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A New National Purpose: A *UK* *Quantum Strategy* for Sovereignty and Scale

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Foreword

Quantum represents the next key stage of the technology revolution. In previous [New National Purpose papers](#) we have stressed that science, technology and innovation are the engines of economic growth, social progress and national security. Those papers made the case for leadership in areas such as artificial intelligence, biotech and robotics, recognising that the technological revolution will come in a succession of waves. This paper argues that the UK must not only catch up with today's wave – AI – but also lead in tomorrow's: quantum.

Across a range of fields, classical approaches are hitting physical and computational limits. [Computing resources](#), for example, are a major bottleneck to innovation and adoption, as we are seeing with AI. Meanwhile, in drug discovery, classical simulations fail to capture the intricacies of chemistry, slowing the development of next-generation therapeutics. In each of these cases, quantum technologies will remove classical bottlenecks and expand the boundaries of possibility, while leaving late movers to the fates of technological dependence. The recent Nobel prize in physics, awarded to researchers working on quantum computing in the 1980s, highlights how decades of research are now converging on real-world technologies.¹

The quantum market is growing and consolidating rapidly; the estimated value-add from quantum computing across the automotive, chemical, financial and life-sciences industries is more than \$1 trillion by 2035.² Some countries are racing ahead: China now leads globally in quantum investment to the tune of \$15 billion, the EU recently set out a comprehensive quantum strategy covering everything from infrastructure to military use, and Germany is awarding large government contracts for scaled systems.

Despite the United Kingdom's strong starting point, the country risks failing to convert its leadership in quantum research into commercial scale and strategic value, which depends on quantum companies thriving and scaling at home. The UK ranks third globally in academic research, while receiving the second-highest amount of venture-capital investment (behind the United States). This owes much to the foresight of government strategy over the past ten years, beginning in 2014 with the National Quantum Technologies Programme. But as we have seen with AI, a strong R&D base is not enough: it is the countries that have the infrastructure and capital for scale that capture technology's economic and strategic benefits.

Today the country's quantum ecosystem is strategically exposed. While the UK is home to the second-highest number of quantum startups in the world, it lacks the necessary high-risk capital and infrastructure to scale those startups. It lags behind countries such as Germany and the Netherlands in its early-stage corporate and government adoption, restricting the early revenue streams that UK companies rely on to compete. This combination of a lack of infrastructure, capital and adoption is limiting the UK's ability to build globally competitive quantum companies and risks forfeiting significant economic benefits.

These structural deficiencies are leading to UK-based quantum companies looking to the door. Oxford Ionics was recently bought out by US-based IonQ; Bristol spinout PsiQuantum is now scaling primarily in the United States; and Universal Quantum has set up a Hamburg office to win a major German procurement contract. In an age where national security will be closely tied to quantum, from navigation to encrypted communication, completely relying on other countries and companies rather than securing sovereign capabilities would be unwise.

The good news is that the UK has the tools to succeed. As laid out in this report, the UK can become a leader in quantum by putting the necessary measures in place: investing in applied research to alleviate engineering bottlenecks; mobilising high-risk capital; securing infrastructure and supply chains to ensure scalability and security; and creating early demand at home, through procurement reforms and incentives for UK companies to adopt quantum technologies.

Success will require a coordinated approach across research, finance, infrastructure and procurement – but also within the government itself, across departments and agendas. For this to happen, quantum cannot be treated as a separate, niche policy area; it must be part of a broader technology strategy and recognised as a catalyst for other crucial technologies, such as AI.

The quantum era will arrive whether Britain leads it or not. But history will not forgive us if we again fumble the chance to lead in a transformative technology.

Tony Blair and William Hague

Executive Summary

Quantum represents the next great platform shift in science and technology, harnessing the strange behaviour of particles at the quantum level to achieve breakthroughs in computing, sensing and secure communication far beyond the limits of classical physics.

From surpassing the encroaching limits of Moore's Law in classical computing (the thinking that processing power would double roughly every two years)³ to making navigation systems less dependent on vulnerable GPS signals,⁴ quantum will clear the hurdles that are slowing classical technologies. But only those countries that scale and adopt quantum at pace will capture a large proportion of its value and therefore ensure that they are not beholden to other countries' technologies.

Quantum should not be treated as a niche area of policymaking, but rather as part of a broader strategy to leverage advances in computation – whether in artificial intelligence or energy abundance – to drive productivity and economic growth.

The global quantum market is small but fast-growing. Funding for quantum startups nearly doubled to \$2 billion in 2024 and projections indicate that the quantum sector will grow by a colossal 35 per cent every year until 2032.⁵ The long-term economic opportunity is immense: by 2045, quantum adoption is expected to deliver a 7 per cent productivity gain across the United Kingdom, with the industry itself contributing 126,100 jobs.⁶

Yet the resource and capital intensity of quantum development means the sector is already showing signs of consolidation: more investment in fewer companies,⁷ the clear emergence of concentrated ecosystems⁸ and fewer pure-play startups being founded year on year.⁹ This means that the risk of technological dependency and losing sovereign capability is real; in other words, this is an inflection point where leadership and sovereignty in quantum are genuine choices.

Technology leaders such as the United States and China are unsurprisingly racing ahead, but other countries – including Germany, Australia, Finland and the Netherlands – are also catching up, leveraging their industrial bases and active early adoption.

The UK's current quantum strategy will not scale national champions capable of reaping the economic rewards and building the necessary sovereign capability. The UK has established an undeniably strong starting point, aided by forward-looking policy in the form of the 2014 National Quantum Technologies Programme,¹⁰ as well as the 2023 National Quantum Strategy¹¹ and recent *Invest 2035 Industrial Strategy*.¹² The country also has a strong R&D base and leads in pure-play quantum startups (those focused exclusively on quantum technologies). However, it does not have the necessary infrastructure, high-risk capital and institutions to translate R&D capacity into commercial scale and strategic advantage.

Overcoming these structural weaknesses means tackling three core challenges:

1. Although the UK leads in long-term foundational research, it lacks commercially oriented research mechanisms that focus on applied-engineering challenges, thereby hampering scale and deployment.
2. The UK's leading quantum companies lack the necessary domestic architecture to scale into global behemoths – partly due to access to capital, but also because of poor demand-signalling from industry and government. In fact, to date the UK's largest funding announcements for quantum-hardware projects have been ten times smaller than those of France and Australia.¹³
3. The UK has the second-highest number of pure-play quantum companies in the world but it lacks broader supply-chain depth. This includes critical inputs into the quantum stack (such as nanofabrication facilities) and the infrastructure for companies to scale (such as advanced packaging).

These core issues undermine the UK's resilience in quantum and put a hard ceiling on its leading quantum companies. If they are not resolved, the UK will miss out on the economic benefits promised by its R&D strength and lose sovereign control over yet another critical, dual-use technology – as has happened with AI.

The government still has the necessary levers to tilt the balance. The recently announced £670 million for quantum in the government's industrial strategy must be used to take large bets, rather than being cautiously sprinkled and fragmented. The UK can scale sovereign champions by investing in translational (lab to market) engineering-focused research, crowding high-risk investment, creating demand at home – through procurement contracts and incentives for UK corporates – and by investing in the necessary enabling infrastructure in coordination with allies.

The UK now needs a quantum industrial strategy that allows it to lead on the next great leap forward for revolutionary technology.

Recommendations

This paper argues that the next phase of the UK's quantum strategy should comprise three joined-up tranches.

First, there should be a strong focus on R&D, ensuring a clear through-line from frontier academic research to translational, engineering-focused research designed to unlock bottlenecks for commercial deployment. Second, the government should help scale national quantum champions by encouraging high-risk investment, while also driving adoption through procurement and incentivising industry experimentation. And third, to build scale and security, the entire chain must be underpinned by resilience and access to the necessary infrastructure.

RESEARCH AND DEVELOPMENT

The UK's leadership in quantum depends not only on excellence in basic research, but also on its ability to turn that research into real-world capability.

The government should set up a pilot Quantum Translational Research Group aimed at overcoming short-term engineering barriers to commercial deployment. The research group would work with industry to understand the last-mile barriers to deployment. The focus would be on either short-term engineering bottlenecks, catalyst areas (which could accelerate the near-term deployment and scaling of quantum systems) or quantum-enabling research to improve the efficiency of inputs or infrastructure.

COMMERCIALISATION AND DEPLOYMENT

Few places play host to more quantum startups than the UK, but if it continues to lack the right demand-signalling, access to infrastructure, high-risk investment and necessary cooperation with the R&D base, these companies will either fail or move abroad.

Revive and modernise the Corporate Venturing Scheme (CVS). Between 2000 and 2010, this initiative incentivised large companies to back high-growth startups, with the aim of bringing more corporate venture-capital investment into UK deep tech. A new CVS should provide targeted tax relief for corporates investing in early-stage UK firms, alongside co-investment from the British Business Bank and NWF, both of which should act as vehicles to channel UK pension funds. The NWF should also consider co-investing in quantum-enabling infrastructure to de-risk investment in UK quantum companies.

Portion off £200 million of the £670 million announced in the *Invest 2035 Industrial Strategy* for quantum¹⁴ to run two to three major procurement competitions, exclusively for UK-based quantum companies. The government could also consider advanced market commitments (AMCs), which have the benefit of providing demand-signalling but delaying payment until the required quantum system is actually built.

Hire an individual quantum-procurement champion within each relevant government department – including the Department for Science, Innovation and Technology (DSIT), the Ministry of Defence (MoD) and the Department for Business and Trade – at an industry-competitive salary. These champions would have technical expertise and serve as dedicated

engagement points for industry, responsible for horizon-scanning possible use cases, trialling proofs of concept (PoCs) and sandboxes, driving AMCs where appropriate and ensuring that government procurement is proactive in adopting quantum solutions. The champions should help identify the government use cases to be prioritised for the major procurement competitions.

Introduce fiscal incentives for large UK-based companies in key sectors where quantum technologies will have major applications (such as finance and health care) to fund quantum PoCs. This could include enhanced R&D tax reliefs or reduced employer National Insurance contributions for quantum-related hires. This would increase the quantum-preparedness of UK-based industry, enhance use-case R&D and create a market for UK quantum companies.

Establish a dedicated quantum-technology coordination function to streamline access to infrastructure. This would also bridge the gap between researchers and the startup community (as well as corporates) in accordance with a recommendation by the Royal Academy of Engineering.¹⁵ The function would help corporates navigate the confusing landscape of resources, funding schemes and facilities; it would also provide clear technology-adoption guidance for industry, explaining emerging use cases and highlighting successful PoCs.

SCALE, SOVEREIGNTY AND SECURITY

Despite its economic promise, the quantum revolution poses threats to sovereignty and national security. First, the UK's ability to scale home-grown quantum companies is directly related to its capacity to build technological sovereignty. If companies do not have the inputs and infrastructure they need to scale, they will simply set up shop elsewhere and the UK will lose technological autonomy across the quantum stack. Second, quantum computing poses a serious threat to national security because it threatens modern cryptography, exposing critical infrastructure and institutions to cyber-attacks.

Ensure that the UK has access to quantum-enabling infrastructure, and the broader quantum supply chain, by combining domestic investment with strategic international partnerships. While the UK cannot feasibly onshore the entire stack, where cost effective and strategically essential it should build critical infrastructure. Where capability already exists, quantum companies should be incentivised to buy components from UK-based suppliers such as Oxford Instruments. At the same time the UK should leverage allies such as Germany, the Netherlands, Japan and Canada for complementary strengths in lasers, photonics, semiconductors and advanced materials. The Office for Quantum should, with its coordination function, lead a systematic mapping of UK capabilities and vulnerabilities, using this to shape bilateral agreements that secure access to vital inputs and manufacturing capacity.

Require the UK's critical industries to publish biennial updates on their quantum-migration plans to prepare the UK for post-quantum cryptography, through bodies such as the National Cyber Security Centre and the MI5 National Protective Security Authority. These updates should include audits of public-key cryptography, inventories of cryptographic assets and evidence of hybrid solutions or PoC trials. Embedding transparency and accountability into governance cycles will force boards to treat migration as a strategic priority, drive coordination across supply chains and ensure crypto-agility.

01

The Technical State of Play for Quantum and Implications for Policymaking

Quantum technologies exploit the laws of quantum mechanics, whereby particles can exist in multiple states at once (superposition), influence each other instantly across space (entanglement) and pass through energy barriers that, based on classical mechanics, they should not be able to cross (tunnelling). Quantum is therefore best understood not as a narrow use-case technology but as a series of technologies acting as horizontal enablers with applications across sectors.

Emerging Uses of Quantum Technology

Quantum technologies are at different stages in their technical and commercial maturity. Some platforms and applications are already in practical deployment, some are in late-stage trials and others remain at the early experimental stage. Being precise about these distinctions is crucial for a clear quantum strategy, highlighting the areas where translational R&D (which bridges the gap between science and industry), procurement, funding and other levers are needed to move technology to application. The key categories of quantum technologies are quantum sensing, quantum communication and quantum computing, with the downstream applications of said categories at different technology-readiness levels.

QUANTUM SENSING

This uses quantum states to detect physical phenomena with unprecedented precision. Applications include:

- **Medical imaging:** Optically pumped magnetometer-based medical-imaging systems – which use tiny, light-powered sensors to detect the brain’s magnetic signals without needing extremely low temperatures – are now being used in hospitals and research settings. They provide

less invasive, more flexible brain imaging compared with the cryogenic option and are one of the most advanced quantum-sensing applications currently in the field.¹⁶

- **Gas detection and environmental monitoring:** Quantum-enabled laser spectroscopy is a highly sensitive technique that uses light to identify and measure substances, and it is already being applied to detect trace gases in industrial and environmental contexts.¹⁷ This is another example of quantum technology crossing into operational use.
- **Quantum-navigation systems:** These rely on quantum sensors and atomic clocks and have the potential to provide precise positioning where GPS is unavailable or unreliable, such as tunnels or contested airspace. Some use cases are in the serious testing phase: the Royal Navy has trialled quantum navigation in maritime vessels,¹⁸ and researchers at Imperial College London have demonstrated their first accelerometer for navigation – a navigation system that does not rely on external signals.¹⁹

QUANTUM COMMUNICATION

This leverages entanglement and quantum-key distribution (a way of safely sharing encryption keys) to enable ultra-secure transmission of information. Applications include quantum networks and secure communication, both of which are systems being trialled to protect critical infrastructure from future cyber-threats. Researchers in Cambridge and Bristol have already successfully demonstrated the UK's first long-distance secure transfer of data over a quantum-communications network.²⁰

Quantum Computing: A New Computational Paradigm

Quantum computing is the most high-profile application of quantum mechanics, as well as being the most strategically and economically valuable. By harnessing qubits – the quantum equivalent of bits that can exist as both zero and one simultaneously – quantum computing can perform calculations exponentially faster than conventional computers.

The speed and energy efficiency²¹ offered by quantum computing will be game-changing. This is particularly true of technologies such as artificial intelligence, for which the lack of sufficient compute capacity (the ability to store, process and transfer data at scale) is a key bottleneck to advancement.²² Oxford Quantum Circuits – a UK company – is already building the first quantum-AI data centre in New York.²³ As such, it is important that the UK government makes progress on quantum computing in conjunction with AI, thereby revolutionising how the country solves its most pressing problems computationally, from public services to military preparedness. Given the time and money spent building out domestic data-centre capacity in the form of AI growth zones,²⁴ it would be a strategic mistake for the UK not to factor quantum-computing hardware into its long-term AI-infrastructure planning.

There are debates around the technological maturity of quantum computing. Some have questioned whether it will happen at all, but there is now broad consensus that it will, with multiple hardware platforms already demonstrating proof-of-principle systems. Another key question is when large-scale, fault-tolerant machines will arrive, though most credible forecasts suggest it will be somewhere between 2030 and 2035.

That said, things are moving fast: early trials for industry adoption of quantum computing are already taking place in the UK. Recently two UK quantum companies, Oxford Quantum Circuits and Riverlane, integrated their technologies to make error-corrected quantum computers available in a commercial data centre for the first time, enabling investment banks and defence companies to test proprietary quantum algorithms on their own data.²⁵

Another recurring question is how useful such systems will be: while breakthroughs in simulation, optimisation and cryptography are widely expected, the full scope of their applications is not set. This is why early testing of use cases in government and industry is critical.

As the rise of generative AI has demonstrated, transformative technologies can move from distant prospect to mainstream reality in a matter of months, often catching governments and businesses unprepared. Importantly, quantum-computing hardware is advancing in several key areas, each with different strengths and weaknesses. Below are some of the leading methods, along with the firms driving them forward.

- **Superconducting quantum computers** (Google, IBM, Rigetti, IQM, Oxford Quantum Circuits) are the largest current computers in terms of sheer scale, with processors exceeding 1,000 qubits and the first error-corrected “logical” qubits (groups of qubits that work together in a way that detects and fixes errors). The making of superconducting qubits requires semiconductor expertise and costly cryogenic cooling, and is limited by nearest-neighbour connectivity (whereby only adjacent qubits can interact).²⁶
- **Trapped ions** (IonQ, Quantinuum) are ions held in electromagnetic fields. They deliver high gate fidelity (that is, they perform very accurate quantum operations) and natural all-to-all connectivity (meaning all qubits can interact with each other), driven by the thinking that focusing on error correction rather than brute-force scale will lead to faster realisation of real-life applications.^{27,28}
- **Neutral atoms** (QuEra, Pasqal) trap and reconfigure atoms with lasers, enabling scalability and efficient error correction without the need for cryogenics. Advances such as the AI-assisted assembly of about 2,000 atoms in mere milliseconds show the rapid momentum of this technique.²⁹ However, gate fidelities lag behind superconductors and ions, and demonstrations of error-corrected qubits are still limited.
- **Photonic quantum computers** (ORCA Computing, Xanadu, PsiQuantum) use photons transmitted through optical circuits rather than electrical ones, with mirrors and beam splitters guiding and manipulating the light. Suited to long-distance networking, they draw on existing photonics industries.³⁰ Their main hurdle is reliably generating and entangling large photon numbers, but success could enable modular, fault-tolerant architectures (systems built from smaller connected units that can continue operating even when parts fail).
- **Spin qubit quantum computers** (Quantum Motion, Silicon Quantum Computing) use the spin of individual electrons – their intrinsic magnetic property – as the qubit itself. These electrons are trapped within tiny regions of semiconductor material, and their spin states are manipulated

using electric and magnetic fields, similar to how conventional transistors are controlled. This approach promises high scalability because it can build on existing silicon-chip fabrication techniques.

No single one of these five modalities has yet emerged as dominant and it is likely that, as modalities are scaled, they will become specialised for different sectors and tasks, rather than an outright winner emerging.³¹ Yet while advances in quantum hardware rightly attract attention, the real power of quantum computing will be unlocked through breakthroughs in quantum software and algorithms. Hardware scales capability, but algorithms determine what those capabilities can actually achieve. Classical computing was the same: it leapt forward not only through faster processors but also innovations in algorithms.

The UK is particularly well placed to lead on quantum software and algorithms. Unlike hardware, which demands vast infrastructure and capital expenditure, algorithmic innovation draws on the country's comparative advantages: world-class academic talent, a thriving R&D base and a proven spinout pipeline. Quantum-software companies are also less capital intensive, reducing the pressure to relocate abroad or sell to overseas tech giants. This gives the UK a realistic chance to anchor long-term economic value in its domestic ecosystem, with quantum-algorithm companies such as Phasecraft already leading the way.³²

Engineering Bottlenecks and Interdisciplinary Enablers

Across all quantum technologies – not just computing – most of the key bottlenecks to commercialisation are generally engineering related rather than theoretical. In the case of computing, qubits are fragile and require resource-intensive error correction;³³ in addition, most platforms depend on costly cryogenics and materials integration, both of which are difficult to scale.³⁴ Building a practical quantum network, such as quantum key distribution (a way of sharing encryption keys securely, also known as QKD), is challenged by signal losses and the need for industrial-scale, highly precise photonic components.³⁵ In short, the barriers to deployment lie in turning proven physics into engineered, scalable systems.

In a sense, therefore, the current state of quantum is the inverse of frontier AI. Whereas AI has surged ahead via rapid scaling led by the private sector – despite unresolved questions about long-term sustainability³⁶ – technologies such as quantum computing are backed by solid theoretical foundations but constrained by short-term engineering realities. Additionally, brute-force private-sector investment works for AI but not quantum: full-stack deployment (building and integrating every layer of a technology, from hardware to applications) depends on breakthroughs in basic research and innovation within startups, not just funding from big tech.

However, quantum technologies are not created in isolation: breakthroughs will likely be made through cross-disciplinary collaboration. Quantum and AI is a case in point: the latter is already being used in qubit routing (deciding the most efficient paths for qubits to interact) and error mitigation (reducing the impact of noise and faults in quantum operations). This synergy was demonstrated most strikingly by a recent advance in China whereby an AI model assembled more than 2,000 neutral atoms in milliseconds, a key step toward scalable neutral-atom arrangements (networks used to process quantum information).³⁷

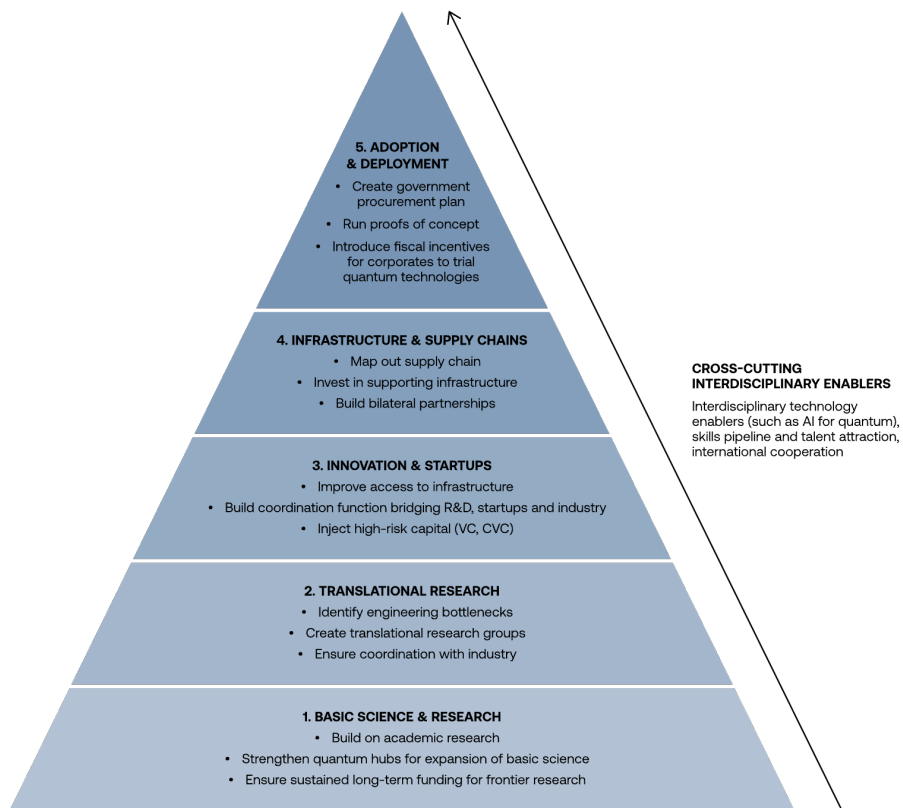
The technical realities of engineering bottlenecks and interdisciplinary enablers get to a core point of the policy challenge. Quantum progress depends on a delicately coordinated ecosystem of the following elements:

- basic science
- translational research to overcome engineering challenges and drive interdisciplinary enablers
- innovative startups
- enabling infrastructure and supply chains
- strong demand-signalling that creates the revenue for further R&D investment

Each element is dependent on the others moving in lockstep (see figure below). Without this orchestrated industrial strategy, the UK's strength in quantum research will struggle to translate into global leadership or economic impact.

FIGURE 1

Building the UK's quantum ecosystem involves five key components working in lockstep



Source: TBI

The Quantum National-Security Imperative

Quantum technologies are not just a driver of innovation: they are a dual-use capability at the heart of a new geopolitical race. Modern digital infrastructure (finance, health care, defence and government) depends on

classical encryption methods that quantum computers will likely break by the 2030s – the anticipated moment has been coined as “Q-Day”.³⁸ This creates a fundamental security dilemma: the first country to reach quantum advantage could decrypt the world’s secrets, impersonate institutions and access sensitive financial, diplomatic and defence data.

Adversaries are already pursuing a strategy of “harvest now, decrypt later”, stockpiling encrypted communications – including UK intelligence and financial data – for future exploitation.³⁹ As both a global financial centre and a critical intelligence hub, the UK is especially exposed to this risk. The defensive imperative, therefore, is to transition government and business systems to post-quantum encryption. This is particularly urgent in sectors with long-lived data, such as health care, where NHS medical records and genomic databases will retain strategic value for decades.

At the same time, emerging technologies such as QKD offer a potential countermeasure, enabling tamper-evident communications and, in theory, unbreakable encryption.⁴⁰ Building quantum-secure infrastructure will be essential not only to defend against adversaries but also to anchor the UK’s future digital sovereignty.

Therefore, quantum technologies will not just protect infrastructure but increasingly become part of it. For the UK, the ability to scale secure communications and national sensing platforms will be decisive for both digital sovereignty and economic independence in the coming decade.

Getting the UK’s quantum industrial strategy right is therefore an investment in the country’s future national security.

The Broader Quantum Stack

Quantum systems such as navigation, computing, and sensing and imaging do not exist in isolation but depend on a broader stack of materials, technology components and enabling infrastructure. Each layer involves a complex mix of actors, including research labs, startups, big tech, systems integrators, manufacturers and end users.

FIGURE 2

The different quantum stacks and their applications

Stack layer	Description	Examples	Key actors
Raw materials	Base inputs required to fabricate quantum components.	Gallium, helium-3, synthetic diamond, ultrapure silicon, rare earths.	Material suppliers, national stockpiles, security-policy bodies.
General-purpose enabling technologies	Non-quantum technologies essential to quantum platforms.	Compound semiconductors, silicon photonics, cryogenics, vacuum systems.	Semiconductor/power-electronics firms, translational engineering labs.
Quantum-specific technologies and components	Core quantum components requiring specialised quantum performance.	Qubits (various types), ultra-stable lasers, ion traps, dilution fridges.	Basic long-term R&D, translational R&D, startups, specialist vendors.
Underlying infrastructure for production	Facilities and tools for prototyping, fabrication and physical testing.	Nanofabs, cleanrooms, cryogenic testbeds, characterisation tools.	Manufacturing/advanced manufacturing base.
Scaling infrastructure (manufacturing and integration)	Capabilities for packaging, integrating and scaling quantum systems.	Advanced packaging, heterogeneous integration, pilot lines.	Integration centres (PHIX, Tyndall), OEMs, public-private scale-up projects.
Full quantum systems	Integrated systems delivering operational quantum capability.	Quantum computers, quantum sensors, quantum communications.	Startups, big tech firms (IBM, Microsoft), systems integrators.
End users and national infrastructure	Sectors applying quantum technologies to real-world use cases.	Defence, national infrastructure (for example, telecoms), finance, pharma, energy.	Vertical industries, mission owners, government departments.

Source: TBI

Understanding this stack is essential for policy: it highlights where the UK must invest in resilient supply chains and enabling infrastructure to ensure that innovation turns into commercial advantage, or double down on UK-based companies such as Oxford Instruments, which provide some of these components. Resilience across the quantum stack will also be directly linked to the UK's overall future resilience, as well as its offensive and defensive quantum capabilities.

Policy Implications

A few key conclusions emerge for UK policymakers based on quantum's technical state of play:

- **Coordination is essential:** Because of the unique nature of quantum – in that, compared to other critical technologies such as AI and biotech, commercial progress still relies on basic R&D, engineering breakthroughs and interdisciplinary enablers – the government needs to coordinate its R&D ecosystem, startups, industry and its own procurement mechanisms to drive growth.
- **Invest in resilience and scaling capacity:** The ability to lead commercially on quantum will depend as much on non-quantum technology inputs and enabling infrastructure as it will on frontier R&D and startups. The UK must therefore build resilient supply chains and infrastructure to enable scaling.
- **There is a national-security imperative:** Getting the quantum industrial strategy right – and having leading, domestically anchored quantum companies – is inseparable from the national-security imperative of being quantum-ready and building quantum sovereignty.
- **AI and quantum must be treated in conjunction:** Breakthroughs in AI will feed quantum, and industry-scalable quantum computing will reshape the paradigm of AI. As such, any long-term AI infrastructure projects, for example, should be coordinated with the UK's quantum strategy.
- **Back software firms, not just hardware companies:** The frontier of quantum, and especially quantum computing, will not only be driven by hardware but will also depend on algorithmic innovation that creates actual use cases. Given its strengths in R&D and low capital intensity, the UK should lead in this area.

02

State of Play of the Global Quantum Industry and Implications for the UK

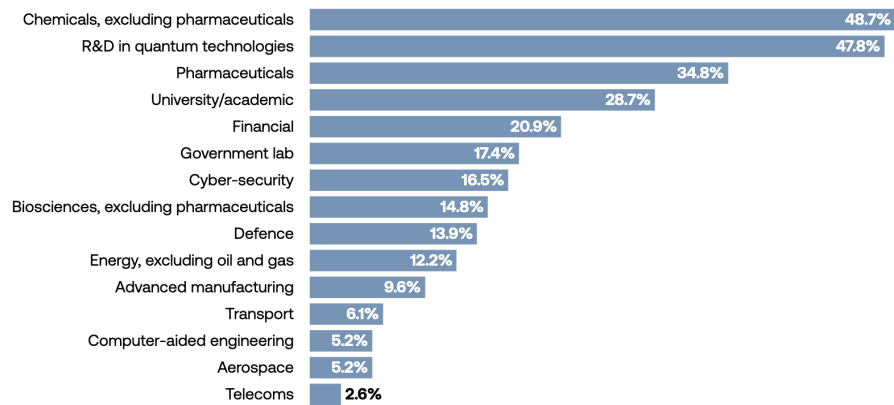
Quantum technologies are transitioning from research areas to multiple industries – a development that calls for a change in government strategy. In quantum computing in particular, an investment race is under way; US company PsiQuantum recently raising \$1 billion, the largest-ever funding round for a quantum-computing startup.⁴¹ Though the market is still relatively small it is growing fast, and talent and capital are concentrated in a handful of hubs. Governments such as Germany's are already betting big and the UK is also among the frontrunners, with world-class research, strong investment and a thriving startup ecosystem, as well as leading quantum-computing and sensing companies. However, the UK has key gaps in investment, government and corporate adoption, and supply-chain depth, making its position fragile.

The Global Quantum Market

The global quantum market is growing and forecast to boom in the coming years. Innovation is accelerating, with a 13 per cent increase in quantum-related patents over the past four years, underscoring a rapid uptick in innovation and intellectual-property activity.⁴² Meanwhile, startup investment in quantum technologies grew by 50 per cent year on year to \$2 billion in 2024, with quantum computing accounting for 80 per cent of total quantum investments.⁴³ When integrated into vertical industries, all quantum technologies combined could add £212 billion to the UK economy by 2045.⁴⁴

FIGURE 3

Chemicals, quantum R&D and pharmaceuticals set to benefit most



Source: Quantum Consortium 2025 Market Forecast

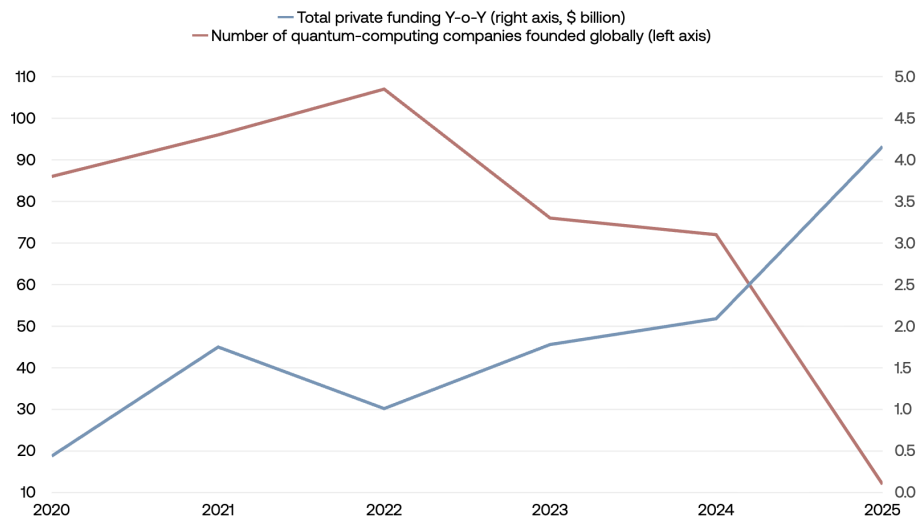
Despite disagreements about the timelines for technologies such as quantum computing, there is evidence to suggest that the market is maturing even if some of the technologies are not yet deployable. The size of the market in terms of raw company numbers is small, with just over 6,000 organisations active in quantum technology but only 513 pure-play quantum companies (that is, firms solely dedicated to quantum technologies).⁴⁵

While this might suggest an immature market with plenty of scope for newcomers, the investment side tells a different story. In 2024, private venture-capital (VC) investments reached a record \$2.6 billion, with almost \$1.7 billion going to US quantum companies. Moreover, compared with 2023, there was 58 per cent more funding – but spread over 54 fewer deals. This indicates that investors are concentrating their bets on more mature companies in the quantum-technology sector.

This market consolidation is also reflected in the diminishing number of pure-play quantum startups that have been founded globally in the past four years, likely stemming from the sector’s emphasis on resources and capital, which pushes investors to back incumbents rather than new starters. This is supported by the fact that in 2024, companies focused on quantum computing amounted to only 6 per cent of the market but received 80 per cent of total VC investment.

FIGURE 4

The number of quantum-computing startups globally is decreasing, but billion-dollar funding for established companies is rising



Source: Data from Tracxn, September 2025

This graphic demonstrates that, as the technology develops, the market is consolidating. Consequently there is the very real prospect of early technology path dependencies being locked in, which in turn means the UK should move quickly to enable its leading quantum companies to scale and compete globally.

The UK's Position in a Global Context

The UK has been a pioneer in quantum policy since 2014. However, underneath the headline investments, there are important nuances that suggest a more fragile system:

- The UK has a strong research base but lags behind peers such as Germany and the US on top-tier quantum output.
- It leads on startups and venture activity, but many flagship firms are moving operations abroad.
- Public investment, grants and procurement contracts are thinly spread and far smaller than competitor countries' large-scale bets.
- Corporate adoption is weak, limiting demand-signalling and early revenue streams.
- The UK's extended quantum stack is shallow, lacking depth in critical components and the infrastructure necessary for scaling.

A STRONG, IF NOT FAULTLESS, R&D BASE

Depending on the metrics used, the UK finds itself either in a top four⁴⁶ or top three⁴⁷ position in terms of quantum research. Between 2013 and 2022, UK-based researchers co-authored 20 of the top 100 most-cited quantum research papers, eight of the top 50 and three of the top ten, placing it third in the world behind the US (47) and China (40), and just ahead of Switzerland (17). However, in elite journals such as Nature and Science, UK authors have featured on just 239 of 1,567 quantum papers over the past decade – about one-fifth of the US total and, notably, only half the output of Germany. Strikingly, Switzerland – despite its much smaller population – matches or

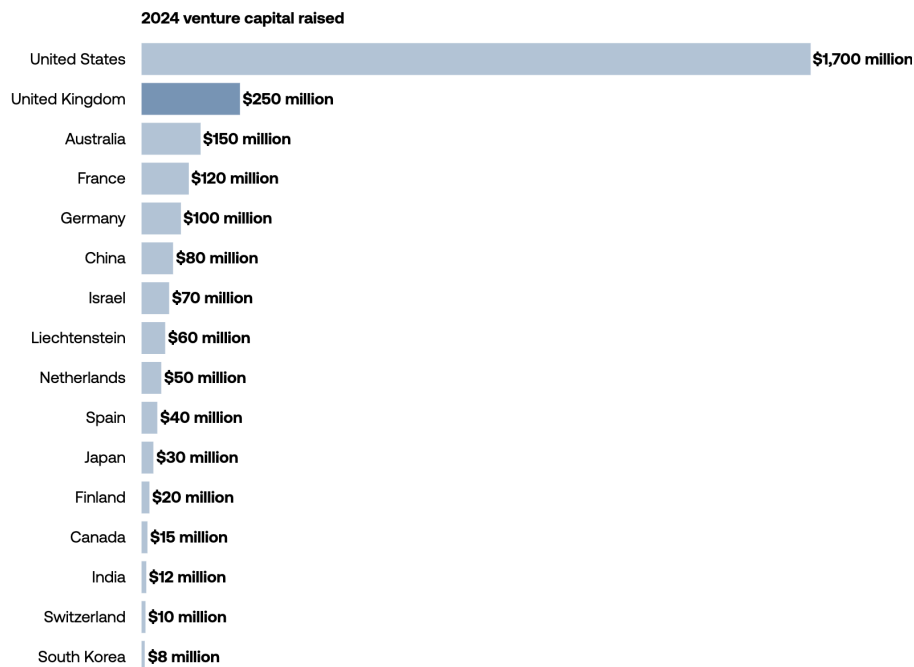
exceeds the UK in top-tier output per capita, especially in the top ten and top 50 papers.⁴⁸ Moreover, the combined output of just two US institutions (MIT and Harvard) surpasses the UK’s total in Nature and Science.

**LEADING IN STARTUPS AND VENTURE CAPITAL BUT COMPANIES
LOOKING TO THE DOOR**

Out of the 513 pure-play quantum companies globally, the UK boasts the second-highest number at 64, behind the US on 148.⁴⁹ Further, the UK has the third-highest number of new quantum startups behind Australia, and in 2024 boasted the second-highest level of VC funding behind the US.

FIGURE 5

The UK does well in raising VC, but lags far behind the US

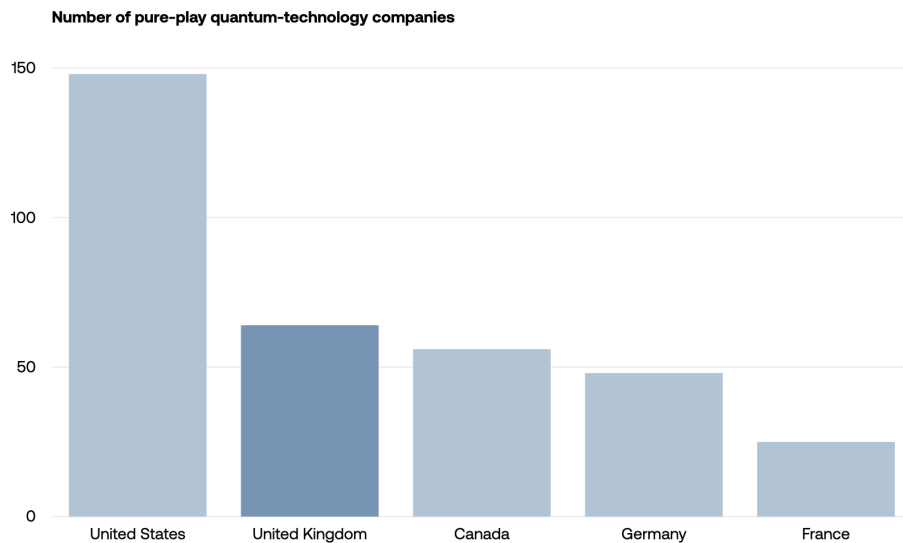


Source: Quantum Consortium State of Quantum Industry 2025

Yet the likelihood of the UK's leading quantum companies scaling and staying in the UK is looking increasingly bleak. Oxford Ionics has been acquired by US-headquartered IonQ, Universal Quantum is running major operations out of Hamburg, and Bristol spin-out PsiQuantum is now scaling primarily from the US.

FIGURE 6

UK plays host to second-highest number of pure-play quantum companies globally, but trails the US



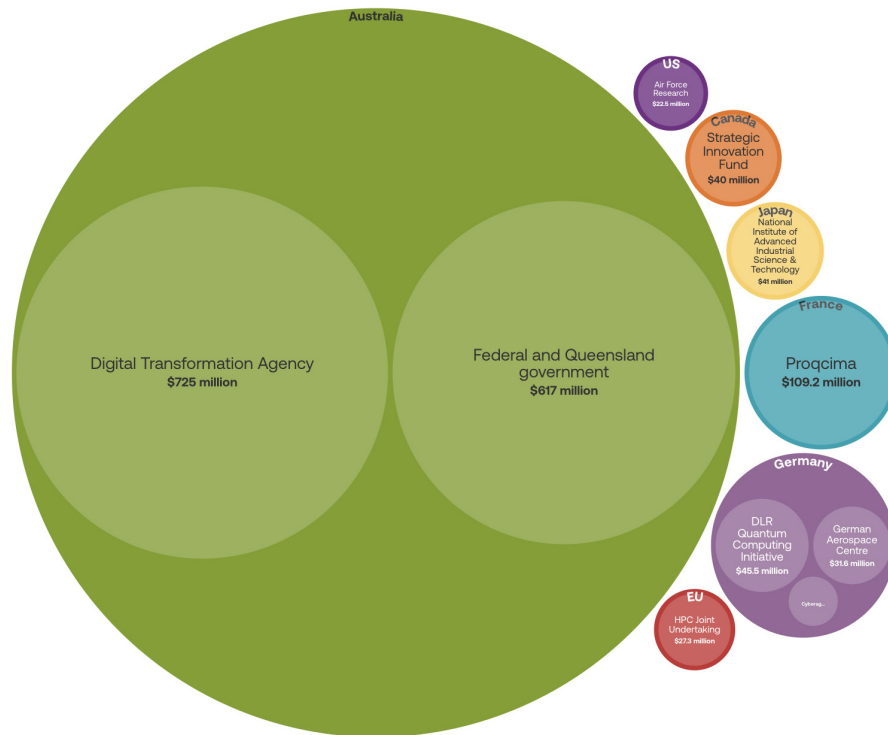
Source: Quantum Consortium State of Quantum Industry 2025

BEGINNING TO TRAIL IN PUBLIC INVESTMENT

Despite the UK's high levels of public funding over the past ten years – especially in research – it is increasingly falling behind. For example, the UK's largest funding announcements for specific quantum-hardware projects are ten times smaller than in France and Australia.⁵⁰ The UK's largest, in 2023, split \$37.6 million across seven quantum-hardware companies in the country. Meanwhile, most Innovate UK awards to the quantum sector are between £100,000 and £210,000. The harsh truth is that, if the UK is outspent on large-ticket government contracts, UK-based quantum companies may well relocate – and their value will accrue abroad.

FIGURE 7

Australia takes the crown for government funding for hardware projects, while the UK falls out of the top ten awarded contracts

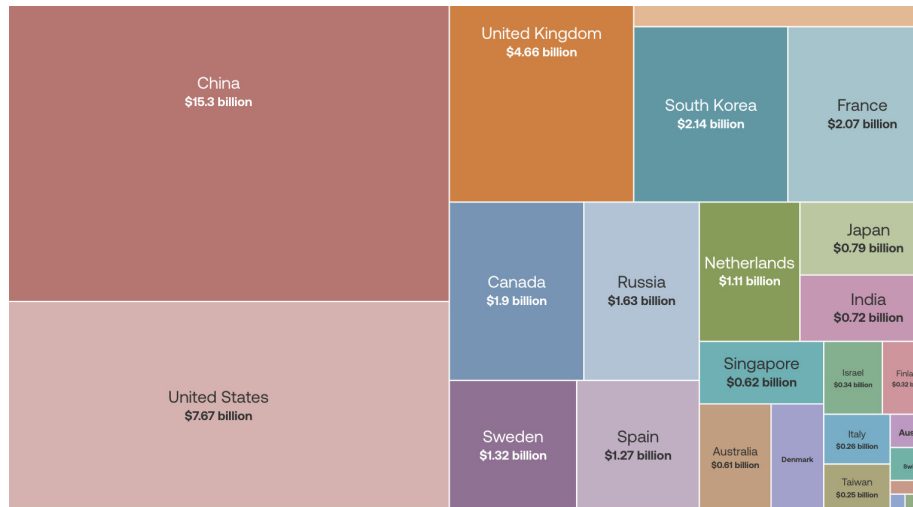


Source: Oxford Economics

Meanwhile, looking at total public funding, the UK is performing well: ahead of European rivals France and Germany, but way behind global leaders the US and China.

FIGURE 8

China racing ahead in terms of public funding for quantum



Source: Qureca

BEHIND IN CORPORATE ADOPTION

While the UK is home to a high number of pure-play quantum companies, it lags behind on early industry adoption: the number of UK corporates adopting quantum technologies trails the Netherlands, Australia and Canada. A lack of quantum readiness will minimise the economic value that can be gained from quantum, while weak demand-signalling will make it harder for UK quantum companies to scale and bring in revenue. Essentially, diffusion across the non-quantum economy is as essential as innovation itself in determining global leadership.

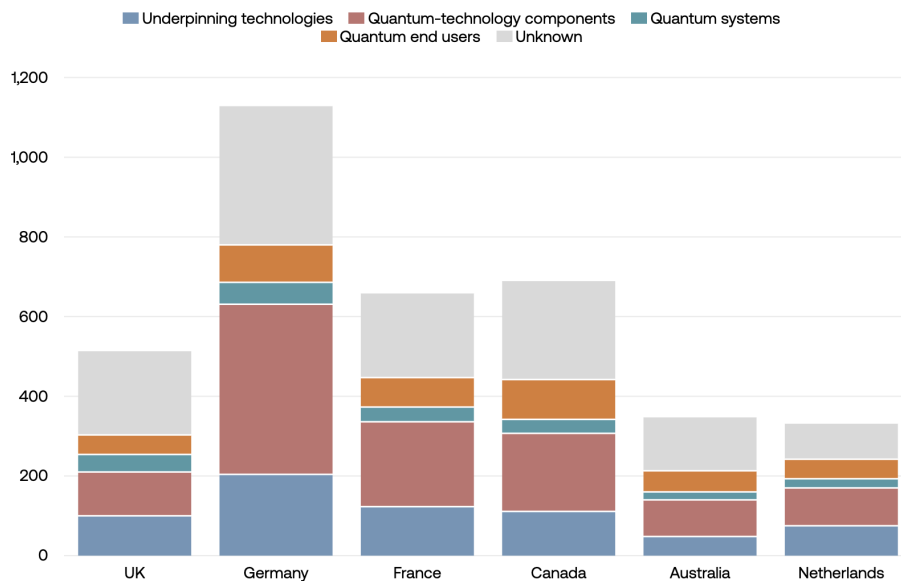
LACKING DEPTH ACROSS THE WIDER QUANTUM STACK AND IN THE NECESSARY INFRASTRUCTURE FOR SCALE

The UK is well served by R&D-intensive pure-play quantum companies. In particular the country has strengths in the development of full-stack quantum systems, integrating all layers of the technology – from hardware and control systems to software – into fully functioning quantum systems such as quantum computers and sensors.

Crucially, however, the UK falls worryingly far behind in terms of the “extended quantum stack”. The extended quantum-technology sector includes companies that supply enabling components – such as lasers, cryogenic technologies and superconductors – which are indispensable for the quantum technologies (such as qubits and communication components) that make up quantum systems. When this extended quantum sector is taken into account, the UK hosts only 513 companies – fewer than Germany (1,128), France (658) and Canada (689).⁵¹

FIGURE 9

The UK trails France, Canada and Germany for companies within the extended quantum sector



Source: UKRI

Given the dual-use nature of quantum technologies, the UK's relatively shallow extended quantum stack is a strategic problem. But it is also a commercial one: the UK's strong R&D base ensures that it is able to spin out leading quantum companies, but without this broader access to supply-chain inputs (such as lasers) and scaling infrastructure (such as advanced packaging facilities) these companies will fail to scale. Either that or they will leave the UK so that they can more readily access the scaling architecture they need.

Strategic Implications for the UK

The country is at a pivotal juncture. While some technologies, such as quantum computing, have not yet reached an industrial scale, the market is consolidating; that means the threat of path dependencies taking hold is real, given the resource-intensiveness of the sector. What is needed now is scale and commercialisation.

The UK made a strong start but it now looks fragile: it leads in pure-play quantum companies, VC funding and research output, but companies are struggling to scale domestically. In addition, government procurement and industry adoption are lagging, and access to infrastructure is shallow, creating supply-chain vulnerabilities and barriers to scale.

The strategic implication is clear: R&D excellence and strong public funding are necessary but simply not enough for long-term competitiveness. As market consolidation accelerates and early-mover advantages set in, the UK must connect its R&D ecosystem to industry, mobilise capital, drive adoption and ensure that its companies have access to enabling infrastructure.

03

Research and Development

The UK's ability to lead on quantum depends on maintaining its foundational science, but also its capacity to translate research into real-world capability.

The UK has a strong research base, and its five quantum hubs are the crown jewels of the government's quantum strategy. For example, the Quantum Communications Hub at the University of York has spearheaded the development of the UK's first quantum networks,⁵² the Hub in Quantum Enhanced Imaging at the University of Glasgow has developed a new imaging technique allowing for precise 3D medical imaging⁵³ and the Quantum Sensors and Timing Hub at the University of Birmingham has designed quantum gradiometers to monitor underground water levels and volcanic eruptions.⁵⁴ Each hub is equipped with specialised facilities that anchor the UK's capacity for quantum research.

However, while the quantum hubs have made major breakthroughs, they may not be sufficient to fully carry out the government's quantum mission programmes. Specifically, the hubs were not designed to overcome short-term engineering challenges blocking commercialisation, meaning there is an R&D gap in the UK between basic research and commercial application. This is not a problem with the hubs per se – they are effectively fulfilling their role in the ecosystem and should continue to do so. But the UK will need other research mechanisms that are more commercially focused – that is to say, less focused on underlying physics and more on tackling engineering challenges and meeting market needs.⁵⁵

Recommendation: *The government should set up a pilot Quantum Translational Research Group, aimed at resolving short-term engineering bottlenecks that are holding up commercial deployment. The pilot could follow various models, including a focused research organisation (FROs) or temporary research lab, such as Advanced Research and Invention Agency (ARIA)-style frontier research contractors (FRCs). Alternatively the pilot could be a sub-unit within the UK's existing quantum hubs or a brand-new mission-driven institute.*

The government could consider getting buy-in from industry, crowding in investment from leading UK quantum companies and key corporate adopters. Regardless of which model the government chooses, the Quantum Translational Research Group should fulfil a number of criteria:

- **Mission focus** on the government’s stated quantum goals around computing, networks, sensing, navigation and health care, but with a research focus on commercial applications.
- **Research focus** should be commercially focused, addressing two primary needs. First, research into technological enablers for quantum: engineering-oriented projects aimed at improving the underlying infrastructure and key non-quantum inputs on which quantum systems depend (for example, advancing cryogenic-refrigeration technologies to reduce energy costs and footprint). Second, translational research: targeted work on short-term bottlenecks affecting specific quantum devices or systems that are blocking deployment (for example, improving the bandwidth of quantum sensors without sacrificing sensitivity, or using AI for error correction).
- **An operating model** that works directly with industry – both UK quantum companies and non-quantum corporates in key areas such as chemicals and finance – to identify specific chokepoints: barriers to adoption, integration and scale. This could include working with corporates on quantum PoCs, as recommended in the next chapter.
- **Responsibility** to contribute to an annual update of technical quantum roadmaps that outline the key impediments facing quantum deployment across different technologies.

The research focus we outline demands government intervention because of a clear gap that exists: the research needed is too applied and engineering-heavy to be driven by universities, but too risky and niche to draw in VC or other private investors. The EU is trying to correct for a similar problem, with a newly announced series of “grand challenges” that will focus on high-impact technical problems, bringing together industrial users and researchers.⁵⁶ Likewise, Finland’s Technical Research Centre is filling precisely this gap: working with Finnish quantum companies to build enabling technologies and overcome engineering constraints.⁵⁷ Without targeted public support in the UK, this gap between basic research and commercialisation will not be filled.

As mentioned, the UK government has a number of models it can choose from for the Quantum Translational Research Group:

- **FRCs:** Small, agile R&D organisations designed to address technical bottlenecks that fall between academia and industry.⁵⁸ Examples of tasks that an FRC might tackle include developing open hybrid software, building data sets for quantum engineering or scaling up a lab experiment to create a pilot manufacturing process. FRCs are typically funded through a patchwork of contracts and grants; historically, institutions such as the US’s Defense Advanced Research Projects Agency have offered the best illustration, but the UK’s ARIA has started to adopt the FRC model to build bespoke hardware, software, data sets and materials.⁵⁹
- **FROs:** Purpose-built, time-limited entities built around a single mission, such as constructing open-access quantum benchmarks or standards. They operate with dedicated teams of between ten and 30 researchers, funded by large upfront philanthropic or government grants that provide stability for a five-year sprint. The UK launched its first FRO in 2025, focusing on transforming disordered proteins into viable drug targets.⁶⁰
- **In-house quantum-hub units:** These would build on the UK’s existing quantum hubs, with small, embedded translational teams working with industry to examine commercial applications. These units, numbering anywhere between five to 15 people, would concentrate on the “last mile” of innovation: taking academic breakthroughs and looking to convert them into prototypes and working models, in close partnership with industry.
- **Quantum Engineering Institute:** This would be a new, national-scale quantum laboratory. It would be overseen by the government and dedicated to tackling deployment bottlenecks in strategic industries such as finance and defence. This would involve 30 to 50 permanent staff, a technical lead directly reporting to the Department of Science, Innovation and Technology (DSIT), ring-fenced funding on a decade-long horizon, and deep partnerships with startups, corporates and end users.

The government should also consider expanding its Research Chairs and Senior Research Fellowships scheme, funded by DSIT, which supports academics to establish or enhance a world-leading engineering research group, focused on use-inspired research that meets the needs of industrial sponsors.⁶¹

FIGURE 10

Different models for the proposed Quantum Translational Research Group have benefits and drawbacks

R&D model	Strengths	Weaknesses
Frontier Research Contractors (FRCs/BBNs)	<ul style="list-style-type: none"> Agile funding mechanisms. Low barrier to start. Suited to niche time-sensitive projects. Proven effectiveness (ARIA). 	<ul style="list-style-type: none"> 'Scrappy' funding model risks instability. Finite lifespan risks lack of continuity. Limited in-house capacity for strong, long-term industrial/corporate partnerships. Limited scope reduces ability to scale. Less easily integrated into long-term national strategy.
Focused Research Organisation (FRO)	<ul style="list-style-type: none"> More reliable, longer-term funding. Operates more like a startup. More proven effectiveness than FRCs. 	<ul style="list-style-type: none"> Finite lifespan risks lack of continuity. Limited in-house capacity for strong, long-term industrial/corporate partnerships. Dependent on large upfront philanthropic/public grants.
New institute	<ul style="list-style-type: none"> Permanent, flagship institutions for UK translational quantum research. High long-term strategic alignment with government quantum missions. Ability to build long-term relationship with UK corporates and quantum industry. Formal home for roadmapping bottlenecks, proofs of concepts. 	<ul style="list-style-type: none"> High set-up and operational costs. Requires careful coordination to avoid duplication with quantum hubs. Potential for mission creep/bureaucracy in the long run.
In-house quantum hubs	<ul style="list-style-type: none"> Lower cost and bureaucratic barriers to setup. Leverages existing hub infrastructure – meaning research is closely embedded in existing academic research. Potential to create very strong feedback loop from academic research to industry. 	<ul style="list-style-type: none"> May lack scale and autonomy of standalone labs or FROs/BBNs. Potential administrative friction between academic and translational/engineering researchers. Danger of being sidelined as an add-on to hubs rather than core to mission delivery.

Source: TBI

Regardless of the specific mechanism, without some version of these dedicated, mission-driven translational entities, the UK risks marooning its stellar quantum research on the lab bench instead of powering new industries and public services.

04

Commercialisation and Deployment

Consolidating a strong R&D base, however, will not guarantee global quantum advantage. As outlined in our paper [From Startup to Scaleup: Turning UK Innovation Into Prosperity and Power](#), the UK must be able to scale – and keep – its leading quantum firms within its borders.

As it stands, the UK's ability to do this looks weak. Lack of investment and revenue capital is a core problem: VC in the country tends not to lead quantum rounds; corporate venture capital (CVC) is scarce; the British Business Bank (BBB) is unable to lead in rounds, which limits its ability to de-risk investments; the National Wealth Fund (NWF) is slow moving; and the government is not providing large enough contracts or AMCs.

The UK risks falling behind, with countries such as Germany and Australia outspending on infrastructure and procurement contracts. The UK's recent industrial strategy announced a £670 million investment in quantum,⁶² although the £2.5 billion promised under the former government looks as though it may slip through the cracks.⁶³ After some of this is portioned off to the National Quantum Computing Centre, the government will have about £500 million to spend. It is essential that this is not sprinkled around in a fragmented way but consolidated for taking big bets on infrastructure and procurement contracts, or AMCs. Without this, the UK will miss out on scaling sovereign quantum scaleups.

Two recent case studies highlight the urgency. In June 2025 the UK's leading quantum-computing company – Oxford Ionics – was bought by US firm IonQ in a billion-dollar deal.⁶⁴ In stark contrast, in September 2025 the world-leading Finnish quantum-computing company IQM raised a \$320 million Series B round through a combination of VC investment, institutional capital (Finnish pension funds) and the European Innovation Council.⁶⁵ So Finland has accelerated and scaled its leading quantum-computing company, while the UK has lost one of its own.

Not scaling national winners is especially problematic in a concentrating market. Major tech players – including Google, IBM and Microsoft – dominate the quantum-computing sector,⁶⁶ with incumbents such as IBM reporting \$1 billion in cumulative revenue from quantum sales.⁶⁷ Not only would monopolisation of the quantum market shut out new players, it would also distort future innovation and risk the UK’s technological sovereignty.⁶⁸

Without action, leading quantum companies like Oxford Ionics will continue to leave and the UK will forfeit sovereign capability in quantum hardware and software.

Supply-Side: Backing National Winners

The capital intensity of quantum hardware in particular means that companies face unique scaling challenges. But investing in UK quantum companies is especially high risk, not just because of the technology, but also because the UK lacks enabling infrastructure (see next chapter) and the necessary signalling from the government. The UK must ensure that its £670 million is invested boldly to de-risk quantum investment.

The government therefore needs to ensure that quantum is explicitly prioritised as a core industry for the BBB and NWF to invest in. Furthermore, the NWF is moving too slowly: it should be leading co-investment into quantum-enabling infrastructure, to de-risk opportunities for investors who want to put their money into companies and not have to worry about said infrastructure. This would also mean that the BBB could focus on de-risking company funding rounds while the NWF de-risks the entire quantum sector through infrastructure investments.

IQM’s recent Series B round in Finland underlines the importance of getting this right: the \$320 million round brought in institutional capital via Tesi, which is the Finnish equivalent of the BBB. The BBB and NWF should play an equivalent catalytic role by crowding in pension funds and other institutional investors for large-ticket rounds.

But this is not just about public investment: the UK needs to make sure that its private investment into quantum is strong. Although the UK does well in attracting VC investment in its quantum sector (it is second globally in this regard), it lacks anchor firms (leading companies that drive growth) with CVC arms. CVC is especially important for deep-tech sectors, since they provide not only patient capital but sectoral expertise, access to supply chains, routes to market and even potential exits (the latter being especially important, given that globally only 16 pure-play quantum companies have gone public as standalone entities).⁶⁹

However, the UK is behind the curve on this: only 8 per cent of VC in the UK comes from corporates, compared to 30 per cent in the US and 35 per cent in China, leaving UK quantum companies at a systemic disadvantage (see [From Startup to Scaleup: Turning UK Innovation Into Prosperity and Power](#)). For example, corporates in other European countries – such as Bosch⁷⁰ – are much more active in deep-tech investment.

Recommendation: *To unlock greater corporate investment in UK deep tech, the government should revive and modernise the Corporate Venturing Scheme (CVS). A new CVS should provide corporate-tax relief for UK businesses investing in early-stage deep-tech firms. The UK could de-risk these investments by leveraging the BBB and NWF for co-investment, and channelling UK pensions into new deep-tech investment funds. The government should also consider soft-landing packages to attract global CVC branches to the UK, including streamlined legal- and visa-advisory services.*

The CVS originally ran between 2000 and 2010 to encourage corporate investment in high-risk businesses.⁷¹ Offering upfront corporation-tax relief of up to 20 per cent, plus loss and deferral reliefs, the CVS channelled £132 million into 579 companies before it was allowed to lapse in 2010, despite corporate venturing rising by 65 per cent in its final year.⁷² With the FTSE 100 sitting on substantial cash reserves, and with structural reforms such as the Mansion House II Accords unlocking greater pension investment into UK assets,⁷³ the conditions are ripe for a modernised scheme.

Demand-Side: Driving Government Adoption

Quantum has advanced hugely in recent years, but government procurement has not.

The government has a crucial role to play as a “first customer”: setting the precedent for wider industry adoption and providing the demand signals to scale quantum companies. Germany’s government understands this and is moving quickly to scale quantum systems, especially for military use.⁷⁴ For the UK, getting procurement right is not only essential for scaling sovereign quantum companies, but also directly linked to ensuring resilience for the day when quantum technologies become critical enablers for the country’s intelligence services, military capability and national infrastructure.⁷⁵

Germany is also forging ahead on investment in quantum hardware. In 2022 the German Aerospace Center commissioned a UK quantum startup, Universal Quantum, to build a fully scalable trapped-ion computer as part of the Quantum Computing Initiative driven by the federal government.⁷⁶ The contract was worth about £70 million.

If the UK fails to match this level of investment, quantum companies will drift towards the territories where demand is real. This has already started to happen: the previously mentioned example of PsiQuantum, a spinout from Bristol University, moving to the US, as well as Universal Quantum forming a subsidiary in Hamburg in order to win its 2022 contract.

The UK government needs to bet on the companies still in the UK that have the potential to be sovereign quantum champions.

Recommendation: *The government should portion off £200 million of the Invest 2035 Industrial Strategy’s announced £670 million for quantum⁷⁷ to run two or three major procurement competitions, exclusively for UK-based quantum companies. This would propel government innovation in quantum and drive the scaling of home-growth champions.*

In awarding these contracts an element of winner-picking is unavoidable, which is often seen as an approach that risks distorting the market. But the UK government will have to take bets when it comes to selective backing if it is to be quantum-ready, and if the UK is to have any leading champions with revenue streams sufficient for global scale.

But capital scale is not the only issue: procurement processes in the UK are highly fragmented. Quantum procurement needs coordination and ownership, but the UK's system for funding and procuring national security technologies is disjointed. Different departments – such as the MOD, Home Office and DSIT – run their own innovation programmes aimed at technologies at different stages of maturity (known as technology-readiness levels). Alongside these sit national-security accelerators such as the National Security Strategic Investment Fund and the National Cyber Security Centre (NCSC) for Startups, each with their own rules and funding models. This patchwork makes it difficult for startups and suppliers to navigate the system and access the full range of opportunities needed to scale.

Recommendation: *The government should adopt an individual quantum-procurement champion within each relevant department, including DSIT, the MOD and the Department for Business and Trade. These champions would have technical expertise and serve as dedicated engagement points for industry, responsible for horizon-scanning possible use cases, trialling PoCs and sandboxes, driving AMCs where appropriate, running procurement competitions and ensuring that government procurement is proactive in adopting quantum solutions. The procurement champions would help identify the government's key quantum use cases, which would form the basis of the procurement competitions.*

Unlike modular technologies such as AI and software, quantum is cross-cutting, system-dependent and still immature across some technologies. It demands the integration of hardware, electronics and software, and bespoke environments such as cryogenics, making it a poor fit for siloed procurement frameworks. The procurement champions would have a remit to connect across silos to make integration more feasible.

Having AMCs as part of the government's arsenal would offer the added benefit of providing demand-signalling, but delaying payment until the required quantum system is actually built.

Demand-Side: Driving Industry Adoption

Technologies such as quantum computing will not be magic, plug-and-play, fix-all technologies. Instead, like AI, their value will derive from application- and industry-specific use; this means that vertical industry integration is essential. However, this cannot happen unless the R&D base, quantum startups and corporates work in lockstep to clear bottlenecks, in order to drive and scale use cases.

Early quantum applications are emerging in sectors where UK industry is globally competitive, such as pharmaceuticals⁷⁸ and financial services,⁷⁹ but the UK trails countries including Canada, the Netherlands and Germany in corporate adoption. This may be a symptom of a broader trend: the number of UK corporates in the top 100 R&D spenders globally has dropped by nearly half over the past decade.⁸⁰ Yet if UK industry does not begin experimenting with quantum adoption and integration, not only will the country fail to gain economic value, but UK quantum companies will not get the demand-signalling they need to attract investment and scale.

Recommendation: The government should introduce fiscal incentives for large UK-based companies in key sectors where quantum technologies will have major applications (such as finance and health care), to fund quantum PoCs. This could include enhanced R&D tax reliefs or reduced employer National Insurance contributions for quantum-related hires. The Translational Quantum Research Group recommended in this paper should work directly with UK corporates to understand the technical barriers they face to integration and adoption, and subsequently provide research direction for resolving engineering bottlenecks.

The government could also consider mandating major UK firms in key sectors to disclose their investment in quantum, to build transparency and competition.

Countries such as Singapore have moved ahead by embedding quantum deployment in industry-facing institutions such as the National Quantum Computing Hub, which directly partners with corporates in areas such as finance, quantum chemistry and combinatorics.⁸¹ Indeed, the lack of quantum adoption in the UK is not just a money problem: it is also an information problem. The country's quantum ecosystem lacks a clear, coordinated body that connects researchers and startups with corporate buyers.

Recommendation: *As proposed by the Royal Academy of Engineering, the UK should establish a dedicated quantum-technology coordination function to streamline access to infrastructure and bridge the gap between its strong R&D base, startup community and industry verticals.⁸² The coordination function could also take on the responsibility of providing clear technology-adoption guidance to industry, explaining emerging use cases and highlighting successful PoCs.*

At present, corporates face a confusing and highly technical landscape whereby trialling or buying quantum solutions seems more trouble than it is worth, especially when AI appears to offer a far cheaper solution for day-to-day productivity problems. The reality is that any company that is serious about building competitive advantage through technology, and scaling AI solutions in a cost-effective way, will have to invest in quantum, as first-movers such as JPMorganChase already have.⁸³ But lack of access to the right people and information is a barrier. A centralised coordination body – staffed with experts who understand both quantum technologies and industry needs – would act as a one-stop shop for advisory support on infrastructure, funding roadmaps, regulatory compliance and other tools.

Ultimately, deriving economic and strategic value from quantum requires a two-pronged strategy: scaling domestic quantum champions, but also being a first-mover when it comes to adoption.

05

Scale, Sovereignty and Security

The imperative to lead in quantum is not only about capitalising on its economic promise: it is also an essential component in securing the UK's sovereignty and national security through a defining dual-use technology.

- **Technological sovereignty:** The UK's ability to scale home-grown quantum companies is directly related to its capacity to build technological sovereignty. If companies do not have the inputs and infrastructure they need to scale, the UK risks losing technological autonomy across the quantum stack and relying on other countries for a critical general-purpose technology.
- **National security:** Quantum computing threatens the security of current cryptography systems, which underpin almost all digital industries and critical national infrastructure. Given the difficulties that the UK and Europe are already experiencing with cyber-warfare,⁸⁴ being ahead of post-quantum cryptography will be critical.

These two challenges are inextricably linked: if the UK does not have the quantum companies to secure its sovereignty, its ability to protect itself in a post-quantum encryption world will be compromised.

Commercial Scale and Technological Sovereignty: Building Infrastructure and Supply-Chain Resilience

As the quantum market matures and demand for applications increases, being at the cutting edge of R&D will be meaningless without having the inputs and infrastructure to deploy quantum systems at scale. Infrastructure and supply-chain inputs are essential for three reasons:

1. To enable the UK's leading quantum companies to scale and therefore remain in the country.
2. To have the right access to infrastructure, enabling UK corporates to adopt quantum at scale.
3. To ensure that the UK has supply-chain resilience across the full quantum stack, which is important because, if the AI playbook is any guide, brittle global supply chains will be a major limitation on technological sovereignty in quantum.⁸⁵

All these factors will underpin the UK's capacity for technological sovereignty and control over its quantum-enabled future. However, beyond a handful of key companies, the UK has limited access to the key supply-chain inputs and infrastructure necessary for companies to scale domestically; EU vendors supply nearly half the hardware and software components used in quantum computers.⁸⁶ In cryogenics, for example, UK firms such as Oxford Instruments and ICEoxford supply some systems, but the supply of ultra-low-temperature refrigerators essential for superconducting quantum computers is dominated by Finland's Bluefors.⁸⁷ And for advanced semiconductor fabrication – including the likes of superconducting chips and photonic integrated circuits – the UK remains reliant on foreign infrastructure.

On the manufacturing side, advanced packaging is another bottleneck for the UK, which lacks the necessary infrastructure for doing it in house. This is not a matter of consumer packaging, but the precise integration of quantum chips, sensors and photonic components into functional modules, which is essential for systems-based quantum companies to scale their products.

As the Royal Academy of Engineering pointed out in its 2024 quantum-infrastructure review, the UK risks “losing ground to countries making significant investments in quantum” infrastructure, even if it leads in quantum startups.

Recommendation: *The government must ensure that the UK has the necessary supply-chain depth and sufficient access to quantum-enabling infrastructure, such as cryogenics, to enable UK-based companies to scale and create resilience across the quantum stack.*

The UK has already made some progress on this,⁸⁸ but the level of ambition needs to be much greater, with interventions as follows:

- **Map capabilities and identify gaps:** In coordination with industry and the Royal Academy of Engineering, the Office for Quantum should develop a detailed map of the quantum stack, highlighting where UK capabilities are strong and where they are lacking. This map will inform investment and partnership priorities; for example, if the UK lacks high-end laser manufacturers, it should target partnerships with countries that have them.

- **Forge strategic bilateral partnerships:** Given the complexity of the quantum stack, no country will control it in its entirety. The government must therefore pursue focused agreements with key countries to secure access to vital supply chains and infrastructure. These should go beyond mere memorandum signings and outline concrete initiatives, as was the case with the recent UK-US quantum initiative.⁸⁹
- **Invest in quantum infrastructure at home:** For areas that are highly cost effective, or where immediate proximity is essential for domestic quantum companies to scale, or where the UK could carve out a global niche (in diamond fabrication, for example), the government should invest in onshore capabilities. The UK should expand its domestic capacity in cryogenics (a critical component for scaling quantum-computing companies), particularly in hubs such as Daresbury in Cheshire, home to the Accelerator Science and Technology Centre. The NWF could play a leading role by co-investing in key quantum-enabling infrastructure, helping to de-risk private investment in UK quantum firms. At present, many investors are hesitant to back UK quantum companies precisely because this supporting infrastructure is limited, which raises both cost and risk.
- **Encourage quantum companies to procure from UK-based components companies:** Where the UK does have domestic capacity in the production of critical enabling technologies, the government should encourage UK quantum companies to procure domestically.

Balancing Onshore Investment With Allied Partnerships

The UK needs to strike a careful balance between building its own extended quantum stack and leveraging those of its allies. Some domestic infrastructure is essential to anchor the ecosystem and build resilience, but trying to onshore the entire supply chain would be prohibitively expensive, inefficient and unrealistic. The real test of sovereignty is whether UK companies can access the infrastructure they need to grow, whether at home or working with trusted allies. Overinvesting in costly, uncompetitive onshore capacity risks driving firms abroad anyway, so the goal should be to target domestic capability for resilience, backed by strong international partnerships to guarantee easy, reliable access to capabilities in other territories.

The UK should identify precisely which parts of the extended quantum stack it should collaborate on with its allies, as well as earmarking priority countries that excel in areas where the UK is weak:

- **United States:** The UK-US quantum agreement is an important milestone, representing a starting point for cooperation on interoperability, market access, benchmarking, talent exchanges and shared leadership in a field that will be as geopolitically consequential as AI.⁹⁰ But to translate this partnership into real delivery, both governments should build on the pledge to “affirm shared dependencies on certain critical infrastructure” through structured assessments of strengths and vulnerabilities across their respective quantum supply chains.
- **Germany:** Has the largest quantum ecosystem in Europe, with roughly twice as many companies in the extended supply chain as the UK. It is particularly strong in photonics and lasers, with firms such as Toptica, Bosch and Zeiss operating alongside specialised small and medium-sized enterprises.
- **The Netherlands:** Has one of the world’s most advanced semiconductor ecosystems, anchored by companies such as ASML, ASM and NXP, which are global leaders in lithography and chip manufacturing.⁹¹ This makes the Netherlands a key partner for quantum technologies requiring advanced semiconductor processes.
- **Japan:** A trusted democratic partner with deep expertise in advanced materials, electronics and photonics. The UK and Japan have already signed a bilateral quantum-cooperation agreement, and alliances such as UKQuantum’s partnership with Japan’s Q-STAR provide a strong basis for expanding collaboration.⁹²
- **Canada:** A natural partner for the UK, with a comparably sized ecosystem, its companies and researchers are global leaders in areas such as quantum cryptography, superconducting quantum computing and quantum software, with notable firms including D-Wave Systems and ID Quantique’s Canadian operations. The UK and Canada have previously launched joint quantum programmes, making future collaboration straightforward and mutually beneficial.⁹³

Trusted partnerships also present a united front against hostile actors. If, for example, certain adversarial countries try to leverage a part of the quantum stack for malign purposes, a tight-knit coalition of democratic quantum powers can respond far better than if each country were left to its own devices.

However, while the case for international collaboration is clear, there are practical bureaucratic, regulatory and political hurdles that must be overcome to make collaboration seamless. One issue is the sort of complex funding and regulatory processes that discourage cross-border projects. For example, in January 2024 the UK re-established its links with the EU's flagship R&D funding programme, Horizon Europe.⁹⁴ This is a welcome development that restores UK access to more than £80 billion of research funding. However, early experience has shown that UK researchers still face challenges in fully reintegrating into the scheme: the application processes for Horizon projects can be complex and there are lingering political frictions that can make it harder for UK entities to coordinate bids as part of European consortia.⁹⁵

Cooperating on quantum means working with allies, especially in Europe, to remove frictions to joint research and infrastructure. In short, the UK must secure the broader quantum stack if it is to translate its R&D and startups into substantial global concerns. However, the test of sovereignty is not whether the UK ends up making every component at home, but whether its companies can reliably access the inputs and infrastructure needed to scale, either domestically or with trusted allies.

National Security: Preparing for Post-Quantum Cryptography

The more acute challenge is that the arrival of quantum computing threatens to render today's public-key cryptography obsolete, leaving critical sectors – from finance to energy – vulnerable to “harvest now, decrypt later” attacks.

The stakes are high. Public-key cryptography is integral to the functioning of the modern digital economy: it secures financial transactions, authenticates identities, underpins digital signatures and enables the encrypted exchange of keys that protect sensitive data.

Without systematic planning – including trust management, crypto-agility and hybrid coexistence – critical infrastructure, private companies and the government risk widespread data exposure and systemic breaches as current encryption becomes vulnerable to quantum attack. Some progress has already been made to secure this transition: the UK has set out a broad migration timeline⁹⁶ and the NCSC’s post-quantum cryptography pilot is building advisory capacity.⁹⁷ Yet many challenges remain. As the White House’s quantum-transition roadmap outlines,⁹⁸ many operators still do not know where public-key cryptography is deployed across their systems, and crypto transitions are rarely treated as board-level resilience priorities. Moreover, not all quantum-safe algorithms will be suitable for every application: trade-offs in speed, key size and the complexity of implementation mean that different systems will require different solutions.⁹⁹

Without visibility, governance and regular stress-testing, migration efforts will lag, leaving essential services exposed well into the 2030s.

Recommendation: *To close this gap, the UK should require regulated critical industries to publish updates on their quantum-migration plans every two years, through organisations such as the NCSC and the MI5 National Protective Security Authority. These updates should demonstrate tangible progress: inventories of cryptographic assets, adoption of hybrid solutions, and evidence of trials or proofs of concept.*¹⁰⁰

As part of this requirement, regulators should also mandate periodic audits of public-key cryptography within critical sectors, ensuring that organisations can identify where and how these systems are deployed. Without such inventories, supported by automated discovery tools, firms will be unable to prioritise migration or manage hybrid states effectively, leaving hidden vulnerabilities in place.

Mandating transparency and accountability will push cryptographic migration on to the strategic agenda of boards, rather than leaving it as a technical afterthought.

06

Conclusion

The UK stands at an inflection point. A decade of smart investment has resulted in world-scientific research and startups, but the centre of gravity in quantum is shifting from discovery to deployment. In a consolidating, capital-intensive market, advantage will accrue to countries that can translate research into products, scale firms at home and be first adopters across the wider economy. The economic prize is considerable and the strategic stakes are high. Without a pivot to commercialisation, the UK risks becoming an incubator for other countries' industries and losing sovereignty over a general-purpose technology that will underpin security, productivity and growth in the 2030s and beyond.

The problem is threefold:

1. **Translation gap:** World-class physics is not being consistently converted into engineered subsystems and deployable prototypes.
2. **Capital and adoption gap:** Limited high-risk and big-ticket investment combined with weak, fragmented demand means UK champions are struggling to scale.
3. **Stack gap:** Shallow access to critical inputs (cryogenics, photonics, advanced packaging, nanofabrication services) and brittle international supply chains.

The solution is a deliberate shift from R&D to commercial leadership. Build dedicated, mission-driven translational engineering capacity focused on deployment; deploy high-risk capital and create early, big-ticket demand in both the government and private sector; and secure the extended quantum stack through targeted UK infrastructure where necessary, complemented by deep partnerships with trusted allies.

The main problem with quantum industrial strategy is that it is not an investment that will immediately pay off – but at the same time, quantum is one of the technologies that will define 21st-century economic and geopolitical power. It is precisely this gap between immediate returns and long-term significance that makes quantum a textbook case for a proactive government industrial strategy.

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