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**QUANTUM TECHNOLOGY AND ARTIFICIAL INTELLIGENCE/
MACHINE LEARNING AS STRATEGIC ENABLERS
TO STRENGTHEN GEOPOLITICAL POSITION
– UNITED KINGDOM PERSPECTIVE**

***Abstract:** Superpowers such as the US, China and the United Kingdom have recognised quantum and Artificial Intelligence/ Machine Learning (AI/ML) based technologies as strategically important from geopolitical, social and economic perspectives. Those technologies have the potential to shift geopolitical points of gravity and either strengthen or weaken them. This article reviews the United Kingdom's strategic approach to quantum and AI/ML technologies and how those technologies could affect the UK's geopolitical position.*

***Keywords:** Quantum Technology, Artificial Intelligence, Machine Learning, Science and Technology, Strategy, United Kingdom*

General information and geopolitical context

The United Kingdom (UK) is one of the leading digital nations. Globally, according to Tech Nation Report 2021², the UK sits behind only the US and China in terms of venture capital investment. As technology becomes an increasingly important enabler of geopolitical power, the UK government recognises, that competition in this arena will intensify. In order to strengthen its geopolitical position, the UK needs to maintain a stake in critical technologies with an ambitious and proactive approach, while, at the same time, avoiding excessive dependence on competitors and adversaries.

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² Tech Nation Report 2021, < <https://stagetechn.wpengine.com/report2021/>>, (26.11.2023).

Multiple official documents, such as Integrated Review Refresh 2023³, and the UK Science and Technology Framework⁴, outline technologies which are recognised to make the UK a Science and Tech Superpower to build and sustain strategic advantage. Quantum technology and Artificial Intelligence (AI) are always listed among them. Recognised as technologies vital to Cyber Power, separate strategies have been published for both, covering wider national and defence areas:

- National Quantum Strategy, March 2023⁵,
- National AI Strategy, September 2021⁶,
- Defence Artificial Intelligence Strategy, June 2022⁷.

A new arms race is underway – superpowers such as the US, China and Russia have also recognised quantum and AI as strategically important technologies⁸. Not only have those powers made strategic plans in areas of quantum and AI but also started building capabilities. Being at the forefront of the technological competition is key for the UK to keep, let alone strengthen, its geopolitical position.

Quantum technology – introduction

Quantum technologies are those based on the use of quantum mechanics and quantum effects. Quantum mechanics, as a branch of physics, arose from the research of Max Planck and Albert Einstein in the early 20th century. The attempt to explain physical phenomena, observations and theories that cannot be described by classical physics, led in the mid-1920s to the further development of quantum mechanics. The UK has a notable history in modern quantum physics, from the work of Paul Dirac, considered one of the founders

³ *Integrated Review Refresh 2023: Responding to a more contested and volatile world*, <<https://www.gov.uk/government/publications/integrated-review-refresh-2023-responding-to-a-more-contested-and-volatile-world>>, (30.11.2023).

⁴ *UK Science and Technology Framework*, <<https://www.gov.uk/government/publications/uk-science-and-technology-framework>>, (30.11.2023).

⁵ *National Quantum Strategy*, <<https://www.gov.uk/government/publications/national-quantum-strategy>>, (30.11.2023).

⁶ *National AI Strategy*, <<https://www.gov.uk/government/publications/national-ai-strategy>>, (30.11.2023).

⁷ *Defence Artificial Intelligence Strategy*, <<https://www.gov.uk/government/publications/defence-artificial-intelligence-strategy/defence-artificial-intelligence-strategy>>, (26.04.2024).

⁸ K. Surdyk, *Wywiad w wojnach hybrydowych*, Ostrowiec Świętokrzyski 2022, p. 202; M. G. Raymer, C. Monroe, *The US National Quantum Initiative*, “Quantum Science and Technology”, Vol 4, No 2, 2019; A. K. Fedorov et al, *Quantum technologies in Russia*, “Quantum Science and Technology”, Vol 4, No 4, 2019; *China to include quantum technology in its 14th Five-Year Plan*, <http://english.www.gov.cn/news/videos/202010/22/content_WS5f90e700c6d0f7257693e3fe.html> (30.11.2023).

of quantum mechanics and quantum electrodynamics, to the theoretical work of Polish-born Artur Ekert in the early 1990s that showed that encrypted keys can be secured by quantum systems.

Currently, we are dealing with the second generation of quantum technologies which are based on the ability to generate, detect and control quantum states⁹. There is a vast, yet not concluded, set of problems that quantum technology, including quantum computers, will be able to tackle. As of today, the research is primarily focusing on the following types of problems: simulation, optimization, Machine Learning, and cryptography¹⁰. Quantum technology has been recognised as one of the foundational technologies. These, according to the Center for Strategic & International Studies (SCIS), will “fundamentally advance national security functions, among other parts of the economy or society, and underpin advancements in numerous sectors”¹¹. Quantum is therefore enabling technology which can unlock further innovations. When integrated, even with existing systems, it could exponentially boost performance across many sectors (telecoms, defence, AI, semiconductor industry, life sciences, high-performance computing, and photonics).

Quantum technology – UK national and global approach

There is no doubt that quantum technology has the potential to shift or cement vectors of geopolitical power. Similarly to the invention of nuclear weapons, in which the UK had its part by supporting the Manhattan Project, quantum technology could find application in modern warfare and signalling. The UK has already formed alliances with other nations to advance in quantum technology. In November 2021, the UK and US issued a joint statement which sets out a shared vision for continued cooperation on quantum information science and technologies between the UK and the US¹². This collaboration aims to promote research and development, grow the global market and support training for engineers and scientists. The UK has signed similar collaboration

⁹ *National Quantum Strategy...*

¹⁰ J-F. Bobier, M. Langione, E. Tao, A. Gourevitch, *Boston Consulting Group – „What happens when it turns to when in quantum computing”*, <<https://web-assets.bcg.com/89/00/d2d074424a6ca820b1238e24ccc0/bcg-what-happens-when-if-turns-to-when-in-quantum-computing-jul-2021-r.pdf>>, (30.11.2023).

¹¹ E. Harding, H. Ghoorhoo *Seven Critical Technologies for Winning the Next War*, <<https://www.csis.org/analysis/seven-critical-technologies-winning-next-war>> (30.11.2023).

¹² *New joint statement between UK and US to strengthen quantum collaboration*, <<https://www.gov.uk/government/news/new-joint-statement-between-uk-and-us-to-strengthen-quantum-collaboration>> (30.11.2023).

agreements with Switzerland¹³ and Japan¹⁴. Initiatives like those can lead to economic growth and global influence through “tech diplomacy”¹⁵ and / or setting standards and regulations – early movers have the advantage of setting them globally.

Although international collaboration is an essential part of the UK approach, it recognises the risk of relying solely on others for access to critical quantum technologies. The UK has taken a strategic approach to strengthen its soft power and domestic technology sector by investing in quantum technology. In 2014, National Quantum Technologies Programme (NQTP), has been set up to support research and commercialise quantum technologies. Since then, the UK invested £1 billion in research and development which resulted in making progress in building quantum capabilities. Today, the UK has a thriving academic and industrial quantum community – ranked in the top five for global academic excellence in quantum space¹⁶. The UK claimed many world firsts quantum advances, such as:

- quantum gravimeter technology for ground mapping (capable of detecting underground objects),
- first chip-to-chip Quantum Key Distribution (QKD) encrypted transmission, achieving world record performance in ion trap quantum computing.

Other examples of quantum technology applications which have been recently developed in the UK include:

- miniaturised atomic clocks which may end dependence on space satellites for timing,
- quantum secured communication service for commercial use,
- quantum gas cameras integrated into monitoring systems in the oil and gas industry,
- platform agnostic quantum computing operating system,
- wearable brain scanners.

¹³ *UK signs major science co-operation agreement with Switzerland*, <<https://www.gov.uk/government/news/uk-signs-major-science-co-operation-agreement-with-switzerland>> (30.11.2023).

¹⁴ *UK-Japan Semiconductors Partnership: joint statement*, <<https://www.gov.uk/government/publications/uk-japan-semiconductors-partnership-joint-statement>> (30.11.2023).

¹⁵ According to Martin Rauchbauer, co-founder of the Tech Diplomacy Network: “Tech diplomacy is a tool that will be crucial for all diplomats no matter what fields they are in or what countries they are working for. We believe that the digital and technological transformation will soon require that all diplomacy will be tech diplomacy.”. S. Buckup, M. Canazza, *What is tech diplomacy and why does it matter?*, <<https://www.weforum.org/agenda/2023/02/what-is-tech-diplomacy-experts-explain/>> (30.11.2023).

¹⁶ *National Quantum Strategy...*

The potential commercial applications of emerging quantum technology are vast. One of the challenges for the UK government is to focus on those which are most impactful strategically and give the most leverage in gaining geopolitical strength. Another challenge for the UK is to become a key part of the supply chains underpinning the quantum sector – those are already truly global (“85% of surveyed UK quantum companies are importing elements of their supply chain to develop quantum technologies”¹⁷) and need security in order to thrive.

Quantum technology in the UK’s defence and security

Apart from supporting commercial use, the UK government is acting as an early adopter of quantum technologies. The Ministry of Defence (MOD) is leading the way in adoption and procurement to support technology development and to show its value to other economic sectors. Two applications of quantum technology will have profound implications for defence and national security and could have a geopolitical impact:

- Quantum sensing. Used for Position Navigation and Timing (PNT), already has military application. In May 2023, a prototype of a quantum sensor was deployed on Royal Navy ship XV Patrick Blackett, allowing more secure and GPS-free navigation¹⁸. Quantum sensors, apart from navigation purposes, could be used as radar to detect submarines, aircraft or other objects by measuring changes in temperature, pressure or acceleration. The capability to detect signals from noise, especially with the support of Artificial Intelligence, could have a game-changing effect.
- Quantum cryptography. Secure communication is key for national security and defence – the ability to decrypt classically encrypted information, with the use of quantum technology, presents a near-term threat. To counter this threat MOD has already taken steps to “ensure Defence is ‘quantum ready’”¹⁹. In November 2020, the National Cyber Security Centre (NCSC) published a white paper “Preparing for

¹⁷ *National Quantum Strategy: technical annexes*, <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1142746/quantum-strategy-technical-annexes.pdf> (30.11.2023).

¹⁸ *Royal Navy and Imperial College London team up to work on cutting-edge navigation system*, <<https://www.royalnavy.mod.uk/news-and-latest-activity/news/2023/may/26/2023-0526-royal-navy-and-imperial-college-london-team-up-to-work-on-cutting-edge-navigation-system>> (30.11.2023).

¹⁹ *National Quantum Strategy...*, p. 45.

Quantum-Safe Cryptography”²⁰, setting out how to prepare for the post-quantum era. Military and government institutions, which hold classified information, should be leading the transition of existing infrastructure to post-quantum-proof. Access to quantum computers, on the other hand, presents an opportunity for the intelligence community to decrypt some communications without the knowledge of the owner. In June 2022, the MOD was already acquired from a UK-based company, the government’s first quantum computer²¹.

Artificial Intelligence technology spillover

The concept of Artificial Intelligence (AI) has been present in stories, myths and literature for centuries²². In the last century, we have seen rapid development of Machine Learning (ML) and AI technologies – from theoretical concept to application. The UK has a strong presence in AI/ML history with figures like Ada Lovelace and Alan Turing. It was Turing who, in 1950, published a paper titled “Computing Machinery and Intelligence”, in which he discussed learning machines, the machine learning approach and the famous Turing test – this paper was fundamental in the development of AI/ML. Today many machine learning²³ models, as Turing proposed, emulate a child’s mind and go through the supervised learning process leading to the emergence of the “thinking machine”²⁴. The very term AI is defined as “machines that perform tasks normally performed by human intelligence, especially when the machines learn from data how to do those tasks”²⁵. AI is considered a deep technology – one which requires a longer period of development and significant scientific advances to mature, having the potential to impact multiple sectors of the economy.

Today, the development and application of AI/ML technologies progressed to the point where almost every citizen of the Western world has interacted with those technologies or is using them in everyday life. We have witnessed unexpected benefits AI technology had on a range of industries – the so-called

²⁰ *Preparing for Quantum-Safe Cryptography*, <<https://www.ncsc.gov.uk/whitepaper/preparing-for-quantum-safe-cryptography>> (30.11.2023).

²¹ *Ministry of Defence acquires government's first quantum computer*, <<https://www.bbc.co.uk/news/technology-61647134>> (30.11.2023).

²² Early mentions of intelligent automata are present in antiquity, in Greek myths, one of which is Thalos – giant automaton made to protect territory.

²³ Alan Turing Institute gives the following definition of Machine Learning: “Computer algorithms that can ‘learn’ by finding patterns in sample data and then apply this to new data to produce useful outputs, often using neural networks.”

²⁴ A. M. Turing, *Computing Machinery and Intelligence*, Oxford 1950, Mind 49, pp. 433-460.

²⁵ *National AI Strategy...*, p. 16.

spillover effect. Use case examples span from smart devices like smart speakers, through social media feeds, autonomous cars, and online banking, to drones used on the battlefield. Soon, there may be no branch of the economy which stays unaffected by this transformative technology.

Artificial Intelligence – UK approach to advancing development

The UK government has already recognised the importance of AI and, in September 2021, published the National AI Strategy. According to UK position, “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”²⁶. Furthermore, UK recognises, AI is one of the transformative technologies which can shift distribution of global power and “rebalance the science and technology dominance of existing superpowers like the US and China”²⁷. In order to strengthen its position in AI Research & Development (R&D), the UK declared a strategic partnership with the US²⁸ and commitment to participate in the Horizon Europe²⁹ programme. The UK has also joined The Global Partnership on AI (GPAI)³⁰, which brings together 29 countries excluding China and Russia. In the defence space, partnerships are being formed with AUKUS³¹ and NATO allies to promote “responsible use of AI”³².

The UK has positioned itself at the forefront of the IA advances ranking third, behind the US and China, in AI-related: private investments, scientific publications and companies’ volume³³. Similarly to the quantum technology approach, the UK has taken steps to contribute to global regulations and

²⁶ *Ibidem*, p. 11.

²⁷ *Ibidem*.

²⁸ *Declaration of the US and the UK&I on Cooperation in AI R&D*, <<https://www.gov.uk/government/publications/declaration-of-the-united-states-of-america-and-the-united-kingdom-of-great-britain-and-northern-ireland-on-cooperation-in-ai-research-and-development/declaration-of-the-united-states-of-america-and-the-united-kingdom-of-great-britain-and-northern-ireland-on-cooperation-in-artificial-intelligence-re>>, (26.04.2024).

²⁹ *Horizon Europe funding*, <<https://www.gov.uk/business-finance-support/horizon-europe-funding>>, (30.11.2023).

³⁰ The Global Partnership on Artificial Intelligence (GPAI), <<https://gpai.ai/>>, (30.11.2023).

³¹ AUKUS comprises of Australia, United Kingdom and United States

³² *AI Partnership for Defense (AI PfD)*, <https://www.ai.mil/docs/AI_PfD_Joint_Statement_09_16_20.pdf>, (30.11.2023).

³³ *National AI Strategy...*, p. 11

standards for AI³⁴. What resonates in the declarations, is the emphasis on regulations which promote freedom, defend human rights and protect against authoritarianism and repression. The UK government is also proactively boosting AI commercialisation by creating market pull with public procurement, especially in the health and defence sectors.

Artificial Intelligence – geopolitical shift in the balance of power

Geopolitically, AI technology can pose risks, and at the same time, may become an opportunity for those nations who are ahead of others in research, development and adoption. The changing technology landscape may lead to the emergence of new geopolitical players, beyond nation-states. In the age of blurred lines between war and peace, tech giants are already influencing geopolitics – for instance by denying service. AI can raise significant strategic challenges and be a direct threat to safety and national security, especially in the following areas:

- Social engineering. Since Web 2.0 and user-driven content creation emergence, social media and other platforms where people interact, have been used to influence society. The Cambridge Analytica³⁵ controversy has shown how people's opinions can be manipulated to destabilise democratic processes and potentially influence elections. Those destabilising new capabilities could be enhanced by AI bots presenting as real humans in social media, giving a false impression of what the majority of the population thinks about politics, culture, ideologies, and war. With the use of deep fakes, society could be deceived to support military invasions, destroy the reputation of political opponents or even encourage self-harm. Social engineering is a double-edged sword, which can be used by adversaries for political gains, but also by the government to control domestic society. Since 2015, the 77th Brigade³⁶, part of the British Army, has been in operation to counter hostile state actors and adversaries in the information domain.

³⁴ *A pro-innovation approach to AI regulation*, <<https://www.gov.uk/government/publications/ai-regulation-a-pro-innovation-approach/white-paper>> (30.11.2023).

³⁵ Cambridge Analytica, established in 2013, was a British political consulting company. The company was accused of misusing personal data, harvested from social media platforms, to influence elections in multiple countries. The unethical practices of Cambridge Analytica are described in the book “Mindf*ck: inside Cambridge Analytica's plot to break the world” by Christopher Wylie.

³⁶ 77th Brigade Information Operations of the British Army, <<https://www.army.mod.uk/who-we-are/formations-divisions-brigades/6th-united-kingdom-division/77-brigade/>>, (30.11.2023).

- Cyber security. The cyber-attacks are threatening national security in all digitalised services from private to public including government administration and the military. In 2022, 39% of UK businesses identified cyber-attacks³⁷. Since the start of 2023, multiple UK public services have been impacted by cyber-attacks. Severe disruption to Royal Mail's international deliveries was caused, in January, by a ransomware attack leaving businesses and citizens unable to post overseas³⁸. In June, a vulnerability exploited by cyber-criminals led to data breaches and leakage of multiple organisations' customer data, including Transport for London, BBC and British Airways³⁹. The AI-driven cyber-attack has even more potential to impact transport, the power grid, and hospitals, resulting in civil uproar and instability. AI can be used to search and exploit a whole range of vulnerabilities at a speed and scale that is not possible for human-monitored systems to defend against. The autonomous cyber defence systems have been researched and promoted, among others, by The Alan Turing Institute's Centre for Emerging Technology and Security (CETaS), to address those kinds of attacks⁴⁰.
- Intelligence operations. The ability to securely transfer information to and from an asset is becoming more challenging with emerging surveillance systems – an AI-driven facial recognition technology combined with CCTV coverage. With AI/ML assistance, HUMINT⁴¹ operations may soon become obsolete or turn into high-risk activity – with CCTV footage and data from other smart devices, human asset movement and activities can be traced over time. Furthermore, AI/ML-supported OSINT operations can make it possible to target particular individuals – “people sitting behind keyboards or headed to the front lines; that targeting could range from psychological pressure up to biological warfare for targeted killings”⁴². Another capability, which AI deep-fakes can enable, is the creation of “robust cover identities for

³⁷ *Cyber Security Breaches Survey 2022*, <<https://www.gov.uk/government/statistics/cyber-security-breaches-survey-2022/cyber-security-breaches-survey-2022>> (26.04.2024).

³⁸ *Royal Mail hit by Russia-linked ransomware attack*, <<https://www.bbc.co.uk/news/business-64244121>>, (30.11.2023).

³⁹ *MOVEit vulnerability and data extortion incident*, National Cyber Security Centre, June 2023, <<https://www.ncsc.gov.uk/information/moveit-vulnerability>>, (30.11.2023).

⁴⁰ A. Lohn, A. Knack, A. Burke, K. Jackson, *Autonomous Cyber Defence: A roadmap from lab to ops*, <<https://cetas.turing.ac.uk/publications/autonomous-cyber-defence>>, (30.11.2023).

⁴¹ HUMINT – Human Intelligence.

⁴² E. Harding, H. Ghooorho, *Seven Critical...*, p. 7.

officers, complete with social media profiles, photos and videos, and call histories”⁴³.

- Autonomous machines and vehicles. Combined with robotics, AI has already led to the creation of autonomous machines which can perform complex tasks utilised in defence, offence, espionage and the magnitude of commercial applications. The UK’s Ministry of Defence has sponsored multiple projects in the area of AI-driven autonomous machines – one example is Nano Uncrewed Air Systems. Those are small autonomous and semi-autonomous drones used on the field, with the ability to navigate through difficult terrain avoiding obstacles. They can enhance patrolling and exploration capabilities. Another example projects are Robotic Platoon Vehicles (RPV) and ATLAS (Autonomous Ground Vehicle Projects). Vehicles developed by those projects, based on Machine Learning and neural networks, aim to penetrate the environment in search of objects without the need for GPS⁴⁴.
- All-domain warfare. The military AI use could change the character of conflict. Lethal weapons have been already developed to operate without humans in the loop. ‘Lethal Autonomous Weapons Systems’ (LAWS), also called slaughterbots, use AI to identify, select and kill human targets without human intervention. Human targets can be selected based on AI-processed biometric data such as facial recognition, silhouette or body heat map. The development of systems like slaughterbots presents serious moral issues and threats to security. LAWS, when employed at scale, increase the threat of proliferation and rapid escalation.
- Bioengineering. AI, in the medical domain, is commercially used to improve human health – medical imaging technology detecting disease early symptoms is already available. Bioengineering is currently employed in drug discovery, toxicity detection, and even human tissue creation and regeneration. Each bioengineering subdomain can be enhanced with AI – alas, some use cases could be turned into bio-weapons degrading human health or even becoming weapons of mass destruction. Already now AI-driven bioengineering systems can generate potentially lethal toxic agents within minutes⁴⁵. The AI-

⁴³ Ibidem, p. 15.

⁴⁴ *Defence Artificial Intelligence Strategy*, <<https://www.gov.uk/government/publications/defence-artificial-intelligence-strategy>>, (30.11.2023).

⁴⁵ *An AI Experiment Generated 40,000 Hypothetical Bioweapons in Just 6 Hours*, <<https://www.sciencealert.com/ai-experiment-generated-40-000-hypothetical-bioweapons-in-6-hours-scientists-warn>>, Science Alert, March 2022

supported gain of function models could lead to the development of deadly viruses able to easily spread.

AI technology development does not always require high expenditure to result in powerful technological gains. In some cases, even smaller nations or geopolitical actors can gain asymmetric advantage. For that reason, geopolitically significant nations must employ resources not to stay behind in strategic AI/ML R&D.

Conclusion

The UK has a mature strategic approach to Science & Technology and this includes quantum technology as well as AI/ML. Strategies have been set out for those technologies and capabilities are being built with the help of multimillion-pound investments. The strategies and key technologies, together with delivery, are continuously reviewed. The UK government is well aware of the strategic geopolitical meaning of quantum and AI/ML technologies – those two technologies, with semiconductors, telecommunications and engineering biology, have been identified as “five priority technologies crucial for delivering UK objectives, including the cyber power agenda”⁴⁶. The ambition is to build the UK into a Science and Technology Superpower by 2030.⁴⁷ This goal can be achieved by building on existing achievements in quantum and AI/ML space where the UK already has achieved substantial academic and industrial advances. Although the UK’s position is favourable, it is falling behind nations such as the US and China. Unlike the US, China is seen as the UK’s competitor in the technology space and seems to be quite ahead of the UK. Just recently, China has “set a world record by achieving twin-field quantum key distribution (QKD) through a 1,002-kilometre optical fibre, marking a critical step toward a future large-scale quantum network”⁴⁸. The UK may have no choice but to continue strategic investments in the development of quantum and AI/ML, as well as delivering on strategic technological goals, otherwise it could keep losing the privilege of being a superpower and become a disadvantaged geopolitical relic.

⁴⁶ *Integrated Review Refresh 2023: Responding to a more contested and volatile world*, <<https://www.gov.uk/government/publications/integrated-review-refresh-2023-responding-to-a-more-contested-and-volatile-world>>, (30.11.2023).

⁴⁷ *The UK Science and Technology Framework*, <<https://www.gov.uk/government/publications/uk-science-and-technology-framework/the-uk-science-and-technology-framework>>, (30.11.2023).

⁴⁸ *Chinese scientists set new record in long-haul quantum communication*, Xinhua, May 2023 <<https://english.news.cn/20230530/e64de946b18c4458adc9f524b34d76b6/c.html>>, (30.11.2023).

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