Department for Business, Energy & Industrial Strategy
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Office for Artificial Intelligence

Guidance

National AI Strategy - HTML version

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Our ten-year plan to make Britain a global AI superpower

Over the next ten years, the impact of AI on businesses across the UK and the wider world will be profound - and UK universities and startups are already leading the world in building the tools for the new economy. New discoveries and methods for harnessing the capacity of machines to learn, aid and assist us in new ways emerge every day from our universities and businesses.

AI gives us new opportunities to grow and transform businesses of all sizes, and capture the benefits of innovation right across the UK. As we build back better from the challenges of the global pandemic, and prepare for new challenges ahead, we are presented with the opportunity to supercharge our already admirable starting position on AI and to make these technologies central to our development as a global science and innovation superpower.

With the help of our thriving AI ecosystem and world leading R&D system, this National AI Strategy will translate the tremendous potential of AI into better growth, prosperity and social benefits for the UK, and to lead the charge in applying AI to the greatest challenges of the 21st Century.

The Rt Hon Kwasi Kwarteng MP
Secretary of State for Business, Energy and Industrial Strategy

This is the age of artificial intelligence. Whether we know it or not, we all interact with AI every day - whether it's in our social media feeds and smart speakers, or on our online banking. AI, and the data that fuels our algorithms, help protect us from fraud and diagnose serious illness. And this technology is evolving every day.

We've got to make sure we keep up with the pace of change. The UK is already a world leader in AI, as the home of trailblazing pioneers like Alan Turing and Ada Lovelace and with our strong history of research excellence. This Strategy outlines our vision for how the UK can maintain and build on its position as other countries also race to deliver their own economic and technological transformations.

The challenge now for the UK is to fully unlock the power of AI and data-driven technologies, to build on our early leadership and legacy, and to look forward to the opportunities of this coming decade.

This National AI Strategy will signal to the world our intention to build the most pro-innovation regulatory environment in the world; to drive prosperity across the UK and ensure everyone can benefit from AI; and to apply AI to help solve global challenges like climate change.

AI will be central to how we drive growth and enrich lives, and the vision set out in our strategy will help us achieve both of those vital goals.

Nadine Dorries MP
Secretary of State for Digital, Culture, Media and Sport

Executive summary

Artificial Intelligence (AI) is the fastest growing deep technology[footnote 1] in the world, with huge potential to rewrite the rules of entire industries, drive substantial economic growth and transform all areas of life. The UK is a global superpower in AI and is well placed to lead the world over the next decade as a genuine research and innovation powerhouse, a hive of global talent and a progressive regulatory and business environment.

Many of the UK's successes in AI were supported by the 2017 Industrial Strategy, which set out the government's vision to make the UK a global centre for AI innovation. In April 2018, the government and the UK's AI ecosystem agreed a near £1 billion AI Sector Deal to boost the UK's global position as a leader in developing AI technologies. This new National AI Strategy builds on the UK's strengths but also represents the start of a step-change for AI in the UK, recognising the power of AI to increase resilience, productivity, growth and innovation across the private and public sectors. This is how we will prepare the UK for the next ten years, and is built on three assumptions about the coming decade:

- The key drivers of progress, discovery and strategic advantage in AI are access to people, data, compute and finance – all of which face huge global competition;
- AI will become mainstream in much of the economy and action will be required to ensure every sector and region of the UK benefit from this transition;
- Our governance and regulatory regimes will need to keep pace with the fast-changing demands of AI, maximising growth and competition, driving UK excellence in innovation, and protecting the safety, security, choices and rights of our citizens.

The UK's National AI Strategy therefore aims to:

1. **Invest and plan for the long-term needs of the AI ecosystem** to continue our leadership as a science and AI superpower;
2. **Support the transition to an AI-enabled economy,** capturing the benefits of innovation in the UK, and ensuring AI benefits all sectors and regions;
3. **Ensure the UK gets the national and international governance of AI technologies righ** t to encourage innovation, investment, and protect the public and our fundamental values.

This will be best achieved through broad public trust and support, and by the involvement of the diverse talents and views of society.

Summary of key actions

	Investing in the long-term needs of the AI ecosystem	Ensuring AI benefits all sectors and regions	Governing AI effectively
Short term (next 3 months):	• Publish a framework for government's role in enabling better **data** availability in the wider economy • Consult on the role and options for a National **Cyber-Physical Infrastructure Framework** • Support the development of AI, data science and digital skills through the **Department for Education's Skills Bootcamps**	• Begin engagement on the Draft National Strategy for AI-driven technologies in **Health and Social Care**, through the NHS AI Lab • Publish the **Defence AI Strategy**, through the Ministry of Defence • Launch a consultation on **copyright and patents for AI** through the IPO	• Publish the CDEI **assurance** roadmap • Determine the role of data protection in wider AI governance following the **Data: A new direction consultation** • Publish details of the **approaches the Ministry of Defence will use when adopting and using AI** • Develop an **all-of-government approach to international AI activity**
Medium term (next 6-12 months):	• Publish research into what **skills** are needed to enable employees to use AI in a business setting and identify how national skills provision can meet those needs • Evaluate the **private funding** needs and challenges of AI scaleups • Support the National Centre for Computing Education to ensure AI programmes for schools are accessible • **Support a broader range of people to enter AI-related jobs** by ensuring career pathways highlight opportunities to work with or develop AI • Implement the **US UK Declaration on Cooperation in AI R&D** • Publish a review into the UK's **compute** capacity needs to support AI innovation, commercialisation and deployment • Roll out **new visa regimes** to attract the world's best AI talent to the UK	• Publish research into opportunities to encourage **diffusion of AI** across the economy • Consider how **Innovation Missions** include AI capabilities, such as in energy • Extend UK aid to support local innovation in developing countries • Build an open **repository of AI challenges** with real-world applications	• Publish White Paper on a pro-innovation national position on **governing and regulating AI** • Complete an in-depth analysis on algorithmic transparency, with a view to develop a cross-government standard • Pilot an **AI Standards** Hub to coordinate UK engagement in AI standardisation globally • Establish medium and long term horizon scanning functions to **increase government's awareness of AI safety**
Long term (next 12 months and beyond):	• Undertake a review of our international and domestic approach to **semiconductor supply chains** • Consider what **open and machine-readable government datasets** can be published for AI models • Launch a new **National AI Research and Innovation Programme** that will align funding programmes across UKRI and support the wider ecosystem • **Back diversity in AI** by continuing existing interventions across top talent, PhDs, AI and Data Science Conversion Courses and Industrial Funded Masters • Monitor and use National Security and Investment Act to protect **national security** while keeping the UK open for business • **Include trade deal provisions in emerging technologies**, including AI	• Launch joint Office for AI / UKRI programme to stimulate the development and **adoption of AI** technologies in high potential, lower-AI-maturity sectors • Continue supporting the development of capabilities around **trustworthiness, adoptability, and transparency** of AI technologies through the National AI Research and Innovation Programme • Join up across government to identify where **using AI can provide a catalytic contribution to strategic challenges**	• Explore with stakeholders the development of an AI **technical standards engagement** toolkit to support the AI ecosystem to engage in the global AI standardisation landscape • **Work with global partners on shared R&D challenges**, leveraging Overseas Development Assistance to put AI at the heart of partnerships worldwide • Work with The Alan Turing Institute to **update guidance on AI ethics and safety in the public sector** • Work with national security, defence, and leading researchers to **understand what public sector actions can safely advance AI and mitigate catastrophic risks**

Introduction

Artificial Intelligence technologies (AI) offer the potential to transform the UK's economic landscape and improve people's lives across the country, transforming industries and delivering first-class public services.

AI may be one of the most important innovations in human history, and the government believes it is critical to both our economic and national security that the UK prepares for the opportunities AI brings, and that the country is at the forefront of solving the complex challenges posed by an increased use of AI.

This country has a long and exceptional history in AI – from Alan Turing's early work through to DeepMind's recent pioneering discoveries. In terms of AI startups and scaleups, private capital invested and conference papers submitted, the UK sits in the top tier of AI nations globally. The UK ranked third in the world for private investment into AI companies in 2020, behind only the USA and China.

The National AI Strategy builds on the UK's current strengths and represents the start of a step-change for AI in the UK, recognising that maximising the potential of AI will increase resilience, productivity, growth and innovation across the private and public sectors. Building on our strengths in AI will take a whole-of-society effort that will span the next decade. This is a top-level economic, security, health and wellbeing priority. The UK government sees being competitive in AI as vital to our national ambitions on regional prosperity and for shared global challenges such as net zero, health resilience and environmental sustainability. AI capability is therefore vital for the UK's international influence as a global science superpower.

The National AI Strategy for the United Kingdom will prepare the UK for the next ten years, and is built on three assumptions about the coming decade:

- The key drivers of progress, discovery and strategic advantage in AI are access to people, data, compute and finance – all of which face huge global competition;
- AI will become mainstream in much of the economy and action will be required to ensure every sector and region of the UK benefit from this transition;
- Our governance and regulatory regimes will need to keep pace with the fast-changing demands of AI, maximising growth and competition, driving UK excellence in innovation, and protecting the safety, security, choices and rights of our citizens.

This document sets out the UK's strategic intent at a level intended to guide action over the next ten years, recognising that AI is a fast moving and dynamic area. Detailed and measurable plans for the execution of the first stage of this strategy will be published later this year.

The UK's National Artificial Intelligence Strategy will:

1. Invest and plan for the long term needs of the AI ecosystem to continue our leadership as a science and AI superpower;
2. Support the transition to an AI-enabled economy, capturing the benefits of innovation in the UK, and ensuring AI benefits all sectors and regions;
3. Ensure the UK gets the national and international governance of AI technologies right to encourage innovation, investment, and protect the public and our fundamental values.

This will be best achieved through broad public trust and support, and by the involvement of the diverse talents and views of society.

10-Year Vision

Over the next decade, as transformative technologies continue to reshape our economy and society, the world is likely to see a shift in the nature and distribution of global power. We are seeing how, in the case of AI, rapid technological change seeks to rebalance the science and technology dominance of existing superpowers like the US and China, and wider transnational challenges demand greater collective action in the face of continued global security and prosperity.

With this in mind, the UK has an opportunity over the next ten years to position itself as the best place to live and work with AI; with clear rules, applied ethical principles and a pro-innovation regulatory environment. With the right ingredients in place, we will be both a genuine innovation powerhouse and the most supportive business environment in the world, where we cooperate on using AI for good, advocate for international standards that reflect our values, and defend against the malign use of AI.

Whether it is making the decision to study AI, work at the cutting edge of research or spin up an AI business, our investments in skills, data and infrastructure will make it easier than ever to succeed. Our world-leading R&D system will step up its support of innovators at every step of their journey, from deep research to building and shipping products. If you are a talented AI researcher from abroad, coming to the UK will be easier than ever through the array of visa routes which are available.

If you run a business – whether it is a startup, SME or a large corporate – the government wants you to have access to the people, knowledge and infrastructure you need to get your business ahead of the transformational change AI will bring, making the UK a globally-competitive, AI-first economy which benefits every region and sector.

By leading with our democratic values, the UK will work with partners around the world to make sure international agreements embed our ethical values, making clear that progress in AI must be achieved responsibly, according to democratic norms and the rule of law.

And by increasing the number and diversity of people working with and developing AI, by putting clear rules of the road in place and by investing across the entire country, we will ensure the real-world benefits of AI are felt by every member of society. Whether that is more accurate AI-enabled diagnostics in the NHS, the promise of driverless cars to make our roads safer and smarter, or the hundreds of unforeseen benefits that AI could bring to improve everyday life.

The goals of this Strategy are that the UK:

1. Experiences a significant growth in both the number and type of discoveries that happen in the UK, and are commercialised and exploited here;
2. Benefits from the highest amount of economic and productivity growth due to AI; and
3. Establishes the most trusted and pro-innovation system for AI governance in the world.

This vision can be achieved if we build on three pillars fundamental to the development of AI:

1. Investing in the needs of the ecosystem to see more people working with AI, more access to data and compute resources to train and deliver AI systems, and access to finance and customers to grow sectors;
2. Supporting the diffusion of AI across the whole economy to ensure all regions, nations, businesses and sectors can benefit from AI; and
3. Developing a pro-innovation regulatory and governance framework that protects the public.

The National AI Strategy does not stand alone. It purposefully supports and amplifies the other, interconnected work of government including:

- **The Plan for Growth and recent Innovation Strategy**, which recognise the need to develop a diverse and inclusive pipeline of AI professionals with the capacity to supercharge innovation;
- **The Integrated Review ,** to find new paths for UK excellence in AI to deliver prosperity and security at home and abroad, and shape the open international order of the future;
- **The National Data Strategy**, published in September 2020, sets out our vision to harness the power of responsible data use to boost productivity, create new businesses and jobs, improve public services, support a fairer society, and drive scientific discovery, positioning the UK as the forerunner of the next wave of innovation;
- **The Plan for Digital Regulation ,** which sets out our pro-innovation approach to regulating digital technologies in a way that drives prosperity and builds trust in their use;
- **The upcoming National Cyber Strategy** to continue the drive for securing emerging technologies, including building security into the development of AI;
- **The forthcoming Digital Strategy,** which will build on DCMS's Ten Tech Priorities to further set out the government's ambitions in the digital sector;
- **A new Defence AI centre** as a keystone piece of the modernisation of Defence;
- The **National Security Technology Innovation exchange** (NSTIx), a data science & AI co-creation space that brings together National Security stakeholders, industry and academic partners to build better national security capabilities; and
- **The upcoming National Resilience Strategy**, which will in part focus on how the UK will stay on top of technological threats.

The government's AI Council has played a central role in gathering evidence to inform the development of this strategy, including through its roadmap published at the beginning of the year, which represents a valuable set of recommendations reflecting much of the wider AI community in the UK. The wider ecosystem also fed in through a survey run by the AI Council in collaboration with The Alan Turing Institute. The government remains grateful to the AI Council for its continued leadership of the AI ecosystem, and would like to thank those from across the United Kingdom who shared their views during the course of developing this strategy.

The AI Council
The AI Council was established in 2019 to provide expert advice to the government and high-level leadership of the AI ecosystem. The AI Council demonstrates a key commitment made in the AI Sector Deal, bringing together respected leaders in their fields from across industry, academia and the public sector. Members meet quarterly to advise the Office for AI and broader government on its current priorities, opportunities and challenges for AI policy.

In January 2021, the AI Council published its 'AI Roadmap' providing 16 recommendations to the government on the strategic direction for AI. Its central call was for the government to develop a National AI Strategy, building on the success of investments made through the AI Sector Deal whilst remaining adaptable to future technological disruption. Since then, the Council has led a programme of engagement with the wider AI community to inform the development of the National AI Strategy.

To guide the delivery and implementation of this strategy the government will renew and strengthen the role of the AI Council, ensuring it continues to provide expert advice to government and high-level leadership of the AI ecosystem.

AI presents unique opportunities and challenges

'Artificial Intelligence' as a term can mean a lot of things, and the government recognises that no single definition is going to be suitable for every scenario. In general, the following definition is sufficient for our purposes: "Machines that perform tasks normally performed by human intelligence, especially when the machines learn from data how to do those tasks." The UK government has also set out a legal definition of AI in the National Security and Investment Act.[footnote 2]

Much like James Watt's 1776 steam engine, AI is a 'general purpose technology' (or more accurately, technologies) that have many possible applications, and we expect them to have a transformational impact on the whole economy. Already, AI is used in everyday contexts like email spam filtering, media recommendation systems, navigation apps, payment transaction validation and verification, and many more. AI technologies will impact the whole economy, all of society and us as individuals.

Many of the themes in AI policy are similar to tech and digital policy more widely: the commercialisation journeys; the reliance on internationally mobile talent; the importance of data; and consolidation of economic functions onto platforms. However there are some key examples of differences derived from the above definition which differentiate AI and require a unique policy response from the government.

- In regulatory matters, a system's autonomy raises unique questions around liability, assurance, and fairness as well as risk and safety - and even ownership of creative content[footnote 3] - in a way which is distinct to AI, and these questions increase with the relative complexity of the algorithm. There are also questions of transparency and bias which arise from decisions made by AI systems.
- There are often greater infrastructure requirements for AI services than in cloud/Software as a Service systems. In building and deploying some models, access to expensive high performance computing and/or large data sets is needed.
- Multiple skills are required to develop, validate and deploy AI systems, and the commercialisation and product journey can be longer and more expensive because so much starts with fundamental R&D.

Reflecting and protecting society

AI makes predictions and decisions, and fulfils tasks normally undertaken by humans. While diverse opinions, skills, backgrounds and experience are hugely important in designing any service – digital or otherwise – it is particularly important in AI because of the executive function of the systems. As AI increasingly becomes an enabler for transforming the economy and our personal lives, there are at least three reasons we should care about diversity in our AI ecosystem:

- **Moral:** As AI becomes an organising principle which creates new opportunities and changes the shape of industries and the dynamics of competition across the economy, there is a moral imperative to ensure people from all backgrounds and parts of the UK are able to participate and thrive in this new AI economy.
- **Social:** AI systems make decisions based on the data they have been trained on. If that data – or the system it is embedded in – is not representative, it risks perpetuating or even cementing new forms of bias in society. It is therefore important that people from diverse backgrounds are included in the development and deployment of AI systems.
- **Economic:** There are big economic benefits to a diverse AI ecosystem. These include increasing the UK's human capital from a diverse labour supply, creating a wider range of AI services that stimulate demand, and ensuring the best talent is discovered from the most diverse talent pool.

The longer term

Making specific predictions about the future impact of a technology – as opposed to the needs of those developing and using it today – has a long history in AI. Since the 1950s various hype cycles have given way to so-called 'AI winters' as the promises made have perpetually remained 'about 20 years away'.

While the emergence of Artificial General Intelligence (AGI) may seem like a science fiction concept, concern about AI safety and non-human-aligned systems[footnote 4] is by no means restricted to the fringes of the field.[footnote 5] The government's first focus is on the economic and social outcomes of autonomous and adaptive systems that exist today. However, we take the firm stance that it is critical to watch the evolution of the technology, to take seriously the possibility of AGI and 'more general AI', and to actively direct the technology in a peaceful, human-aligned direction.[footnote 6]

The emergence of full AGI would have a transformational impact on almost every aspect of life, but there are many challenges which could be presented by AI which could emerge much sooner than this. As a general purpose technology AI will have economic and social impacts comparable to the combustion engine, the car, the computer and the internet. As each of these has disrupted and changed the shape of the world we live in - so too could AI, long before any system 'wakes up.'

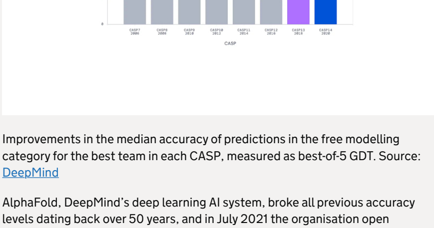
The choices that are made in the here and now to develop AI will shape the future of humanity and the course of international affairs. For example, whether AI is used to enhance peace, or a cause for war; whether AI is used to strengthen our democracies, or embolden authoritarian regimes. As such we have a responsibility to not only look at the extreme risks that could be made real with AGI, but also to consider the dual-use threats we are already faced with today.

From Sector Deal to AI Strategy

The UK is an AI superpower, with particular strengths in research, investment and innovation. The UK's academic and commercial institutions are well known for conducting world-leading AI research, and the UK ranks 3rd in the world for AI publication citations per capita.[footnote 7] This research strength was most recently demonstrated in November 2020 when DeepMind, a UK-based AI company, used AlphaFold to find a solution to a 50-year-old grand challenge in biology.[footnote 8]

The UK has the 3rd highest number of AI companies in the world after the US and China. Alongside DeepMind, the UK is home to Graphcore, a Bristol-based machine learning semiconductor company; Darktrace, a world-leading AI company for cybersecurity; and BenevolentAI, a company changing the way we treat disease. The UK also attracts some of the best AI talent from around the world[footnote 9] - the UK was the second most likely global destination for mobile AI researchers after the USA.

AlphaFold and AlphaFold 2
In November 2020, London-based DeepMind announced that they had solved one of the longest running modern challenges in biology: predicting how proteins - the building blocks of life which underpin every biological process in every living thing - take shape, or 'fold'.



Improvements in the median accuracy of predictions in the free modelling category for the best team in each CASP, measured as best-of-5 GDT. Source: DeepMind

AlphaFold, DeepMind's deep learning AI system, broke all previous accuracy levels dating back over 50 years, and in July 2021 the organisation open sourced the code for AlphaFold together with over 350,000 protein structure predictions, including the entire human proteome, via the AlphaFold database in partnership with EMBL-EBI.

DeepMind's decision to share this knowledge openly with the world, demonstrates both the opportunity that AI presents, as well as what this strategy seeks to support: bleeding-edge research happening in the UK and with partners around the world, solving big global challenges.

AlphaFold opens up a multitude of new avenues in research – helping to further our understanding of biology and the nature of the world around us. It also has a

multitude of potential real-world applications, such as deepening our understanding of how bacteria and viruses attack the body in order to develop more effective prevention and treatment, or support the identification of proteins and enzymes that can break down industrial or plastic waste.

The government has invested more than £2.3 billion into Artificial Intelligence across a range of initiatives since 2014.[footnote 10] This portfolio of investment includes, but is not limited to:

- £250 million to develop the NHS AI Lab at NHSX to accelerate the safe adoption of Artificial Intelligence in health and care;
- £250 million into Connected and Autonomous Mobility (CAM) technology through the Centre for Connected and Autonomous Vehicles (CCAV) to develop the future of mobility in the UK;
- 16 new AI Centres for Doctoral Training at universities across the country, backed by up to £100 million and delivering 1,000 new PhDs over five years;
- A new industry-funded AI Masters programme and up to 2,500 places for AI and data science conversion courses. This includes up to 1,000 government-funded scholarships;
- Investment into The Alan Turing Institute and over £46 million to support the Turing AI Fellowships to develop the next generation of top AI talent;
- Over £372 million of investment into UK AI companies through the British Business Bank for the growing AI sector;
- £172 million of investment through the UKRI into the Hartree National Centre for Digital Innovation, leveraging an additional £38 million of private investment into High Performance Computing.

Further investments have been made into the Tech Nation Applied AI programme – now in its third iteration; establishing the Office for National Statistics Data Science Campus; the Crown Commercial Service's public sector AI procurement portal; and support for the Department for International Trade attracting AI related Foreign Direct Investment into the UK.

As part of the AI Sector Deal, the government established the AI Council to bring together respected leaders to strengthen the conversation between academia, industry, and the public sector. The Office for Artificial Intelligence was created as a new team within government to take responsibility for overarching AI policy across government and to be a focal point for the AI ecosystem through its secretariat of the AI Council. The Centre for Data Ethics and Innovation (CDEI) was established as a government expert body focused on the trustworthy use of data and AI in the public and private sector.

This strategy builds on the recent history of government support for AI and considers the next key steps to harness its potential in the UK for the coming decade. In doing so, the National AI Strategy leads on from the ambitions outlined in the government's Innovation Strategy to enable UK businesses and innovators to respond to economic opportunities and real-world problems through our national innovation prowess. AI was identified in the Innovation Strategy as one of the seven technology families where the UK has a globally competitive R&D and industrial strength[footnote 11] and has been widely cited as a set of technologies in which the UK must maintain a leading edge to guarantee our continued security and prosperity in an intensifying geopolitical landscape.

Pillar 1: Investing in the long-term needs of the AI ecosystem

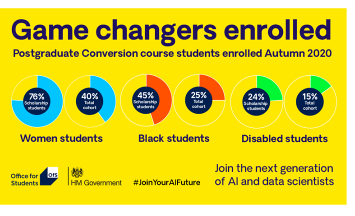
Investing in and planning for the long term needs of the AI ecosystem to remain a science and AI superpower

To maintain the UK's position amongst the global AI superpowers and ensure the UK continues to lead in the research, development, commercialisation and deployment of AI, we need to invest in, plan for, secure and unlock the critical inputs that underpin AI innovation.

Government's aim is to greatly increase the type, frequency and scale of AI discoveries which are developed and exploited in the UK. This will be achieved by:

- Making sure the UK's research, development and innovation system continues to be world leading, providing the support to allow researchers and entrepreneurs to forge new frontiers in AI;
- Guaranteeing that the UK has access to a diverse range of people with the skills needed to develop the AI of the future and to deploy it to meet the demands of the new economy;
- Ensuring innovators have access to the data and computing resources necessary to develop and deliver the systems that will drive the UK economy for the next decade;
- Supporting growth for AI through a pro-innovation business environment and capital market, and attracting the best people and firms to set up shop in the UK;
- Ensuring UK AI developers can access markets around the world.

Increasing diversity and closing the skills gap through postgraduate conversion courses in data science and artificial



Autumn 2020 student admissions data shows a diverse range of students have enrolled on AI and data science postgraduate conversion courses funded by the Office for Students. The data shows that 40% of the total students are women, one quarter are Black students and 15% are students that are disabled. Source:_ Office for Students

As a result of the growing skills gap in AI and data science, 2,500 new Masters conversion courses in AI and data science are now being delivered across universities in England. The conversion course programme included up to 1,000 scholarships to increase the number of people from underrepresented groups and to encourage graduates from diverse backgrounds to consider a future in AI and Data Science.

In the first year over 1,200 students enrolled, with 22% awarded scholarships. Over 40% of the total students are women, one quarter are black students and 15% of students are disabled. 70% of the total students are studying on courses based outside of London and the South East.

These conversion courses are providing the opportunity to develop new digital skills or retrain to help find new employment in the UK's cutting-edge AI and data science sectors, ensuring that industry and the public sector can access the greatest supply of talent across the whole country.

Skills and talent

Continuing to develop, attract and train the best people to build and use AI is at the core of maintaining the UK's world-leading position. By inspiring all with the possibilities AI presents, the UK will continue to develop the brightest, most diverse workforce.

Building a tech-savvy nation by supporting skills for the future is one of the government's ten tech priorities. The gap between demand and supply of AI skills remains significant and growing,[footnote 12],[footnote 13] despite a number of new AI skills initiatives since the 2018 AI Sector Deal. In order to meet demand, the UK needs a larger workforce with AI expertise. Last year there was a 16% increase for online AI and Data Science job vacancies and research found that 69% of vacancies were hard to fill.[footnote 14] Data from an ecosystem survey conducted by the AI Council and The Alan Turing Institute showed that 81% of respondents agreed there were significant barriers in recruiting and retaining top AI talent in their domain within the UK.

Research into the AI Labour Market showed that technical AI skill gaps are a concern for many firms, with 35% of firms revealing that a lack of technical AI skills from existing employees had prevented them from meeting their business goals, and 49% saying that a lack of required AI skills from job applicants also affected their business outcomes.[footnote 15] To support the adoption of AI we need to ensure that non-technical employees understand the opportunities, limitations and ethics of using AI in a business setting, rather than these being the exclusive domain of technical practitioners.

Understanding the UK AI Labour Market Understanding the UK AI Labour Market**' research**

In 2021, the Office for AI published research to investigate Artificial Intelligence and Data science skills in the UK labour market in 2020. Some key findings from the research:

- Half of surveyed firms' business plans had been impacted by a lack of suitable candidates with the appropriate AI knowledge and skills.
- Two thirds of firms (67%) expected that the demand for AI skills in their organisation was likely to increase in the next 12 months.
- Diversity in the AI sector was generally low. Over half of firms (53%) said none of their AI employees were female, and 40% said none were from ethnic minority backgrounds.
- There were over 110,000 UK job vacancies in 2020 for AI and Data Science roles.

The findings from this research will help the Office for AI address the AI skills challenge and ensure UK businesses can take advantage of the potential of AI and Data Science.

We need to inspire a diverse set of people across the UK to ensure the AI that is built and used in the UK reflects the needs and make-up of society. To close the skills gap, the government will focus on three areas to attract and train the best people: those who build AI, those who use AI, and those we want to be inspired by AI.

Build: Train and attract the brightest and best people at developing AI

To meet the demand seen in industry and academia, the government will continue supporting existing interventions across top talent, PhDs and Masters levels. This includes Turing Fellowships, Centres for Doctoral Training and Postgraduate Industrial-Funded Masters and AI Conversion Courses.

Government will seek to build upon the £46 million Turing AI Fellowships investment to attract, recruit, and retain a substantial cohort of leading researchers and innovators at all career stages. Our approach will enable Fellows to work flexibly between academia and other sectors, creating an environment for them to discover and develop cutting edge AI technologies and drive the use of AI to address societal, economic and environmental challenges in the UK. We note that recently, research breakthroughs in the field of AI have been disproportionately driven by a small number of luminary talents and their trainees. In line with the Innovation Strategy, the government affirms our commitment to empowering distinguished academics.

Research[footnote 16] and industry engagement has demonstrated the need for graduates with business experience, indicating a need to continue supporting industry/academic partnerships to ensure graduates leave education with business-ready experience. Our particular focus will be on software engineers, data scientists, data engineers, machine learning engineers and scientists, product managers, and related roles.

We recognise that global AI talent is scarce, and the topic of fierce competition internationally. As announced in the Innovation Strategy, the government is revitalising and introducing new visa routes that encourage innovators and entrepreneurs to the UK. Support for diverse and inclusive researchers and innovators across sectors, and new environments for collaboratively developing AI, will be key to ensuring the UK's success in developing AI and investing in the long term health of our AI ecosystem.

Attracting the best AI talent from around the world

The UK is already the top global destination for AI graduates in the United States and we punch above our weight globally in attracting talent. The UK nearly leads the world in its proportion of top-skilled AI researchers. Government wants to take this to the next level and make the UK the global home for AI researchers, entrepreneurs, businesses and investors.

As well as ensuring the UK produces the next generation of AI talent we need, the government is broadening the routes that talented AI researchers and individuals can work in the UK, through the recently announced Innovation Strategy.

- The **Global Talent** visa route is open to those who are leaders or potential leaders in AI - and those who have won prestigious global prizes automatically qualify. Government is currently looking at how to broaden this list of prizes.
- A **new High Potential Individual route** will 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, with no job offer requirement. This gives individuals the flexibility to work, switch jobs or employers – keeping pace with the UK's fast-moving AI sector.
- A **new scale-up route** will 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. Scaleups will be able to apply through a fast-track verification process to use the route, so long as 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.
- 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 make it even more open to:
  - 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 government'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 AI businesses greater flexibility in transferring workers to the UK, in order to establish and expand their business here.

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 work on the most challenging AI problems. These are all in addition to our existing skills visa schemes for those with UK job offers.

Use: Empower employers and employees to upskill and understand the opportunities for using AI in a business setting_

The AI Council ecosystem survey found that only 18% agreed there was sufficient provision of training and development in AI skills available to the current UK workforce. As the possibilities to develop and use AI grow, so will people's need to understand and apply AI in their jobs. This will range from people working adjacent to the technical aspects such as product managers and compliance, through to those who are applying AI within their business, such as in advertising and HR. Below degree level, there is a need to clearly articulate the skills employers and employees need to use AI effectively in the workplace. For example, industries have expressed their willingness to fund employees to undertake training but have not found training that suits their needs: including training that is business-focused, modular and flexible.

Skills for Jobs White Paper

The Skills for Jobs: Lifelong Learning for Opportunity and Growth White Paper was published in January 2021 and is focused on giving people the skills they need, in a way that suits them, so they can get great jobs in sectors the economy needs and boost the country's productivity.

These reforms aim to ensure that people can access training and learning flexibly throughout their lives and that they are well-informed about what is on offer, including opportunities in valuable growth sectors. This will also involve reconfiguring the skills system to give employers a leading role in delivering the reforms and influencing the system to generate the skills they need to grow.

To more effectively use AI in a business setting, employees, including those who would not have traditionally engaged with AI, will require a clear articulation of the different skills required, so they can identify what training already exists and understand if there is still a gap.

Using the Skills Value Chain approach piloted by the Department for Education,[footnote 17] the government will help industry and providers to identify what skills are needed. Lessons learned from this pilot will support this work to help businesses adopt the skills needed to get the best from AI. The Office for AI will then work with the Department for Education to explore how these needs can be met and mainstreamed through national skills provision.

The government will also support people to develop skills in AI, machine learning, data science and digital through the Department for Education's Skills Bootcamps. The Bootcamps are free, flexible courses of up to 16 weeks, giving adults aged 19 and over the opportunity to build up in-demand, sector-specific skills and fast-track to an interview with a local employer; improving their job prospects and supporting the economy.

Inspire: Support all to be excited by the possibilities of AI

The AI Council's Roadmap makes clear that inspiring those who are not currently using AI, and allowing children to explore and be amazed by the potential of AI, will be integral to ensuring we continue to have a growing and diverse AI-literate workforce.

Through supporting the National Centre for Computing Education(NCCE) the government will continue to ensure programmes that engage children with AI concepts are accessible and reach the widest demographic.

The Office for AI will also work with the Department for Education to ensure career pathways for those working with or developing AI are clearly articulated on career guidance platforms, including the National Careers Service, demonstrating role models and opportunities to those exploring AI. This will support a broader range of people to consider careers in AI. The government will ensure that leaders within the National AI Research and Innovation Programme will play a key role in engaging with the public and inspiring the leaders of the future.

Research, development and innovation

Our vision is that the UK builds on our excellence in research and innovation in the next generation of AI technologies.

The UK has been a leader in AI research since it developed as a field, thanks to our strengths in computational and mathematical sciences.[footnote 18] The UK's AI base has been built upon this foundation,[footnote 19] and the recently announced Advanced Research and Invention Agency (ARIA) will complement our efforts to cement our status as a global science superpower. The UK also has globally recognised institutes such as The Alan Turing Institute and the high-performing universities which are core to research in AI.[footnote 20]

Currently, AI research undertaken in the UK is world class, and investments in AI R&D contribute to the Government's target of increasing overall public and private sector R&D expenditure to 2.4% of GDP by 2027. But generating economic and societal impact through adoption and diffusion of AI technologies is behind where it could be.[footnote 21] There is a real opportunity to build on our existing strengths in fundamental AI research to ensure they translate into productive processes throughout the economy.

At the same time, the field of AI is advancing rapidly, with breakthrough innovations being generated by a diverse set of institutions and countries. The past decade has seen the rise of deep learning, compute-intensive models, routine deployment of vision, speech, and language modelling in the real world, the emergence of responsible AI and AI safety, among other advances. These are being developed by new types of research labs in private companies and public institutions around the world. We expect that the next decade will bring equally transformative breakthroughs. Our goal is to make the UK the starting point for a large proportion of them, and to be the fastest at turning them into benefits for all.

To do this, UKRI will support the transformation of the UK's capability in AI by launching a National AI Research and Innovation (R&I) Programme. The programme will shift us from a rich but siloed and discipline-focused national AI landscape to an inclusive, interconnected, collaborative, and interdisciplinary research and innovation ecosystem. It will work across all the Councils of UKRI and will be fully-joined up with business of all sizes and government departments. It will translate fundamental scientific discoveries into real-world AI applications, address some limitations in the ability of current AI to be effectively used in numerous real world contexts, such as tackling complex and undefined problems, and explore using legacy data such as non-digital public records.

The National AI Research and Innovation (R&I) Programme has five main aims:

Discovering and developing transformative new AI technologies, leading the world in the development of frontier AI and the key technical capabilities to develop responsible and trustworthy AI.The programme will support:

- foundational research to develop novel next generation AI technologies and approaches which could address current limitations of AI, focusing on low power and sustainable AI, and AI which can work differently with a diverse range of challenging data sets, human-AI interaction, reasoning, and the maths underpinning the theoretical foundations of AI.
- technical and socio-technical capability development to overcome current limitations around the responsible trustworthy nature of AI.

Maximising the creativity and adventure of researchers and innovators, building on UK strengths and developing strategic advantage through a diverse range of AI technologies. The programme will support:

- specific routes to enable the exploration of high-risk ideas in the development and application of AI;
- follow-on funding to maximise the impact of the ideas with the most potential.

Building new research and innovation capacity to deliver the ideas, technologies, and workforce of the future, recruiting and retaining AI leaders, supporting the development of new collaborative AI ecosystems, and developing collaborative, multidisciplinary, multi-partner teams. The programme will support:

- the recruitment, retention, training and development of current and future leaders in AI, and flexible working across sectoral and organisational interfaces using tools such as fellowships, and building on the success of the Turing AI Fellowships scheme;
- enhanced UK capacity in key AI professional skills for research and innovation, such as data scientists and software engineers.

Connecting across the UK AI Research and Innovation ecosystem, building on the success of The Alan Turing Institute as the National Centre for AI and Data Science, and building collaborative partnerships nationally and regionally between and across sectors, diverse AI research and innovation stakeholders. The programme will support:

- the development of a number of nationally distributed AI ecosystems which enable researchers and innovators to collaborate in new environments and integrate basic research through application and innovation. These ecosystems will be networked into a national AI effort with the Alan Turing Institute as its hub, convening and coordinating the national research and innovation programme and enabling business and government departments to access the UK's AI expertise and skills capability e.g. the catapult network and compute capability.

Supporting the UK's AI Sector and the adoption of AI, connecting research and innovation and supporting AI adoption and innovation in the private sector. The programme will support:

- challenge-driven AI research and innovation programmes in key UK priorities, such as health and the transition to net zero;
- collaborative work with the public sector and government organisations to facilitate leading researchers and innovators engaging with the AI transformation of the public sector;
- innovation activities in the private sector, both in terms of supporting the development of the UK's burgeoning AI sector and the adoption of AI across sectors.

International collaboration on research and innovation

As well as better coordination at home, the UK will work with friends and partners around the world on shared challenges in research and development and lead the global conversation on AI.

The UK will participate in Horizon Europe, enabling collaboration with other European researchers, and will build a strong and varied network of international science and technology partnerships to support R&I collaboration. By shaping the responsible use of technology, we will put science and technology, including AI, at the heart of our alliances and partnerships worldwide. We will continue to use Official Development Assistance to support R&D partnerships with developing countries.

We are also deepening our collaboration with the United States, implementing the US UK Declaration on Cooperation in AI Research and DevelopmentThis declaration outlines a shared vision for driving technological breakthroughs in AI between the US and the UK. As we build materially on this partnership, we will seek to enable UK partnership with other key global actors in AI, to grow influential R&I collaborations.

Access to data

The National Data Strategy sets out the government's approach to unlocking the power of data. Access to good quality, representative data from which AI can learn is critical to the development and application of robust and effective AI systems.

The AI Sector Deal recognised this and since then the government has established evidence on which to make policies to harness the positive economic and social benefit of increased availability of data. This includes the Open Data Institute's original research into data trusts as a model of data stewardship to realise the value of data for AI. The research established a repeatable model for data trusts which others have begun to apply.

Mission 1 of the National Data Strategy seeks to unlock the value of data across the economy, and is a vital enabler for AI. This mission explores how the government can apply six evidenced levers to tackle barriers to data availability. The government will publish a policy framework in Autumn 2021 informed by the outcomes of Mission 1, setting out its role in enabling better data availability in the wider economy. The policy framework includes supporting the activities of intermediaries, including data trusts, and providing stewardship services between those sharing and accessing data.

The AI Council and the Ada Lovelace Institute recently explored three legal mechanisms that could help facilitate responsible data stewardship – data trusts, data cooperatives and corporate and contractual mechanisms. The ongoing Data: A new direction consultation asks what role the government should have in enabling and engendering confidence in responsible data intermediary activity. The government is also exploring how privacy enhancing technologies can remove barriers to data sharing by more effectively managing the risks associated with sharing commercially sensitive and personal data.

Data foundations and use in AI systems

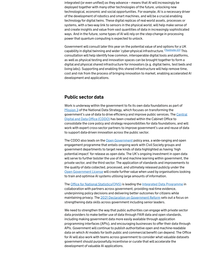
Data foundations refer to various characteristics of data that contribute to its overall condition, whether it is fit for purpose, recorded in standardised formats on modern, future-proof systems and held in a condition that means it is findable, accessible, interoperable and reusable (FAIR). A recent EY study delivered on behalf of DCMS has found that organisations that report higher AI adoption levels also have a higher level of data foundations.

The government is considering how to improve data foundations in the private and third sectors. Through the National AI R&I Programme and ambitions to lead best practices in FAIR data, we will grow our capacity in professional AI, software and data skills, and support the development of key new data infrastructure capabilities. Technical professionals such as data engineers have a key role to play in opening up access to the most critical data and compute infrastructures on FAIR data principles, and in accelerating the pathway to using AI technologies to make best use of the UK's healthy data ecosystem.

Data foundations are crucial to the effective use of AI and it is estimated that, on average, 80% of the time spent on an AI project is cleaning, standardising and making the data fit for purpose. Furthermore, when the source data needed to power AI or machine learning is not fit for purpose, it leads to poor or inaccurate results, and to delays in realising the benefits of innovation.[footnote 22] Poor quality datasets can also be un-representative, especially when it comes to minority groups, and this can propagate existing biases and exclusions when they are used for AI.

The government is looking to support action to mitigate the effects of quality issues and underrepresentation in AI systems. Subject to the outcomes of the Data: A new direction consultation, the government will more explicitly permit the collection and processing of sensitive and protected characteristics data to monitor and mitigate bias in AI systems.

An important outcome for increasing access to data and improving data foundations is in how technology will be better able to use that data. Technological convergence – the tendency for technologies that were originally unrelated to become more closely



Ensuring AI benefits all sectors and regions

Supporting the transition to an AI-enabled economy, capturing the benefits of AI innovation and ensuring that AI is deployed in a trustworthy and ethical way

To ensure that all sectors and regions of the UK economy can benefit from the transformation that AI will bring, the government will back the domestic design and deployment of AI technologies that are trustworthy, ethical and secure, and which adapt there, grow and become productive. The UK has historically been strong at developing new technologies but less so at commercialising them into products and services.

As well as smart action to support both suppliers, developers and adopters, we will need to ensure that the UK's institutional and legal framework is fit for purpose. Important work is in train on public procurement, such as the SAFE and the Algorithmic Transparency Standard, with a dedicated Defence AI Strategy and AI Centre, but also in terms of using the UK's leverage as a leading AI buyer to drive up standards. We need to do more, though. Finally, it requires being bold and experimental, and supporting the use of AI in the service of innovation and productivity.

The UK will take action to ensure that the whole economy is in line for the highest amount of economic and social benefit such as AI.

This will be achieved by:

- Supporting AI businesses on their commercial journey, understanding the unique challenges they face and helping them get to market and supporting innovation-led growth and productivity through the adoption and diffusion of AI.
- Understanding barriers the factors that influence the decision to adopt AI in organisations - which includes an understanding of when not to.
- Ensuring that our institutional and legal framework is fit for purpose in a transition to AI, including accountability for algorithmic decisions, and ensuring that we have the right rewards and incentives for AI and work through our Innovation Phoenix, Regulatory Innovation Office and Digital Regulators.
- Leveraging the whole public sector's capacity to create demand for AI and markets for new services.

Commercialisation

Developing a commercial AI product or service is more than just bringing an idea to market and selling it to customers. It is a complex process, with a high probability that obtaining private funding will stop short, leaving many other obstacles to successfully commercial outcomes in AI-related projects. As well as the well-known barriers such as access to talent, data and computing power, there are other, more subtle and sometimes other challenges reported by businesses are the lack of engagement with customers, limiting adoption and commercialisation. Commercialisation outcomes are also often hindered by a lack of business management capability, a lack of understanding of the related impact, or even a misunderstanding of the related impact, where adoption is concerned.

AI deployment - understanding new dynamics

To grow the market and spread AI to more areas of our economy, the government aims to support the demand side as well as the means for commercialising AI - understanding the dynamics of AI adoption and what it means for business models. The UK's ability to planning is a prerequisite to be confident to encourage wider adoption of AI technologies and services.

AI Innovation [1] delivered on behalf of DCMS shows that AI remains an emerging technology with only 3% of businesses using AI applications in the UK. 37% of organisations have implemented AI technologies in business processes. 28% of organisations are considering implementing AI in the next 12 months, and 34% have not adopted AI and are not considering it. Government will create an Adoption Hub [2] the size of an organisation was found to be a large contributing factor to the adoption of AI, with 50% of large organisations having adopted AI technologies compared to 34% of medium-sized organisations and 26% of small organisations. Recognising that for many sectors this is the critical stage of development, and beyond the pilot stage, the **Office for AI will publish research later this year into the drivers of AI adoption and diffusion.**

To stimulate the development and adoption of AI technologies in high-potential, high-productivity sectors, the Office for AI will publish a sector plan by June 2021.

- Support the identification and creation of opportunities for business, whether SMEs or larger firms, to use and for AI developers to build new products and services, including exports.
- Create pathways for businesses and their companies around new products and services or evolved and diversify their product offering if they are looking to pivot or grow.
- Facilitate cross-organisational partnerships between and AI developers and products and services developed address business needs, are responsibly developed and deployed, and are ready for market. Ensure that the UK's institutions are able and prepared and ready for AI implementation.
- Incentivise innovators to learn about these new market opportunities, products, and services, so that value-creating finance is needed, the right financing is made available to AI developers.

Creating and protecting Intellectual Property

Intellectual Property (IP) plays a significant part in building a successful business by rewarding people for innovativeness and creativity and enabling innovation. IP supports the commercialisation of AI by providing companies with the confidence to invest in the sharing of know-how. The Intellectual Property Office (IPO) is keen to hear from researchers and developers need the right support to commercialise their IP, and helps companies and individuals to make the most of their intellectual property (IP) by being balanced, support and enforce their rights to improve their chances of success and growth.

AI and Intellectual Property (IP): Call for Views and Government Response

An effective Intellectual Property (IP) system is fundamental to the Government's ambition for the UK to be a 'science superpower' and the best place to invent, develop and grow a business. Artificial Intelligence (AI) technology raises thorny IP issues for innovation, our exploration in that the UK's domestic IP framework gives the UK a competitive edge.

In support of this ambition, the IPO published its AI and IP call for views [3] and the UK at the forefront of emerging technological opportunities, by considering how our IP system should adapt to the rise of AI technology, ensuring our society's insights have to the new tech-related harms.

In March this year, the government published its response to the call for views, which committed to the following next steps:

- To consult on the extent to which copyright and patents should protect AI-generated creations and inventions.
- To consult on measures to clarify the liability for copyright and patent material in AI development.
- To explore options to enhance understanding of the role the IP framework plays in incentivising investments in AI.

The consultation, on copyright areas of computer generated works and text and data mining, and on patents for AI-devised inventions, will be launched this year. The aim of the year is to that the UK harnesses the opportunities of AI to further support innovation and creativity.

Using AI for the public benefit

AI can contribute to solving the greatest challenges we face. AI has contributed to tackling COVID-19, demonstrating how these technologies can be brought to bear alongside other approaches to create effective, efficient and citizen-centric solutions.

AI and COVID-19

When the pandemic began it created a unique environment where AI developers and researchers were able to work with healthcare professionals with starting treatments earlier and to reduce the likelihood that people need intensive care. Working with Faculty, NHS England and NHS Improvement developed a tool to predict the oxygen requirements of COVID-19 patients in order that hospitals could make early and COVID-19 hospitals. Hospitals in London and need backup up to three weeks in advance, looked at a wide range of data from patients' NHS records, including their ethnicity, underlying conditions and blood tests the confidence to provide practice for patients which are treatment patients to COVID-related hospital admissions.

The tool was rolled out across last year, the NHS X Lab has collected more than 40,000 X-ray, CT and PINN chest scans of over 15,000 patients from 130 NHS trusts through the National COVID-19 Chest Imaging Database (NCCID), one of the largest datasets of its kind. Data from the NCCID has been and is being used to study and develop COVID-19 deep learning AI models, which can care for patients hospitalised with severe infection. The database has enabled the development of AI models that predict how patients will need to be treated, supporting clinical management and monitoring of COVID-19.

UK companies have also shown how AI can play a key at scale the search for potential drug candidates, prevention trials and contribute to global research efforts. Benevolent AI, a world leading AI company focused on drug discovery, has been collaborating with the Medicines and Healthcare products Regulatory Agency (MHRA) and Imperial College London to find drug candidates that could be repurposed to tackle the virus. This was based on a machine learning platform that integrates and organises large and complex biomedical data, including over 1 million peer-reviewed research papers, clinical trials, and other data. This platform enabled Benevolent AI to identify baricitinib as a potential treatment for COVID-19 patients, which the MHRA then rapidly assessed and approved for emergency use in the fastest clinical trial ever conducted in the UK.

There are many areas of development that have featured to the point that industry and the NHS have been able to deploy AI-enabled tools to support COVID-19 patients. These investments are helping to know-how of from the use of AI in medical products and services. But there remain more complex, cross-sector challenges that need to be addressed. The COVID-19 Data Strategy for Health and Care, set out by Hackney, identifying strategic priorities that will enable the sharing of data across health and care.

The government has a clear role to play in stimulating and supporting AI innovation in priority applications and wider strategic goals. The government is also supporting a group of different actors to harness innovation for improving lives, simultaneously ensuring that the benefits of AI are felt across the economy and society. The COVID-19 pandemic has underlined, to the role of open source in the public sector, and in society sectors. In raising productivity, **Over the next six to twelve months, the Office for AI will publish a sector plan for AI in healthcare, including a framework for government departments to understand the government's ambition for AI and where AI can provide a catalytic contribution.** [illegible] including Innovation Finance and the Innovation Growth Plan.

The COVID-19 pandemic has shown that global challenges need global solutions. The UK's ability to collaborate internationally on research, development and deployment of innovation efforts, and research and innovation hubs, are working alongside UK researchers, research institutes and beyond to tackle new collaborations to tackle the challenge. The UK's ability to collaborate internationally on research, development and deployment of innovation efforts, and research and innovation hubs, and beyond to tackle the challenge.

Missions

The Industrial Strategy set out the government's plans to stimulate innovation to tackle major challenges facing the UK and the world, and drive capability across technologies. This will be achieved through Innovation Missions. [illegible] which will be ambitious, cross-cutting, and will drive innovation across sectors and industries. They will be supported by Innovation Technologies. [illegible] supporting their capability to tackle pressing global and national challenges within a mission-based framework. Missions will be set by Ministers and will be overseen by an expert panel on a science and AI expertise.

Some of these challenges have been [illegible] and resolve around the future health, wellbeing, prosperity and climate resilience of the economy, and overcome inequalities in UK and globally. These challenges are worthwhile and therefore difficult, and will require innovation across disciplines and institutions. Some will be local, some will be urban, rural, and will contain a high range of possible impacts on citizens and society. The pace of AI development is often fast, paradoxical and non-linear, and finding the right balance between the need for innovation and the need for protection of vulnerable stakeholders, agencies and institutions to consider the technical and social implications of AI and its potential to be used for creativity or problem solving. In doing so, the UK will be able to find new ways to harness the power of AI to address the challenges we face and deliver benefits.

At the same time, we need capabilities these also bet to some of the most impactful and transformative AI innovations. Some of the UK's strengths in AI, Quantum Computing, and robots, drones and related datasets are fundamental to breakthroughs in vision, language, reinforcement systems, and other capabilities. [illegible] **This will ensure that government is leveraging its AI capabilities to maximise significant progress in tackling the most pressing challenges.**

This will ensure, that government will develop a portfolio of short, medium and long term AI challenges to mobilise industry and society to identify and implement high-impact, transformative AI innovations. Some of the UK's strengths in AI, Quantum Computing, and robots, drones and related datasets are fundamental to breakthroughs in vision, language, reinforcement systems, and other capabilities.

Pillar 2: Ensuring AI benefits all sectors and regions

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AI can contribute to solving the greatest challenges we face. AI has contributed to tackling COVID-19, demonstrating how these technologies can be brought to bear alongside other approaches to create effective, efficient and citizen-centric solutions.

AI and COVID-19

When the pandemic began it created a unique environment where AI developers and researchers were able to work with healthcare professionals with starting treatments earlier and to reduce the likelihood that people need intensive care. Working with Faculty, NHS England and NHS Improvement developed a tool to predict the oxygen requirements of COVID-19 patients in order that hospitals could make early and COVID-19 hospitals. Hospitals in London and need backup up to three weeks in advance, looked at a wide range of data from patients' NHS records, including their ethnicity, underlying conditions and blood tests the confidence to provide practice for patients which are treatment patients to COVID-related hospital admissions.

The tool was rolled out across last year, the NHS X Lab has collected more than 40,000 X-ray, CT and PINN chest scans of over 15,000 patients from 130 NHS trusts through the National COVID-19 Chest Imaging Database (NCCID), one of the largest datasets of its kind. Data from the NCCID has been and is being used to study and develop COVID-19 deep learning AI models, which care for patients hospitalised with severe infection. The database has enabled the development of AI models that predict how patients will need to be treated, supporting clinical management and monitoring of COVID-19.

UK companies have also shown how AI can play key at scale the search for potential drug candidates, prevention trials and contribute to global research efforts. Benevolent AI, a world leading AI company focused on drug discovery, has been collaborating with the Medicines and Healthcare products Regulatory Agency (MHRA) and Imperial College London to find drug candidates that could be repurposed to tackle the virus. This was based on a machine learning platform that integrates and organises large and complex biomedical data, including over 1 million peer-reviewed research papers, clinical trials, and other data. This platform enabled Benevolent AI to identify baricitinib as a potential treatment for COVID-19 patients, which the MHRA then rapidly assessed and approved for emergency use in the fastest clinical trial ever conducted in the UK.

There are many areas of development that have featured to the point that industry and the NHS have been able to deploy AI-enabled tools to support COVID-19 patients. These investments are helping to know-how of from the use of AI in medical products and services. But there remain more complex, cross-sector challenges that need to be addressed. The COVID-19 Data Strategy for Health and Care, set out by Hackney, identifying strategic priorities that will enable the sharing of data across health and care.

The government has a clear role to play in stimulating and supporting AI innovation in priority applications and wider strategic goals. The government is also supporting a group of different actors to harness innovation for improving lives, simultaneously ensuring that the benefits of AI are felt across the economy and society. The COVID-19 pandemic has underlined, to the role of open source in the public sector, and in society sectors. In raising productivity, **Over the next six to twelve months, the Office for AI will publish a sector plan for AI in healthcare, including a framework for government departments to understand the government's ambition for AI and where AI can provide a catalytic contribution.** [illegible] including Innovation Finance and the Innovation Growth Plan.

The COVID-19 pandemic has shown that global challenges need global solutions. The UK's ability to collaborate internationally on research, development and deployment of innovation efforts, and research and innovation hubs, are working alongside UK researchers, research institutes and beyond to tackle new collaborations to tackle the challenge. The UK's ability to collaborate internationally on research, development and deployment of innovation efforts, and research and innovation hubs, and beyond to tackle the challenge.

Missions

The Industrial Strategy set out the government's plans to stimulate innovation to tackle major challenges facing the UK and the world, and drive capability across technologies. This will be achieved through Innovation Missions. [illegible] which will be ambitious, cross-cutting, and will drive innovation across sectors and industries. They will be supported by Innovation Technologies. [illegible] supporting their capability to tackle pressing global and national challenges within a mission-based framework. Missions will be set by Ministers and will be overseen by an expert panel on a science and AI expertise.

Some of these challenges have been [illegible] and resolve around the future health, wellbeing, prosperity and climate resilience of the economy, and overcome inequalities in UK and globally. These challenges are worthwhile and therefore difficult, and will require innovation across disciplines and institutions. Some will be local, some will be urban, rural, and will contain a high range of possible impacts on citizens and society. The pace of AI development is often fast, paradoxical and non-linear, and finding the right balance between the need for innovation and the need for protection of vulnerable stakeholders, agencies and institutions to consider the technical and social implications of AI and its potential to be used for creativity or problem solving. In doing so, the UK will be able to find new ways to harness the power of AI to address the challenges we face and deliver benefits.

At the same time, we need capabilities these also bet to some of the most impactful and transformative AI innovations. Some of the UK's strengths in AI, Quantum Computing, and robots, drones and related datasets are fundamental to breakthroughs in vision, language, reinforcement systems, and other capabilities. [illegible] **This will ensure that government is leveraging its AI capabilities to maximise significant progress in tackling the most pressing challenges.**

This will ensure, that government will develop a portfolio of short, medium and long term AI challenges to mobilise industry and society to identify and implement high-impact, transformative AI innovations. Some of the UK's strengths in AI, Quantum Computing, and robots, drones and related datasets are fundamental to breakthroughs in vision, language, reinforcement systems, and other capabilities.

Climate change and global health threats are examples of shared international challenges that require coordinated, cross-sector and cross-border responses. Particularly the case where frameworks are lacking or where there are conflicting or incompatible available coding platforms to produce new algorithms. **The UK will extend the science and innovation network (SIN) to 20 more countries, including emerging economies and developing countries. Through our leadership in international standards and data diplomacy, we will work to ensure international collaboration can unlock the potential of AI and data to accelerate progress on global challenges, from climate change to poverty.**

Net zero

The Prime Minister's Net Zero Plan for a Green Industrial Revolution highlights the development of disruptive technologies such as AI for energy as a key priority, and is underpinned by the UK's Net Zero Strategy. AI can help to accelerate the transition to net zero, the UK has the opportunity to lead the world in climate technologies, and we can do so deliver our ambitious net zero targets. This will be key to reach our stated ambition to be the first major economy to be net zero, and the UK's ambition has to achieve the maximum possible value of emissions reductions.

AI and net zero

AI works best when presented with specific problems alongside clear system boundaries and where there are large datasets being produced. In these scenarios, AI has the capability to identify complex patterns, unlock new insights, and optimise processes. There are several areas where AI can make a difference and accelerate the transition to net zero. These include:

- using AI to optimise energy systems;
- using machine learning (forecast electricity generation and demand and control its distribution around the network);
- using data analysis to find inefficiencies in emission-heavy industries; and
- using AI to model complex systems, the Earth's own climate, so we can understand the impact of our actions.

AI applications for energy and climate challenges are already being developed, but they are predominantly outliers and there are many applications across industry that are underpinned by AI that are not being used. The UK's Net Zero Strategy sets out the ambition to generate 40 gigawatts of offshore wind by 2030 (compared to business as usual, with a government uptake of 8 GW by 2030)[1]. Offshore wind farms are a complex system that accounts over time for the potential of AI to achieve more significant gains.

Over the last ten years there have been a series of advances in AI. These advances offer opportunities to rapidly increase the efficiency of energy systems and help reduce emissions across the economy. For example, Google DeepMind's work on AI for Basic Research advances the UK's strategies to play a role in innovating solutions to climate change, and Deepmind is emerging that shows how 'exponential technologies' such as AI can be used to accelerate the development of low carbon fuels. Although AI is increasingly seen as a critical technology, there are still many untapped AI applications and emissions-saving big ideas.[Footnote 2], [Footnote 3], [Footnote 4]

In the UK we have previously commissioned research into innovation policy to promote a range of technologies towards the delivery of social, economic and environmental goals. Commissioned research by the Science Policy Research Unit (SPRU) has found that these critical mass investments in particular capabilities of AI technology that will generate new solutions to tackle net zero challenges.

Players will also be important through the Government's Industrial Strategy Challenge Fund, which is a £1 billion investment to ensure the UK's industrial strengths are supported and will develop these innovators in a way that considers the promise of AI technologies. Additionally, the Government's Research and Development Roadmap will ensure that 'a key area of international collaboration such as the UK-US Declaration on Cooperation in AI Research and Development' and the Global Partnership on Artificial Intelligence (GPAI) will be important in coordinating areas of expertise in the energy sector to maximise our strategic advantage.

Health

In August 2019, the Health Secretary announced a £250 million investment[5] to create the NHS AI Lab in NHS to accelerate the safe, ethical and effective development, testing and adoption of AI technologies. The NHS AI Lab will support challenges in health and social care, including earlier cancer detection, addressing priorities in the NHS Long Term Plan, and relieving pressure on the workforce.

AI technologies have the potential to improve health outcomes for patients and service users, and free up staff time for care.[Footnote 6] The NHS AI Lab aiming to deploy AI at scale by 2025 to improve the care pathway for patients with Health and Care Research and the Medicines and Healthcare products Regulatory Agency (MHRA) are working to ensure the evidence base for AI technologies is robust and that the UK's regulatory system is fit for purpose, so that AI technologies can be evaluated, supported, deployed and responsibly procured for technologies for the benefit of citizens.[Footnote 7], [Footnote 8]

The Government has published five plans to rapidly modernise our Armed Forces.[Footnote 9] The Ministry of Defence has set up the agile Defence Artificial Intelligence Centre (DAIC) to ensure that the Armed Forces are able to take full advantage of AI and have set ambitious goals for AI and technological advantage, and to ensure that we are in defence. This will include the establishment of the new Defence AI Centre which will provide a coordinated approach to AI development across Defence. The Ministry of Defence should be a natural partner for the wider AI community and should actively seek to achieve synergies and exploit opportunities where it can, and should actively seek to work closely with the Office for AI and other government departments to ensure that we are embracing the key drivers set out in the National AI Strategy.

Ministry of Defence using AI to reduce costs and meet climate goals

The MOD is trialling a UK market 'Software Defined Electronic EW' system, which aims to optimise electricity in real time. To help meet its climate goals and reduce its carbon footprint, the Ministry of Defence (MOD) is trialling a new system, which, given the potential electricity bill for the MOD's new EW fleet, is set to STRIKE and £200 MOD, would equate to savings of £30-35 MOD every year and significant reductions in CO2 emissions.

Crown Commercial Service

The Crown Commercial Service worked closely with colleagues in the Office for AI and our government partner during all stages of Capability for AI procurement. They was asked to design their AI Dynamic Purchasing System (DPS) framework to ensure it was fit for purpose, easy to use and accessible to suppliers and buyers. Suppliers commit only to bidding where they are capable and willing to deliver both the ethical and technical dimensions of a service.

The Crown Commercial Service's commitment to AI ethics continues to help improve the public sector's capability to buy AI products and services, and will continue to work closely with the Office for AI and other government departments to ensure we are addressing the key drivers set out in the National AI Strategy.

Pillar 2: Ensuring AI Benefits all Sectors and Regions

Actions

1. Launch a programme as part of UKRI's National AI R&I Programme, designed to stimulate the development and adoption of AI technologies in high-potential areas of the economy, including: manufacturing, construction, communication networks, creative and digital, and healthcare. Ensure potential market opportunities where their products and services are competitive.
2. Launch a Kickstart Strategy for AI in Health and Social Care in line with the National AI Strategy. This will set the direction for AI in health and social care, and will be published in the spring of 2021.
3. Ensure that public sector departments's ambition to secure strategic advantage through science and technology.
4. Ensure that our regulatory and standards infrastructures also incorporate the potential of AI solutions to tackling long, real-world problems and to ensure that our institutions are able to pursue ambitious bilateral and multilateral collaborations. Ensure that our regulatory bodies and cross-sector such as energy, and through the extension of GPI AI to support local innovation ecosystems in developing AI nations.
5. Ensure that our public procurement, including for defence applications, to empower when civil society is identified and implemented as well as promoting the strategic priorities identified through the Phase 1 Programme and Industrial Strategy Challenge Fund and Research and Development.
6. Publish research into the dependencies impacting the diffusion of AI across the economy.
7. Ensure the Ministry of Defence AI Strategy, which will explain how we can achieve and sustain technological advantage and be a cross-government defence, including detail on the establishment of a new Defence AI Centre.

Pillar 3: Governing AI effectively

Ensuring that national government of AI technologies encourages innovation, protects citizens' rights and manages risks to national security and stability will global partners to promote the responsible development of AI technologies.

Artificial intelligence requires that scientists, researchers and entrepreneurs to innovate without stepping consumer and citizen confidence in AI technologies is fundamental to the government's vision over the next decade.

In a world where systematic international competition will have a significant impact on security and prosperity around the world, the government wants the UK to be most trusted place in the world to develop and deploy AI technologies, with the public, businesses and the consumer which increasing confidence and investment in the technology in the UK.

Effective, pro-innovation governance of AI means that (1) the UK has a clear, proportionate and effective framework for regulating AI that supports innovation while addressing actual risks and harms, (2) UK regulators have the flexibility and capabilities to govern AI technologies in their sectors, and (3) UK regulatory institutions are resourced and adapt AI technologies with the right tools and mechanisms to manage risks and harms. The UK public sector will lead the way by setting an example for the safe and ethical deployment of AI through how it governs its own use of AI technologies.

We will collaborate with key actors and partners on the global stage to promote the development of AI technologies that are in line with UK ethical and regulatory priorities to adapt and apply the technologies in the service of a liberal framework and repression. Through our science partnerships and wider development and diplomacy work, the UK will promote the adoption of AI technologies that are in line with our ethical and regulatory priorities.

Government's aim is to build the most trusted and pro-innovation system for AI governance in the world.

This will be achieved by: Establishing an AI governance framework that addresses the unique challenges and opportunities of AI, while being flexible, proportionate and pro-innovation. This framework will:

- Establish a clear set of principles for trustworthy AI, to underpin the development of an ecosystem of AI assurance tools and services to provide meaningful information about AI systems and suppliers.
- Growing the UK's contribution to the development of global AI technical standards, to ensure that UK AI is able to meet the technical specifications and processes that will support AI governance needs, including cybersecurity and minimise the costs of regulatory compliance.
- Building AI regulators' capacities to understand and assess AI, ensuring that they can deploy an AI ecosystem as new AI-based products and services emerge in their sectors.
- Setting an example for safe and ethical deployment of AI, with the government leading from the bench.
- Ensure that our regulatory institutions are agile enough to promote international agreements and standards that deliver for our prosperity and security, and promote innovation that harnesses the benefits of AI as we extend our values and institutions of liberty, security, democracy, rule of law and respect for human rights.

Supporting innovation and adoption while protecting the public and building trust

The UK has a strong international reputation for the rule of law and technological breakthroughs. To build on this the government set out its pro-innovation approach in the Plan for Digital Regulation. The Plan recognises that well-designed regulation can be a powerful tool to drive innovation, protect citizens' rights and rebuild economic and social, where development of restrictive regulation can hinder innovation. The Plan also acknowledges that digital businesses, which include those developing and deploying AI, have expressed concerns that the current system is unclear and unnecessarily complex. The existing rules and norms, which have grown over time, have created a complex landscape that can be difficult to navigate and has unintended costs and risks.

This is especially the case for AI which, with its powerful data processing and analytical capabilities, has the potential to transform the economy and society, but it is also leading to systemic uncertainty in history and confusion. The complexity of the system is most acute in the area of data protection, where the Information Commissioner's Office (ICO) has raised concerns about the current approach to AI governance and data protection, and has introduced through AI. Other concerns include the ability of AI to undermine privacy rights and to be used to make decisions that discriminate against UK citizens or unsystematically to the disadvantage. For example, there is evidence of bias in the development and deployment of AI systems to prevent such harm from arising. Equality law sets out the legal approach to mitigate against cases of algorithmic bias or unfairness.

This is not to say that AI is currently unregulated. The UK already regulates many aspects of the development and use of AI through cross-sector legislation and different regulators. For example, there is coverage in areas like data protection (the Information Commissioner's Office), competition (the Competition and Markets Authority), human rights and equality (including by Human Rights Commission, the Equality and Human Rights Commission), health and safety (the Health and Safety Executive), financial services (the Financial Conduct Authority) and medical products (the Medicines and Healthcare products Regulatory Agency).

As the use of AI increases, the UK has responded by reviewing and adapting the regulatory framework. For example, the Data Protection and Digital Information consultation sets the month, review on the role of the data protection framework in the broader context of AI governance. Specifically, the consultation examines the risk of bias and discrimination in AI systems and proposes that it may be in the public interest for data Tsarnaev to a data protection context.

Data Protection Framework and AI: Using A new direction/consultation

The UK data protection framework (UK General Data Protection Regulation and Data Protection Act 2018) is technology neutral and was not intended comprehensively govern AI systems, or any other specific technologies. Many AI systems do not use personal data at all.

Navigating and applying relevant data protection provisions can be perceived as a complex exercise for organisations developing and deploying AI systems, mainly because of the interplay between groups of technologies.

DCPD is currently running a consultation on potential reforms to the data protection framework. The consultation sets out that the UK GDPR is technology-agnostic (as does our wider data protection provisions) that are intended to be engaged in the process of developing and deploying AI. In particular, the consultation covers:

- Clarifying the use and reuse of personal data for research (including AI development and deployment);
- Clarifying the use and reuse of personal data under the legitimate interests test, including data detection and mitigation unsystematic (CI);
- Clarifying the application of purpose limitation to AI systems, including adapting data detection and mitigation in AI systems (CI);
- Clarifying the use of the term 'fairness' in data protection context (CI);
- Clarifying the application of the data protection framework in developing and deploying AI responsibly (CI);
- Assessing the general suitability and operation of UK GDPR Article 22 rights relating to automated decision-making and profiling (CI);
- Mandating transparency requirements for the use of algorithmic decision-making in the public sector (CI).

In 2018, the government agreed with the Report of Lords, stipe that "Everyone AI-specific regulation, at this stage would be premature. [and] that existing sectoral regulation and bend product to consider the impact on their sector of any subsequent regulation which may be needed."

There are some strong reasons why our sectoral approach makes sense:

- **The heterogeneity of AI means it is difficult to define AI in a way that is useful for regulation.** AI is not a single technology, but a broad, multi-purpose technology. It is rapidly developing and therefore would course on the AI part of a system is constantly changing.
- **Uses cases for AI, and their impacts, can be highly contextual in their strength.** There is a big difference in what can be covered in cross-cutting legislation on AI, and what is useful and proportionate to ensure that people and society can reap the benefit of the ease of individual harms and risks.
- Individual regulators and institutions **are already starting to respond to the risks of AI in their sectors.** Many regulators are already developing guidance, standards, and AI-specific regulatory responses and approaches, and are also empowering individual bodies to research a much quicker response to individual harms and risks posed by AI. For example, the Financial Conduct Authority is approaching AI technologies. For example, sector-specific security and safety standards in the development and deployment of AI systems to prevent such harm from arising. Equality law sets out the legal approach to mitigate against cases of algorithmic bias or unfairness.

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- **The complexity of the current regulatory landscape.** Many AI systems will be governed by several regulators, and will need to be able to navigate and understand how different regulators expectations and requirements are applicable to their AI system. This is especially the case for AI which, with its powerful data processing and analytical capabilities, has the potential to transform the economy and society, but it is also leading to systemic uncertainty in history and confusion. The complexity of the system is most acute in the area of data protection, where the Information Commissioner's Office (ICO) has raised concerns about the current approach to AI governance and data protection, and has introduced through AI. Other concerns include the ability of AI to undermine privacy rights and to be used to make decisions that discriminate against UK citizens or unsystematically to the disadvantage. For example, there is evidence of bias in the development and deployment of AI systems to prevent such harm from arising. Equality law sets out the legal approach to mitigate against cases of algorithmic bias or unfairness.
- **Cross-cutting AI-specific regulation would be premature.** The UK already regulates many aspects of the development and use of AI through cross-sector legislation and different regulators. For example, there is coverage in areas like data protection (the Information Commissioner's Office), competition (the Competition and Markets Authority), human rights and equality (including by Human Rights Commission, the Equality and Human Rights Commission), health and safety (the Health and Safety Executive), financial services (the Financial Conduct Authority) and medical products (the Medicines and Healthcare products Regulatory Agency).

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Alternative options

The UK's 2018 policy position that "avoiding sector-specific regulations seen best placed to provide the impact on their sector of any subsequent regulation which may be needed" will be tested in our work towards the development of a White Paper, along with potential alternatives. The main alternatives are:

- Removing some existing regulatory functions where there is evidence they are unnecessarily burdensome on AI developers.
- Bolstering the existing sector-based approach, ensuring that individual regulators are empowered to work flexibly within their sect-wards to ensure AI delivers the right outcomes.
- Introducing additional cross-sector protections in rules, such as the requirement the rule of individual regulators to enable more consistency across existing regimes.

Any of these options, it will be necessary to ensure that regulators are given the relevant levers are equipped to tackle the challenges raised by AI. This may require additional powers, resources, or capabilities to ensure regulators can interpret new guidance, or standards to better enable consistency across existing regulatory regimes.

In developing our White Paper position, the Office for AI will consider all of these, and potentially other, options for governing AI technologies. Having regard for the need for the opportunity to build on our world leading regulatory regime by setting out a pro-innovation approach to AI governance that is proportionate to risk. The UK will consider what AI assurance we need to ensure that our institutions are able to manage existing regulators' remits and consider the risk that standards, assurance, and international engagement plays.

Regulators' coordination and capacity

While some regulators are leading the way in understanding the implications of AI for their sector or priority, we need all regulators to be able to do this. The economic and discipline nature of AI also raises new challenges in terms of regulatory overlap. For example, many AI systems will need to be governed by several regulators, and will need to consider the liquidity for the use of personal data including sensitive personal data for specific regulatory purposes such as the Financial Conduct Authority's Fair Data Strategy.

The government is working with The Alan Turing Institute on a pilot scheme to capacity regulators' existing AI capacities. In particular, this work is exploring monitoring and evaluation tools for AI, and will inform the Office for AI's wider work on building cross-sector AI capacity.[Footnote 10]

Greater cooperation is also being established through initiatives such as through the Digital Regulators Cooperation Forum, a voluntary forum recently established comprising the Competition & Markets Authority (CMA), Financial Conduct Authority (FCA), Information Commissioner's Office (ICO) and Ofcom. The forum is intended to deliver a joined approach to digital regulation.

International governance and collaboration

The UK will work with partners to support the international development of AI governance in line with our values. We will do this by working with partners around the world to promote the UK's vision for AI governance, including through the Global Partnership for AI (GPAI), and potential Council of Europe AI agreements. We will also work with our partners in the Five Eyes intelligence community and the Defence and Security Partnership to protect and support development of AI.

The UK is already working with like-minded partners to ensure that AI systems respect human rights, democratic principles and the rule of law shape AI regulation and governance globally. We will continue to promote a pro-innovation, risk-based, and outcome-focused approach to open innovation and ensure these processes. As the international debate on these frameworks has gained momentum, the UK has proactively engaged on AI at the Council of Europe, the Organisation for Economic Co-operation and Development (OECD), the Global Partnership on AI, providing significant contributions to these fora. Alongside these initiatives, such as the recently announced Elsa investment in DRAI's data trust research by BPI.

The UK will act to protect against efforts to adapt and apply these technologies in the service of a liberal framework and repression. We will also work with our partners to ensure development and diplomacy work seek to engage early and in sufficient depth with our partners to ensure our ethical and regulatory priorities are reflected in the private-sector-led values and defined human rights.

UK Defence has a strong international collaboration with international partners and allies. Key collaborations include engagement with NATO allies to lead AI integration and interoperability, through the Five Eyes Intelligence Community, the Defence and Security Partnership and the Combined Joint Expeditionary Force.

The government will continue to work with our partners around the world to shape international norms and standards relating to AI, including those developed by multilateral and multistakeholder bodies at global and regional level. We will continue to work with our partners in the Five Eyes intelligence community, the Defence and Security Partnership and the Combined Joint Expeditionary Force, underpinned by our shared values of freedom, fairness, and democracy.

AI and global digital technical standards

The UK's Plan for Digital Regulation sets out our ambition to use digital technical standards to promote an agile and pro-innovation approach to regulatory AI technologies and cybersecurity. Technical standards, as part of a wider suite of governance instruments, can be a powerful tool for innovation.

The integration of standards in our model for AI governance and regulation is crucial for unlocking the benefits of AI for the economy and society, and for the UK, and ensuring that the principles of trustworthy AI are translated into robust technical specifications and processes that are globally recognised and interoperable.

What are technical standards and how do they benefit the UK?

Global technical standards set out good practice that can be consistently implemented across borders to ensure products and services are interoperable, safety and efficiently. They are generally voluntary and developed through an industry led process in global standards developing organisations, based on the principles of transparency, openness, consensus and relevance. There are many global technical standards and best practice. For example, technical standards are referenced alongside regulatory tools in the UK's Digital Identity and Attributes Trust Framework (DIATF), which represents a collaborative approach to digital identity services.

We want global technical standards for AI to benefit UK citizens, businesses, and the economy by:

- **Supporting R&D and innovation.** Technical standards should provide clear, robust, and flexible technical specifications that support innovation, drive product complexity and improving product consistency and interoperability, supporting market uptake.
- **Supporting trade.** Technical standards should facilitate digital trade by minimising regulatory requirements across different markets.
- **Giving UK businesses more opportunities.** Standardisation is a co-creation process that offers UK businesses the chance to influence markets, gain access to market intelligence, new customers, and commercial and research partnerships.
- **Ensuring safety, security and trust.** The integrated Review set out the role of technical standards in enhancing cybersecurity and interoperability in the design and development of technologies. At technical standards (e.g. for software development) can ensure that cybersecurity is built into the security and lifecycle of products and services.
- **Supporting conformity assessments and regulatory compliance.** Technical standards can underpin conformity assessments to demonstrate product performance, reliability of products before they enter the market. This includes providing a means of compliance with requirements set out in regulation.

The UK is taking a global approach to shaping technical standards for AI. Transformative, seeking to embed accuracy, reliability, security, and other features of trustworthiness into AI standards and technical specifications, to ensure that AI standards aligned with international partners, industry, and other organisations, and potential foundation to complement our governance and regulatory approach.

The UK's approach to AI standards development is underpinned by our commitments with the British Standards Institution (BSI) and the National Physical Laboratory (NPL) to work to close up the UK's engagement in global standards developing organisations. **The government is also supporting UK standards bodies to:**

- **Pilot an AI Standards Hub** to expand the UK's international engagement and influence in AI standards.
- **Develop an AI standards engagement toolkit** to provide a 'Guide to UK AI standards' and a 'Guide to AI standards development'.

stakeholders to engage in the global AI standardisation landscape.

Internationally, the government is:

- Increasing bilateral engagement with partners, including strengthening coordination and information sharing.
- Bringing together conversations of standards developing organisations and multilateral fora. BSI and the government are members of the Open Community for Ethics in Autonomous and Intelligent Systems (OCEANIS), which aims to bring SDOs, businesses, and research institutes.
- Engaging in the OECD's Network of Experts Group on Implementing Trustworthy AI, collaborating with governments, academics, and experts to build guidance.
- Promoting the 2021 Carlos Bas-Ci Leader's Compendium, an expanding inclusive, multi-stakeholder approaches to standards development, by ensuring our UK approach to AI standards is multidisciplinary, and encourages a wide set of stakeholders in standards developing organisations.

The UK is leading the way on AI technical standards internationally

The UK's global approach to AI standardisation is exemplified by our leadership in the International Organisation for Standardisation and International Electrotechnical Commission (ISO/IEC) on four active AI projects, as well as the UK's initiation of and strong engagement in the Industry Specification Group on Securing AI at the European Telecommunications Standards Institute (ETSI).

At ISO/IEC, the UK, through BSI, is leading the development of AI international standards in concepts and terminology; data; bias; governance implications; and data life cycles. At ETSI we have published, among other documents, ETSI GR SAI 002 on Data Supply Chain Security, which was led by the UK's National Cyber Security Centre.

The ISO/IEC work programme includes the development of an AI Management System Standard (AIMS) which intends to help notes some of the implementation challenges of AI. This standard will be known as ISO/IEC 42001 and will help an organisation develop or use artificial intelligence responsibly in pursuing its objectives, and deliver its expected obligations related to interested parties.

AI Assurance

Understanding whether AI systems are safe, fair or are otherwise trustworthy requires rigorous assessment and independent scrutiny. Assurance techniques can provide such systems partners, how they are governed and operated, whether they are compliant with standards and regulations, and whether they will reliably operate as intended. AI assurance will play an important enabling role, unlocking economic and social benefits of AI systems.

What is Assurance?

Assurance covers a number of governance mechanisms for third parties to develop trust in the compliance and risk of a system or organisation. Assurance as a service draws originally from the accounting profession, but has since been adapted to cover many areas such as cyber security, product safety, quality and risk management.

In these areas, mature ecosystems of assurance products and services enable people to understand whether systems are trustworthy and direct their trust or distrust appropriately. These products and services include: process and technical standards; repeatable audits; impact assessments; certification schemes; advisory and training services.

An AI assurance ecosystem is emerging within both the public and private sectors, with a range of companies including established accountancy firms and specialised start-ups, beginning to offer assurance services. A number of possible assurance techniques[footnote 1] have been proposed and regulators are beginning to set out how AI might be assured (for example, the ICO's Auditing Framework for AI).

However, the assurance ecosystem is currently fragmented and there have been several calls for better coordination, including from the Committee on Standards in Public Life and the Office for Statistics Regulation. The CDEI's recently published review into bias in algorithmic decision-making also points to the need for an ecosystem of industry standards and professional services to help organisations address algorithmic bias in the UK and beyond.

Playing this crucial role in the development and deployment of AI, assurance is likely to become a significant economic activity in its own right and is an area in which the UK, with particular strengths in legal and professional services, has the potential to excel.

To support the development of a mature AI assurance ecosystem, the CDEI is publishing an AI assurance roadmap. This roadmap clarifies the set of activities needed to build a mature assurance ecosystem and identifies the roles and responsibilities of different stakeholders across these activities.

Public sector as an exemplar

The government must lead from the front and set an example in the safe and ethical deployment of AI. The AI Sector Deal commitment to pilot AI assurance techniques with the Alan Turing Institute to produce an AI ethics and safety impact assessment in the public sector in 2019. This guidance identifies the potential harms caused by AI systems and proposes measures to counteract them. **The government is working through the Alan Turing Institute to update this guidance in order to provide public servants with the most current information about the state of the art in Responsible AI Innovation.** This update incorporates the delivery of interactive workbooks aimed to equip public sector stakeholders with the practical tools and skills needed to bring the content of the original guidance to life. [footnote 2]

The Ministry of Defence is moving quickly against a fast-evolving threat picture to secure the benefits of these transformative technologies. The Ministry of Defence has rigorous codes of conduct and regulation which uphold responsible AI use, and is working closely with the wider government on approaches to ensure clear alignment with the values and norms of the society we represent.

As the CDEI conducts its ongoing work to address bias in algorithmic decision-making, the Commission on Race and Ethnic Disparities recommended that a mandatory transparency obligation be placed on all public sector organisations applying algorithms that have an impact on significant decisions affecting individuals, highlighting the importance of stewarding AI systems in a responsible manner to increase overall trust in their use.

To ensure that citizens have confidence and trust in how data is being processed and analysed to derive insights, **the Centre for Data Ethics and Innovation (CDEI) is undertaking research with a view to developing a cross-government standard for algorithmic transparency** in line with the commitment in the National Data Strategy.

The CDDO work is being conducted collaboratively with leading organisations in AI and data ethics and it has been informed by a range of public engagement processes. To date, no other country has developed a standard for algorithmic transparency at a national level. Proactive transparency in this field will be an extension of the UK's long standing open data and open algorithms leadership.

AI risk, safety, and long-term development

The government takes the long term risk of non-aligned Artificial General Intelligence, and the unforeseeable changes that it would mean for the UK and the world, seriously.

There are also risks, safety and national security concerns that must be considered here and now - from deployed and targeted misinformation from authoritarian regimes, to sophisticated attacks on consumers or critical infrastructure. As AI becomes increasingly ubiquitous, it has the potential to bring risks to consumers, the UK's businesses and into national security and defence. So as AI becomes more general and is simply used in more diverse ways, we must maintain a broad perspective on implications and threats, with the tools to understand its most subtle impacts, and ensure the UK's institutions are able to act on this. The UK's approach to AI safety and long-term risk is the technology itself. **The Office for AI will continue to monitor developments and work to accurately assess long term AI safety and risks**, which will include activities such as evaluating technical expertise in government and the value of research infrastructure. Given the speed at which AI developments are impacting our world, it is also critical that the government takes a more precise and timely approach to monitoring progress on AI, and the government will work to do so.

The government will support the safe and ethical development of these technologies as well as using powers through the National Security & Investment Act to mitigate risks arising from a small number of potentially concerning actors. At a strategic level, the **National Resilience Strategy** will review our approach to emerging technologies; the **Ministry of Defence** will set out the details of the approach by which Defence AI is developed and used; the **National AI R&D Programme's** emphasis on AI theory will support safety; and **central government** will work with the national security apparatus to consider narrow and more general AI as a top-level security issue.

Pillar 3 - Governing AI Effectively

Actions:

1. Develop a pro-innovation national position on governing and regulating AI, which will be set out in a White Paper, to be published in early 2022.
2. Publish the CDEI AI assurance roadmap and use this to continue work to develop a mature AI assurance ecosystem in the UK.
3. Pilot an AI Standards Hub to coordinate UK engagement in AI standardisation, including to support UK businesses to navigate the development of an AI standards engagement toolkit to support the AI ecosystem to engage in the global AI standardisation landscape.
4. Continue our engagement to help shape international governance, and international norms and standards for governing AI, to reflect human rights, democratic principles, and the rule of law on the international stage.
5. Support the continuing development of new capabilities around trustworthiness, accountability, adoptability, and transparency of AI technologies via the national AI Research and Innovation Programme.
6. Publish details of the approaches which the Ministry of Defence will use when adopting and using AI.
7. Develop a cross-government standard for algorithmic transparency.
8. Work with The Alan Turing Institute to update the guidance on AI ethics and safety in the public sector.
9. Coordinate cross-government processes to accurately assess long term AI safety and risks, which will include activities such as evaluating technical expertise in government and the value of research infrastructure.
10. Work with national security, defence, and leading researchers to understand how to anticipate and prevent catastrophic risks.

Next steps

The National AI Strategy proposes three core pillars which, taken together, are areas the UK can make the biggest impact to set the country on its way to being an AI and science superpower for the coming decades.

By their nature, strategies are a response to the moment in which they exist - further actions will also be required to elaborate on the ideas set out in this document in ways that responds to the fast-changing landscape in the years to come. A plan to execute against the vision set out in this strategy will be published in the near future. Alongside this, we will put mechanisms in place to monitor and assess progress.

We will publish a set of quantitative indicators, open the for-ranging yard ball-to-define impacts AI will have on the economy and society. We will publish these indicators separately to this document and at regular intervals to provide a transparent view on progress and to hold ourselves to account. Given the cross-cutting nature of AI, collaboration across a wide range of sectors and stakeholders will be paramount. The Office for AI will be responsible for overall delivery of the strategy, monitoring progress and enabling its implementation across government, industry, academia and civil society.

We will also continue talking with the wider community to get their feedback on AI 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.

The government is ready to act as independent expert group formed to representing the interests of the UK's AI ecosystem, and to advise on the delivery of the National AI Strategy and informing its direction. As we move into an implementation phase, the AI Council will continue to help galvanise action from across the ecosystem in fulfilling our objectives and holding the government to account on the actions contained in this strategy. The recently established Office for Science and Technology Strategy, National Science and Technology Council and National Technology Adviser work with the rest of government to drive forward Whitehall's science and technology priorities from the centre. As a part of this, we will collectively identify the technological capabilities required in the UK and in the government to deliver the Prime Minister's global science superpower ambitions through AI.

1. Deep technologies are based on significant scientific advances or engineering innovations, but which require a longer period of development and/or considerable capital investment before commercial application. Transformative technologies are those that have the potential for impact across many sectors of the economy, not just within a single sector. ↩
2. This definition is different due to the clarity needed for legislation. See National security and investment: mandatory notification sectors for more information. ↩
3. This refers to the ownership of creative content generated by an algorithm. While this is an open discussion, the Intellectual Property Office has covered this topic in a recent consultation outcome and has committed to consult on the extent to which copyright and patents should protect AI generated creative works and inventions. ↩
4. Technology Review, Yes, We Are Worried About the Existential Risk of Artificial Intelligence (2020) ↩
5. Human Compatible, Stuart Russell (2019) ↩
6. GCHQ, Pioneering a New National Security: The Ethics of Artificial Intelligence (2020) ↩
7. Stanford University, Artificial Intelligence Index Report 2021 (2021) ↩
8. DeepMind, AlphaFold: a solution to a 50-year-old grand challenge in biology (2020) ↩
9. Perry Mindel House, The Immigration Preferences of Top AI Researchers (2020) ↩
10. This is not an exhaustive list and does not capture the full spectrum of AI spend, either day-to-day or single investments, across the whole of central government. This also excludes defence spend on AI. ↩
11. The Innovation Strategy's seven technology families were 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. ↩
12. Microsoft, AI Scale to The UK (2020) ↩
13. Ipsos MORI, Understanding the UK AI labour market 2020 (2020) ↩
14. Ibid. ↩
15. Ibid. ↩
16. Ibid. ↩
17. GOV.UK, UK Innovation Strategy: Leading the future by creating it, pg 55 (2021) ↩
18. Times Higher Education, Which countries and universities are leading on AI research? (2021) ↩
19. GOV.UK, Growing the Artificial Intelligence Industry in the UK (2017) ↩
20. House of Lords Select Committee on Artificial Intelligence: AI in the UK: ready, willing and able? (2018) ↩
21. Global Innovation Index, Global Innovation Index 2020 Report (2020) ↩
22. This is supported by research findings from BEIS research that private and third sector organisations overwhelmingly identified quality as the most important data characteristic to their success. ↩
23. Sometimes referred to as the 'metaverse'. ↩
24. Large-Scale Computing means computer systems where processing power, memory, data storage and networks are assembled at scale to tackle computational tasks beyond the capabilities of everyday computers. Often involves the widespread use of supercomputers, but also includes distributed systems such as cloud computing, grid computing, high throughput computing, supercomputing and novel computing paradigms. ↩
25. Recognition of the important role of computing capacity as an enabler for AI technologies is increasing. The OECD has established an OECD AI task force on AI compute to create a framework for understanding, measuring and benchmarking domestic AI computing supply by country and region. ↩
26. UKRI, £230m to upgrade the UK's world-class research infrastructure (2020) ↩
27. The Verge, British chip designer Graphcore unveils new AI processor more complex than Nvidia's (2020) ↩
28. Gerard Grech, CEO of Tech Nation, Figures from 2021 survey, unpublished ↩
29. British Business Bank, Small Businesses Equity Tracker (2020) ↩
30. Innovate UK research found that the benefits in developing or developing these technologies lead to significant economic impacts by increasing the number of 'investable' propositions but, given the long commercialisation cycles, it is something that takes time and might not be considered an attractive quick win, leading to a decrease of funding for lower maturity AI technologies with less developed commercialisation plan. ↩
31. Deep tech companies have additional difficulties raising equity funding compared to software companies because of their complex nature, long development times and large amounts of financing required. Tech Nation (2021) supports this finding, with "deep tech start-ups taking 8-12 years for VCs to see returns, versus 3-5 years" for start-up companies in general, including software companies. ↩
32. Based on data from DCMS Sectors Economic Estimates 2019: exports of digital goods and exports of digital services. ↩
33. pg. 60-64 of the Innovation Strategy ↩
34. e.g. Advanced Technology Adoption And Use By U.S. Firms: Evidence From The Annual Business Survey (2020) ↩
35. GOV.UK, Prime Minister sets out plans to realise and maximise the opportunities of scientific and technological breakthroughs (2021) ↩
36. pg. 80-84 of the Innovation Strategy ↩
37. pg. 84-100 of the Innovation Strategy ↩
38. Quartz, Innoarchitect: the data that spawned the current AI boom (2017) ↩
39. The Exponential Roadmap Initiative (2019) ↩
40. ITU/UN, Frontier Technologies To Protect the Environment and Tackle Climate Change (2020) ↩
41. D. Rolnick et al., Tackling Climate Change with Machine Learning (2019) ↩
42. GOV.UK, Health Secretary announces £250 million investment in artificial intelligence (2019) ↩
43. Global Digital Health Partnership, AI for healthcare: Creating an international approach together (2021) ↩
44. This includes work with the Crown Commercial Service to produce a new AI services procurement framework, and work with the National Cyber Security Centre for the Fourth Industrial Revolution to produce guidelines on AI procurement. ↩
45. GOV.UK, Global Britain in a Competitive Age: the Integrated Review of Security, Defence, Development and Foreign Policy (2021) ↩
46. GOV.UK, The Defence Cloudwise Paper sets out the future for our armed forces (2021) ↩
47. GOV.UK, Multi Science and Technology Strategy (2020) ↩
48. GOV.UK, Defence and Security Industrial Strategy (2021) ↩
49. Deloitte, Artificial intelligence (AI) goes mainstream (2021) ↩
50. This work is also looking at how AI technologies can be used by regulators to discharge their legal duties. ↩
51. OECD AI Policies and OECD.AI Policy Observatory ↩
52. NPL, Unlocking standards for AI industrial revolution (2021) ↩
53. Alex Lawrence Institute, Examining the Black Box: Tools for assessing algorithmic systems (2020) ↩
54. The practice- and activity-based approach of the workbooks aims to increase public sector adoption of the guidance by engaging civil servants in capacity building workshops that support the execution of ethically sound practices throughout the AI design, development, and implementation lifecycle. ↩

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