Sainsburys Supermarket	University of Dundee
Moy Park	Satellite applications catapult	University of Edinburgh
Naaut		
National Centre for Atmospheric Science		

University of Exeter
University of Glasgow
University of Lancaster
University of Leeds
University of Leicester
University of Lincoln
University of Liverpool
University of Nottingham
University of Oxford
University of Reading
University of Sheffield
University of Southampton
University of St Andrews
University of Stirling
University of Strathclyde
University of Surrey
University of Sussex
University of the West of England
University of Warwick
University of York
Urban Tide
UtterBerry Ltd
Valuechain Technology
Vidronia
Vivacity Labs
Wayve
Wessex Water
Wood PLC
XR Stories York



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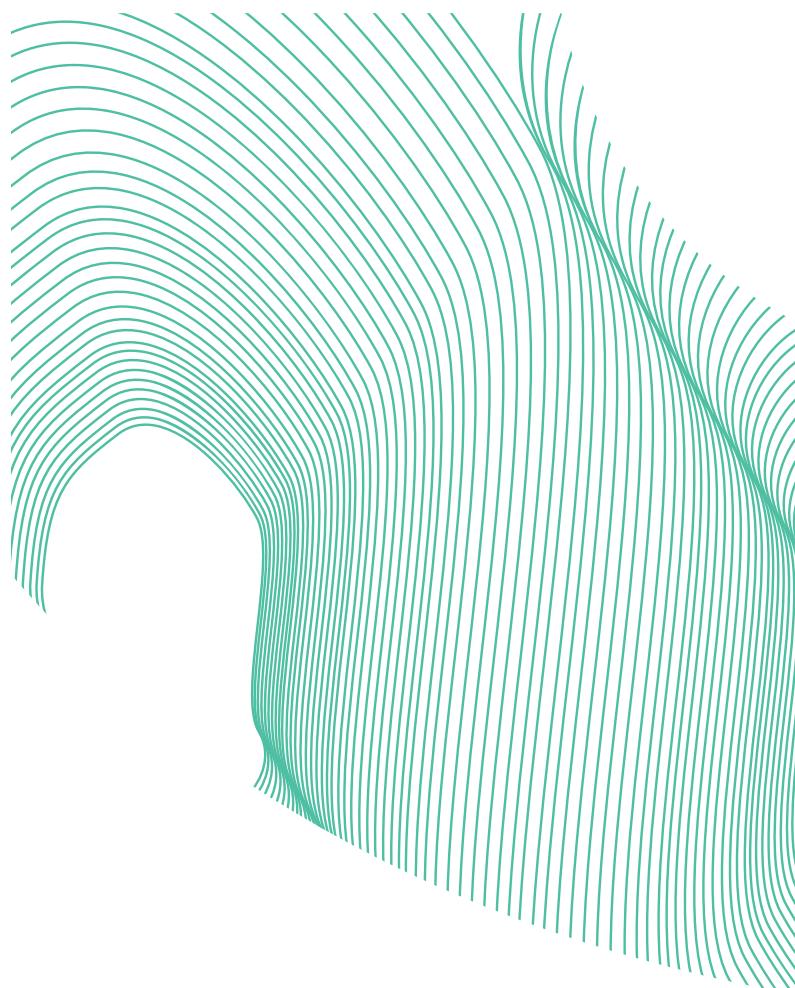
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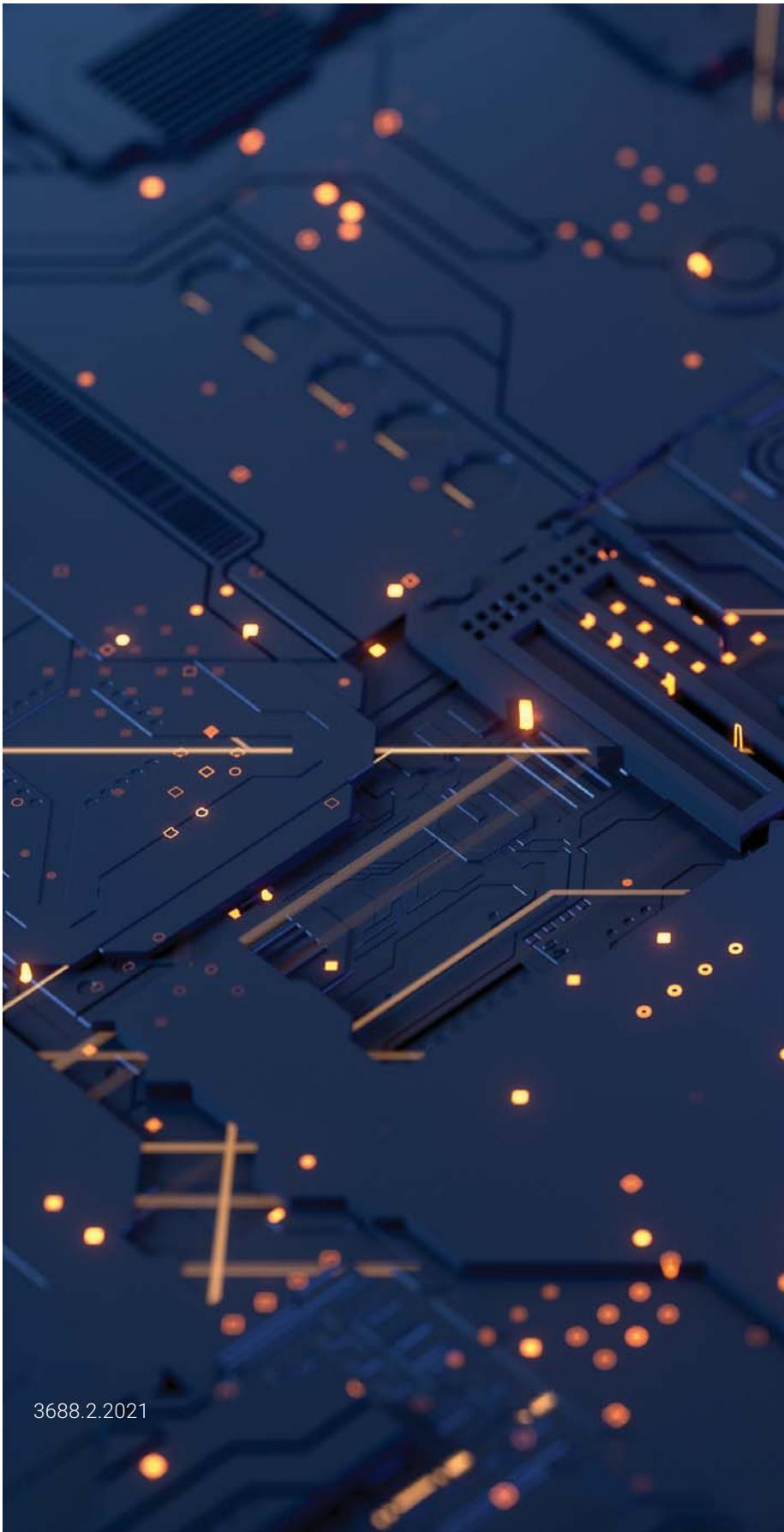
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