FUND OR FADE
POWERING A SOVEREIGN QUANTUM BRITAIN

LABOUR TECH

THE YIMBY INITIATIVE

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POWERING A SOVEREIGN QUANTUM BRITAIN

A call for mission-led investment to secure UK leadership in the next frontier of national interest.

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About Labour Tech

We are a group of professionals with experience in the technology sector and members of the Labour Party, working together to help shape forward-looking policies. We collaborate with experts from industry, academia, and politics to support ideas that drive progress. Britain needs growth now more than ever, and by supporting our homegrown technology sector, we can help deliver the economic renewal our country urgently needs.

labour-tech.org.uk

All experts featured in this report are independent of the Labour Party.

About the YIMBY Initiative

The YIMBY Initiative is a research centre and stakeholder management partner dedicated to creating a UK with abundant housing, clean energy, and modern infrastructure.

We advocate for bold reforms that accelerate development, lower costs, and improve quality of life for all.

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Quantum Britain at the Crossroads

Lewis Bailey
Founder, Labour Tech

While Labour Tech has facilitated this policy conversation, the brilliance belongs to the experts. Our role is to make sure their ideas are heard, acted upon, and translated into policy that delivers real change.

Our inaugural pamphlet is a call to action. It brings together policy insights, technical expertise, and strategic recommendations from across the UK quantum ecosystem: physicists, defence analysts, engineers, and entrepreneurs. It distils their thinking into a cohesive, national agenda—one that not only recognises Britain's extraordinary scientific foundations, but that insists on turning those breakthroughs into sovereign advantage.

Quantum is no longer a theoretical frontier; it is the new terrain of geopolitical competition. From the Korean peninsula to Silicon Valley, governments are investing billions to secure quantum capabilities in communications, computing, and warfare. China is fielding satellite QKD networks. South Korea is targeting 1,000-qubit machines by 2035. The United States has already aligned its quantum programme with defence and critical infrastructure goals.

Britain cannot afford to be passive in the face of this acceleration.

Yet while the UK leads in academic discovery—from trapped ion hardware to post-quantum cryptography—our quantum future remains vulnerable to foreign capital, fragmented infrastructure, and a lack of defence-aligned strategy. As multiple contributors to this pamphlet warn, we risk becoming the research lab for technologies scaled elsewhere.

We do not lack talent. We lack policy clarity. The quantum age requires not just vision, but execution.

This paper sets out five core imperatives for a sovereign, competitive, and economically inclusive UK quantum strategy:

1. **Establish Sovereign Capabilities and Strategic** Investment Quantum must be treated as a strategic asset—supported through mission-led investment, public procurement, and long-term capital for British firms.
2. **Build Industrial Capacity and Ecosystem Support** Nurture domestic hardware and software vendors. Support UK-based manufacturing and secure quantum supply chains.
3. **Reform and Expand the Quantum Talent** Pipeline From PhDs to apprenticeships, quantum education must be radically reformed to meet 21st-century workforce needs—diverse, interdisciplinary, and technically bold.
4. **Stimulate Demand and Early Adoption** Government must become a first customer. Regional testbeds, NHS pilots, and MoD demonstrators can de-risk commercial deployment and stimulate private sector confidence.
5. **Align Regulation, Standards and Global** PartnershipsThe UK must lead on setting quantum norms—ensuring our technologies are trusted, exportable, and interoperable with allies.

This document also explores key applied domains—from military simulation and secure drone communication, to quantum-enhanced AI and creative industries. These case studies are not science fiction—they are already being prototyped in Korean aerospace labs, Israeli incubators, and North American start-ups.

Britain can lead. But leadership is not inherited—it is asserted.

The next Labour government has the opportunity—and the obligation—to make quantum a foundation of Britain's next industrial revolution. That means funding with ambition, regulating with foresight, and leading with clarity.

Because quantum is not just a scientific opportunity. It's a political responsibility. And in this new era of global competition, Britain must choose not just to participate—but to lead.

A Quantum State of the Union

Bringing Cardiff, Glasgow, and Belfast into Britain's next industrial revolution—without decoherence.

Tris Osborne MP
Member of Parliament for Chatham and Aylesford

Quantum computing is no longer a distant scientific curiosity—it's quickly becoming a game-changing technology with the potential to reshape the economy, transform industries, and redefine the UK's position on the global innovation stage. As a Member of Parliament committed to both technological leadership and social fairness, I believe we must act now to unlock the full benefits of quantum computing. This isn't just a scientific issue; I believe this to be a national policy priority.

The macroeconomic and strategic case for a more coordinated, government-led approach to quantum argues that public leadership is essential—not just to capture economic returns, but to make sure the social benefits of this technology are shared widely across the country.

Why Government Must Lead

The UK government has a crucial role to play in making sure quantum computing supports national goals like higher productivity, inclusive growth, and global competitiveness. Like the Industrial Revolution and the digital age before it, we're at a turning point: with the right action, we could lead this next wave of innovation—or fall behind.

Studies from IBM and Oxford Quantum Circuits show just how big this opportunity is. If the UK reaches commercial viability in quantum by 2035, it could lift national productivity by 1%, rising to 8% by 2050. That's like every worker delivering three extra weeks of output per year, without working longer hours. The economic impact would be huge—boosting GDP, tax revenues, and our ability to fund public services.

The benefits grow even more if we move faster. Hitting viability by 2029 could bring a 5% productivity boost as early as 2035. In short, speed matters. If we want to stay competitive, we need policies that support early adoption and avoid falling behind in the global race.

Strategic Sectors and National Priorities

Quantum could transform key sectors where the UK already has strengths. In pharmaceuticals, it could speed up drug discovery by simulating molecules in ways classical computers can't. In logistics, it could optimise supply chains—vital in a post-Brexit world. In finance, it could supercharge forecasting and risk analysis, boosting our globally competitive financial sector.

There's also a national security angle. Quantum could enable secure communication and better cybersecurity—but it also threatens current encryption methods. The UK needs to be proactive: developing quantum-safe cryptography and ensuring we build domestic capabilities to avoid overreliance on foreign tech, especially given today's geopolitical tensions.

To make all this happen, policy can't stop at research grants. We need a full-spectrum approach: investment in infrastructure, procurement strategies, smart regulation, workforce development, and regionally balanced innovation hubs. Quantum needs to be part of a bigger industrial strategy—one that connects universities, startups, big industry, and the public sector into a national ecosystem.

Regional Growth and Social Equity

Just as important are the regional and social benefits. If handled well, quantum could help deliver the government's levelling up agenda—creating high-skilled, future-ready jobs beyond London and the South East. Existing hubs like Oxford, Cambridge, and London are key, but we also need to build up centres in places like Manchester, Birmingham, Glasgow, Belfast, and Cardiff.

Investing in education and skills is critical. We'll need not just PhDs in quantum physics, but also engineers, technicians, and software developers who understand

quantum concepts. That means creating a broader talent pipeline—through apprenticeships, vocational courses, and cross-disciplinary education that covers ethics, policy, and business.

Staying Competitive Globally

The global quantum race is already on. The US, China, and EU countries are pouring public funds into quantum, seeing it as central to economic security and sovereignty. The UK can't afford to sit back. Our research base is strong, but without matching industrial and policy support, we risk losing our edge.

To stay ahead, the UK should adopt a formal Quantum Strategy—like the Life Sciences Vision or National AI Strategy—with long-term funding and clear goals. This needs cross-department coordination (BEIS, DSIT, Treasury, Defence) and strong ties between national and devolved governments. A dedicated National Quantum Mission, led by a commissioner or taskforce, could help align investment, regulation, and education with our commercialisation goals.

We should also lead on setting the global standards for how quantum is used—ensuring it's developed responsibly, ethically, and in a way that avoids deepening digital divides or concentrating power in the hands of a few.

Conclusion

Quantum computing is more than just a scientific milestone—it's a strategic moment for the UK. If we move boldly and inclusively, it could bring major productivity gains, boost regional growth, and secure our place as a global tech leader. If we don't, we risk falling behind and becoming dependent on others for the next generation of technology.

As policymakers, we must ensure quantum computing is developed not just for scientific prestige, but for the benefit of all. Now's the time to build a future where quantum serves the public good, drives sustainable growth, and reflects the values of a forward-thinking, inclusive Britain.

Quantum Britain Needs a Bigger Bang

Other nations are funding like it's the Manhattan Project. We're stuck in Dragon's Den.

Dr. Ilana Wisby
CEO, MOTH • Founding CEO,
Oxford Quantum Circuits

The View From A Builder

In 2017, Oxford Quantum Circuits (OQC) spun out of the University of Oxford with a mission to bring quantum computing to humanity.

OQC is now one of the world's leading quantum hardware companies, with machines deployed in Tier 1 data centres worldwide. Its clients include major corporations and governments, and its partnerships span Tokyo to Texas.

When I joined as founding CEO, I brought a PhD in quantum physics, experience in deep-tech commercialisation, and a conviction that quantum needed to move from theoretical promise to practical infrastructure. That belief became seven years of navigating underdeveloped infrastructure, constrained capital, and a fierce global race for talent.

The UK has the raw materials to lead the global quantum economy. But the supporting systems — capital, infrastructure, policy, and leadership — continue to lag. In quantum, ecosystem and ambition matter.

The Strengths: Science, Talent and Collaboration

The UK's quantum ecosystem has grown rapidly. As of April 2025, it is home to 73 quantum computing-related startups, up from 51 in 2022 — a 43% increase in just three years. This momentum is thanks to early public investment, particularly through the National Quantum Technologies Programme (NQTP), which committed £1bn across multiple phases. That laid the foundation for infrastructure like the National Quantum Computing Centre (NQCC) in Harwell, regional quantum hubs, and commercial testbeds.

Our academic base remains world-class. The UK ranks third in global quantum research output, behind only the U.S. and China. Institutions like Oxford, Imperial, UCL, and Bristol produce outstanding talent across superconducting qubits, trapped ions, photonics, and cold atoms.

At OQC, we recruited diversely and globally. We proved that quantum talent can thrive far beyond traditional hubs — if given the right mission, culture, and infrastructure.

Importantly, the UK quantum community is collaborative. Founders, scientists, and policymakers often work side by side. We compete, but we also share. That collaborative culture is an under-recognised strategic advantage.

Capital: Why We're Falling Behind

Quantum is capital-intensive: long commercialisation cycles, cross-disciplinary R&D, and uncertain markets demand strategic, patient capital.

At OQC, I raised over $100m from spinout through Series B. However, UK quantum companies raise significantly less than their global peers — typically at lower valuations and with shorter runways. Fundraising became a constant distraction from execution.

While early-stage funding has improved thanks to British Patient Capital, Innovate UK, and the Future Fund, later-stage capital remains scarce:

- Less than 5% of UK venture capital from 2019 to 2023 went to hardware-based deep tech.
- UK funds led fewer than 20% of Series B+ rounds in UK quantum startups (2020–2024).
- In contrast, U.S. VCs led over 75% of Series B+ rounds in American quantum ventures (Pitchbook, 2024).

That leadership gap in growth rounds is existential. At OQC, our Series A and B were led by Japanese investors when no UK institution stepped up. Most other leading UK quantum companies have faced similar patterns. Too often, foreign capital leads our most strategic rounds.

That's not just a capital gap — it's a conviction gap.

And it comes at a cost. When UK-born IP scales on foreign capital, we lose control of technologies critical to our national resilience, economic strength, and security.

Infrastructure & Talent: The Strategic Gaps

Quantum isn't software. It demands hardware, and with it, heavy infrastructure: cryogenics, RF shielding, vibration isolation, cleanrooms, and secure networks. In the UK, we had to build much of this from scratch.

There is still no national quantum infrastructure platform. Cleanrooms are fragmented or oversubscribed. Fabrication and testbeds remain limited.

But that challenge is also an opportunity. The UK can lead by building a sovereign quantum supply chain — reducing dependence on foreign infrastructure and embedding capability in critical sectors: health, defence, finance, and intelligence.

As quantum converges with semiconductors and classical HPC, the geopolitical stakes rise. Without domestic infrastructure, we risk handing strategic leverage to foreign fabs and platforms.

Immigration Compounds the Problem Since Brexit

Talent is mobile — and perception matters. Global talent will go elsewhere if the UK is seen as harder to enter, slower to integrate, or less welcoming.

- Non-EU PhD applications in physics and engineering have declined (UKRI, 2023).
- Startups have opened EU subsidiaries to retain hiring flexibility.
- The path to Indefinite Leave to Remain now takes 10 years, compared to 2–5 years in Canada, the U.S., and Germany.

Why This Moment Matters

Quantum is where AI was in 2015: a scientific frontier turning into a commercial arms race. Early applications are emerging in materials science, pharma, optimisation, and secure communications.

Oxford Economics projects quantum computing could add £212bn to the UK economy by 2045 across energy, defence, health, and finance.

But others are moving faster. China is reportedly investing at the Manhattan Project scale. The U.S. has allocated over $3 billion through the National Quantum Initiative. India's £730m National Quantum Mission is fully funded. Qatar has pledged $1 billion+ via a joint venture with Quantinuum.

Those who scale quantum will not just profit. They will define standards, set norms, and control the platforms of a new computational era.

The UK has the science. But unless we act now, we won't have the scale.

A Final Word: Rebuilding Risk Culture

This isn't just about capital. It's about commitment.

I believe in British science, in our founders, and in what we can achieve when we choose to lead.

But to do that, we must rebuild a culture that understands deep tech — one that rewards long-term thinking, backs bold builders, welcomes global talent, and funds with strategic patience.

Right now, our policies send mixed signals. Founder tax relief and capital gains incentives have been diluted. Visa pathways are slow. Public markets remain inhospitable to deep tech exits.

If we don't fix this, the UK risks becoming a science incubator for other nations' economic gain.

Let's change that. Let's start funding with trust, not just terms. Let's visit the labs. Listen to the builders. And most of all — let's build with belief.

The window to lead is closing. But it hasn't closed yet.

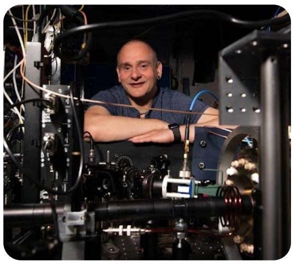
What Needs to Happen (2025-2030)

- **Scale Public Investment**
  Commit £1bn/year by 2027 for sovereign infrastructure, strategic modalities, and public-private consortia in health, energy, and defence.
- **Launch a UK Quantum Growth Fund**
  Create a £2bn public-private Series B–D fund. Co-investment aligned with national security and IP retention.
- **Unlock Capital Beyond the Golden Triangle**
  Introduce a 30% enhanced EIS for regional deep-tech funds ("NorthGrit uplift"). Activate angel syndicates outside London, Oxford, and Cambridge.
- **Build Shared National Infrastructure**
  Invest £500m in cleanrooms, fabrication, cryogenic systems, and sovereign cloud testbeds. Develop platforms for sensing, timing, and other modalities with end users in mind.
- **Create a Quantum Procurement Challenge Fund**
  Allocate £100m/year across MoD, NHS, and GCHQ for real-world pilots and pull-through programmes.
- **Restore the Founder Pipeline**
  Reinstate £10m CGT relief cap for qualifying deep-tech founders. Standardise founder-friendly public co-investment terms.
- **Launch a Global Quantum Talent Visa**
  Create a 3–5 year pathway to Indefinite Leave to Remain for key hires tied to certified quantum excellence centres.

We have the science. We have the talent. What we need now is the will.

Born in Britain, Scaled in Silicon Valley

A cautionary tale of IP leakage, venture capital migration, and missed opportunities.



Prof. Winfried Hensinger
Professor of Quantum Technologies at the University of Sussex • Chairman, Co-founder and Chief Scientist of Universal Quantum

Practical quantum computers have the potential to solve extremely complex problems much faster than their classical counterparts, and to disrupt sectors such as finance, drug discovery, and materials science, thereby changing the way we work and live. The uptake of quantum computing in different sectors within the UK makes its potential economic impact clear: according to a report by Oxford Economics, quantum computing is predicted to create 148,000 UK jobs by 2055 and ca. £12.9 billion to GDP. Quantum-driven productivity gains could increase by 33% across key industries and 8% economy-wide.

These projections are rooted in the UK's historic and existing world-leading capabilities and landmark breakthroughs in quantum computing that have emerged from its universities and successful startups; and these successes have been enabled by proactive government funding into research and innovation. The importance of quantum technologies as a whole for the UK's economy and security has long been recognised by the UK Government and led to strategic investment into research and innovation over the last decade through UK's pioneering National Quantum Technology Programme (NQTP) that was initiated in 2013.

Quantum computing provides a significant opportunity for the UK, but its continued development and future adoption is at a critical juncture. For the UK to maintain its world-leading position in quantum computing strategic investment must be made across the country, and both private and public investment must be raised to secure this substantial economic opportunity for the UK.

Mobilising capital in support of quantum computing is challenging: it's an emerging technology and includes a large 'valley of death'. However, several strategic levers exist that, if deployed correctly, will enable the potential of quantum computing and quantum technologies in the UK to be maximised.

Leverage Regional Excellence and Capability

A "Hub & Spoke" Approach for the NQCC

The key role of the NQCC should be to nurture the UK quantum computing sector, act as first customer acting to independently verify the system specifications. A secondary role should be to help educate customers and to provide suitable incentives for partnerships of different stakeholders (e.g. partnerships of hardware and software companies) that strengthen UK's overall quantum computing capabilities.

A key role of the NQCC should be to strengthen the vulnerable UK ecosystem, provide topical and coherent funding for academic stakeholders to address critical research challenges where existing funding mechanisms may not be suitable for or where natural funding gaps appear within the transition from one grant to another. The NQCC should also play a role in showcasing UK quantum computing capability.

Whilst significant government investment has been made into quantum computing research and innovation as part of the first, second and third phases of the NQTP, much of it has been focused on the Oxford regional area (Oxford as the location of the quantum computing hub and Harwell as the location of the National Quantum Computing Centre, NQCC). The current focus of investment in the University of Oxford as a lead partner of the current and past quantum computing hub along with investment in the core site of the NQCC that is co-located in the wider Oxford region does not capitalise on quantum computing excellence located elsewhere.

For example, focus on machines to be deployed in the regional Oxford area, such as at the core site of the NQCC, do not support stakeholders that form the catalyst of regional quantum computing concentrations in other regions, harming the growth of a sizable and diverse national quantum computing ecosystem.

In order to initiate growth all across the UK we propose a "hub and spoke" model for the NQCC. Such a model would leverage regional strengths in quantum computing across the UK, thus enhancing nationwide economic growth and diversification. Here, Harwell would remain the central hub and primary connection point, while government funding would simultaneously encourage regional concentrations of quantum excellence wherever there is merit.

This approach complements the activity in the Oxford area expanding quantum computing excellence widely across the UK. Universities and companies across the UK could then become catalysts for developing world-leading quantum computing industry eco-systems. Local governments can act as facilitators, bringing key stakeholders together and creating supportive policies and strategies specific to their area.

Government Investment Attracts Multiples In Private Investment

The UK Risks Falling Behind

It is critical that the government makes co-investment at scale to ensure that regional quantum computing and quantum technologies ecosystems continue to flourish. The UK is at risk of falling behind other nations such as the USA, China, Germany, and a lack of investment in quantum computing and technologies within the UK would push innovators to move their operations elsewhere. To maintain global competitiveness, strategic UK government investment into quantum facilities and infrastructure is essential.

Intensify development to accelerate adoption

A key aim is to build the world's first quantum computer that possesses millions of qubits and is powerful enough to enable us to solve important real-world challenges. Bringing together some of the world's brightest talent, state-of-the-art facilities, and key stakeholders will make the dream of practical large-scale quantum computers a tangible reality.

Establishing world-leading state-of-the-art quantum computing facilities in regions with a strong quantum computing ecosystem has been established would secure the UK's long-term scientific, economic, and strategic leadership in quantum computing and give rise to deployment of this technology all across the UK, enabling quantum computing end-user companies in the UK, such as pharmaceutical companies, to integrate quantum computing capability to enhance their productivity.

Providing such quantum computing infrastructure would make the UK more attractive for a wide range of industry sectors and provide for a sovereign quantum computing capability. By providing shared access to advanced quantum hardware and software, it would empower industry, relevant startups, and researchers to accelerate innovation and tackle complex real-world challenges.

Such facilities would expediate adoption of quantum computing across a wide range of industry sectors, and the commercial use cases that would emerge will bridge the gap between quantum computing research and real-world adoption. It would foster talent development and support commercialisation of homegrown technologies.

Critically, it would ensure national sovereignty over a transformative technology and enable the country to compete globally while safeguarding its intellectual property, data, and future digital infrastructure.

Capitalise on co-investment

A suitable mechanism for establishing the proposed state-of-the-art quantum computing facilities could consist of a co-funding model where a proportion of the cost is secured as public funding, and leverage the remainder as private investment provided by the company or consortium that constructs the facility. The use time of the facility would then be equally shared according to the same proportion.

A co-investment model increases the return on public spending by leveraging private capital to multiply the overall impact. The government's investment will attract significant private sector investment and customer contracts, generating income rather than constituting a real cost to the UK taxpayer in the mid and long terms.

This public investment into such facilities acts as a catalyst that unlocks a much larger total investment and stimulates activity across the broader economy via commercially viable technologies (that are then adopted by other sectors and create further economic boosts), tax revenues, and high-value job creation that attracts and retains talent. Money invested now has exponential impact later.

Invest in innovation to drive and secure growth

While the UK has secured impressive venture capital investment in the development of quantum computing, government co-investment must complement private investment to bridge the large 'valley of death' inherent to the technology.

It is necessary forthe government to act as an early quantum computing customer (in e.g., health, defence, transport, and logistics) to garner confidence from private investment and create a significant uplift in what is possible. Otherwise, companies will move to countries where such co-investment is available, there will be a significant loss in knowledge base and industrial/ international investment, and promising regions will lose the opportunity to convert academic excellence into real-world economic growth.

Countries such as Germany and France are proactively investing in quantum computing, successfully leveraging substantial private capital by providing attractive government initiatives. Creating a framework of government contracts would propel development of practical quantum computers in the UK, similar to the model implemented by the German Space Agency in Germany. This will complement existing private and government investment and allow the healthy development of a quantum computing industry sector in the UK. This will also allow the creation of sovereign UK capability and retention of key talent.

We recommend investing into many promising UK hardware companies without specific focus on a few contenders too. As companies are only a few years old, and technologies are developing fast, it is important to provide many of them with government contracts as it is impossible to reliably predict the best contenders so early in the development of this technology. This will also serve to create an ecosystem and healthy competition between stakeholders.

Focus needs to be on systems with world-leading specifications rather than deployable systems. IP must stay with companies in order to enable commercial success and provide investor confidence. It is acceptable to constrain companies to assure production of goods generated via this IP is carried out in the UK, provided the company retains the IP.

Without sufficient and targeted funding, the UK is at risk of losing a major stake in a sector predicted to have a global value creation of $450-850 billion by 2035 [BCG 2024]. Most venture capital funds capable of supporting larger ticket sizes (size of investment per fund) for investment rounds B, C etc are located in the USA and elsewhere.

If the UK is serious in its desire to obtain a large share of the quantum computing hardware market, it needs to assure large scale investment is available for quantum computing companies. In the past, the lack of large-scale funding has driven innovators to move to the Silicon Valley (e.g., PsiQuantum).

Sufficient funding should be made available for quantum computing companies in the UK for later stage funding rounds so that these companies can remain in the UK rather than having to move to the USA or other countries. Mechanisms could include government supporting venture capital funds, interventions via the British Business Bank, investment incentives and government contracts.

Minimise Hurdles to Maximise Mobilisation

Create more suitable mechanisms to fund research and innovation

Innovate UK implemented large-scale industry led collaborative research and development projects that provided incentives for quantum computing companies, subsystem manufacturers, academic institutions, and users to effectively address real-world challenges in quantum computing. However, more recent calls from Innovate UK have been of insufficient duration (just one year long) and budget (calls were vastly oversubscribed leading to a very small success rate).

These issues hamper realisation of the commercial impact such consortia wish to achieve and negatively impact fluid interaction between partners. Funding mechanisms that are more flexible, longer-term, and are apt for different technology readiness levels (TRLs) will secure retention of the essential skills force and unlock the intended commercialisation potential of quantum computing projects.

We propose a new and expanded ISCF Quantum Technologies programme in order to further catalyse the creation of quantum computing ecosystems here in the UK.

The budget needs to be sufficient to support the wide array of stakeholder and should particularly focus on nurturing UK quantum computing start-ups and the creation of regional and national quantum computing ecosystems capitalizing on existing UK strength of relevant quantum computing companies, subsystem manufacturers (for example existing vacuum company clusters) and users.

Streamline regulatory processes and assist with the creation of a workforce

A major challenge in quantum computing is attracting and retaining the talent essential to building the necessary knowledge-base and expertise within the UK and driving innovation. The Academic Technology Approval Scheme (ATAS) is aimed at safeguarding national security by preventing the misuse of advanced technologies.

However, as quantum computing is considered a 'dual use' technology (civilian and military use), it leaves the field particularly susceptible to unintended consequences of this scheme, such as long delays in recruitment. It often leads to long delays in recruitment of talent with essential experts.

If a candidate is then rejected, the delay makes it very difficult to find a replacement. This makes the UK less attractive to applicants, stifles international and cross-sectoral collaboration and, in turn, puts the UK at a disadvantage. It is important to re-evaluate ATAS to avoid such unintended consequences, streamline the process to reduce the administrative burden on applicants, and accelerate the review process whilst ensuring robustness.

In a parallel vein, the recent expansion of **UK export control regulations** to cover semiconductor, quantum, and cryogenic technologies represents a similar dilemma. These controls were introduced with legitimate security concerns in mind: to prevent sensitive technologies from being misused or exported to adversarial entities. As someone who works daily on the frontlines of quantum hardware development, I fully support the need to protect sovereign technologies.

But we must not **confuse strategic caution with regulatory overreach.** If poorly designed or applied too broadly, export restrictions can deter international partnerships, slow down commercialisation, and prevent UK companies from participating in global supply chains. In quantum computing—where early-mover advantage is everything—the cost of inertia can be measured not just in lost market share, but in scientific irrelevance.

We need a **smarter, more adaptive export control regime**—one that safeguards critical knowledge but also enables legitimate, secure, and commercially viable technology transfer.

This includes:

- **Regular consultation with industry and academia** to assess the practical impact of new rules
- **Tiered risk-based approaches** that distinguish between foundational research, collaborative innovation, and sensitive IP
- **Clear exemptions or fast-track pathways** for trusted academic and commercial actors operating within allied ecosystems

In short, Britain must not become the place where quantum ideas are born, only to be scaled elsewhere. If we are serious about becoming a global leader in quantum computing, our regulatory frameworks must reflect that ambition—not inhibit it.

Qubits and Kick Drums: Composing the Future of Britain's Quantum Creative Economy

Prof. Eduardo Reck Miranda
Composer and Professor of Computer Music, University of Plymouth, UK

Why the next industrial revolution might come with a bassline—and a UK export strategy.

Emerging quantum computing technology is bound to revolutionise how we create, experience, and commercialise music in the future.

Most people do not typically associate the concepts of "quantum computer" and "music" with one another. While music is a form of artistic expression, quantum computing refers to advanced science and technology. Nevertheless, a concert billed as *quantum computer music*—by a collective of musicians at the CTM Music Festival in Berlin a few months ago—was sold out. This is a glimpse of things to come. Indeed, as the wheel of history turns, familiar patterns emerge again.

Progress in computing technology and musical innovation has always gone hand in hand. Avant-garde composers experimenting with computers in the 1960s and 1970s played a crucial role in this evolution. For instance, John Cage, Iannis Xenakis, and John Chowning were relatively unknown to wider audiences, but their work pushed boundaries. They paved the way for technologies that enabled the success of numerous popular artists—from Kraftwerk and Pink Floyd to today's Radiohead and Dua Lipa.

Enter Artificial Intelligence (AI). As computers became increasingly available and user-friendly in the early 21st century, avant-garde musicians such as Brian Eno and Holly Herndon began leveraging AI to make music. Today, AI is already having a profound impact on the music industry.

As policymakers strive to craft ethical guidelines and regulations to harness AI's benefits—while shielding the industry from bad actors—another transformative technology looms on the horizon: quantum computing.

AI is software, and software requires hardware. AI still runs on processor architectures that haven't changed significantly since the 1950s, using switches to represent binary numbers—0s and 1s. Quantum processors, by contrast, compute with **qubits.**

A qubit is to a quantum computer what a bit is to classical processors: the basic unit of information. Qubits leverage quantum mechanical properties we have only recently learned to control for computation. This represents an entirely new class of hardware, with the potential to enable novel kinds of AI yet to be invented.

Computers are now ubiquitous in music. Therefore, it is a no-brainer: quantum computing will significantly impact the music industry.

Potential Applications

- **Copyright Management**
  Quantum-secure blockchain, quantum cryptography, and quantum watermarking could provide more secure, tamper-proof methods for protecting intellectual property rights.
- **Copyright Enforcement**
  Quantum algorithms could assist in detecting cloning, unauthorised usage, and assessing originality in music content.
- **Personalised Experiences**
  Quantum-powered search could dramatically improve the speed and accuracy of finding specific tracks or artists. Enhanced listener preference analysis—even incorporating biometrics—may lead to highly customised music recommendation systems and real-time remixing.
- **Creative Tools**
  Quantum search algorithms could explore vast compositional spaces, enabling entirely new musical styles and performance practices.
- **Production and Delivery**
  Quantum modelling of acoustic environments and musical instruments could improve the design of instruments, recording techniques, and delivery platforms.
- **Audio Engineering**
  Quantum audio representation, compression, noise reduction, and restoration may allow for high-fidelity (Qu-Fi) playback and more efficient storage solutions.
- **Education**
  Quantum algorithms could assist in real-time, highly accurate transcription of musical performances and provide advanced analytical tools for music education.
- **Ultra-Real-Time Telematic Interaction**
  Quantum teleportation of music data could enable live, immersive collaboration among musicians and audiences across real-world and virtual metaverse venues.

Economic Outlook

Although general-purpose quantum computers are still under development, the quantum industry already contributed **£135 million** to the UK GDP in 2023 and is projected to grow to between **£1.7 billion and £3.8 billion** by 2045, depending on commercialisation trajectories

The UK music market, meanwhile, reached **$7.26** billion in 2024 and is projected to grow at a CAGR of **8.54%**, potentially hitting $15.17 billion by 2033.

The time is ripe to make these two markets talk to each other—**and to leverage the economic potential of quantum computing in the music industry.**

Bridging the Divide

The challenge is twofold:

1. **Quantum technologists** often lack understanding of the music industry and underestimate its commercial potential. Music is too often viewed as a hobby ("Einstein played the violin") or as conference entertainment—rather than a frontier for innovation.
2. **The music industry,** in turn, shows little awareness of how quantum computing could transform its practices—from production and rights management to composition and delivery.

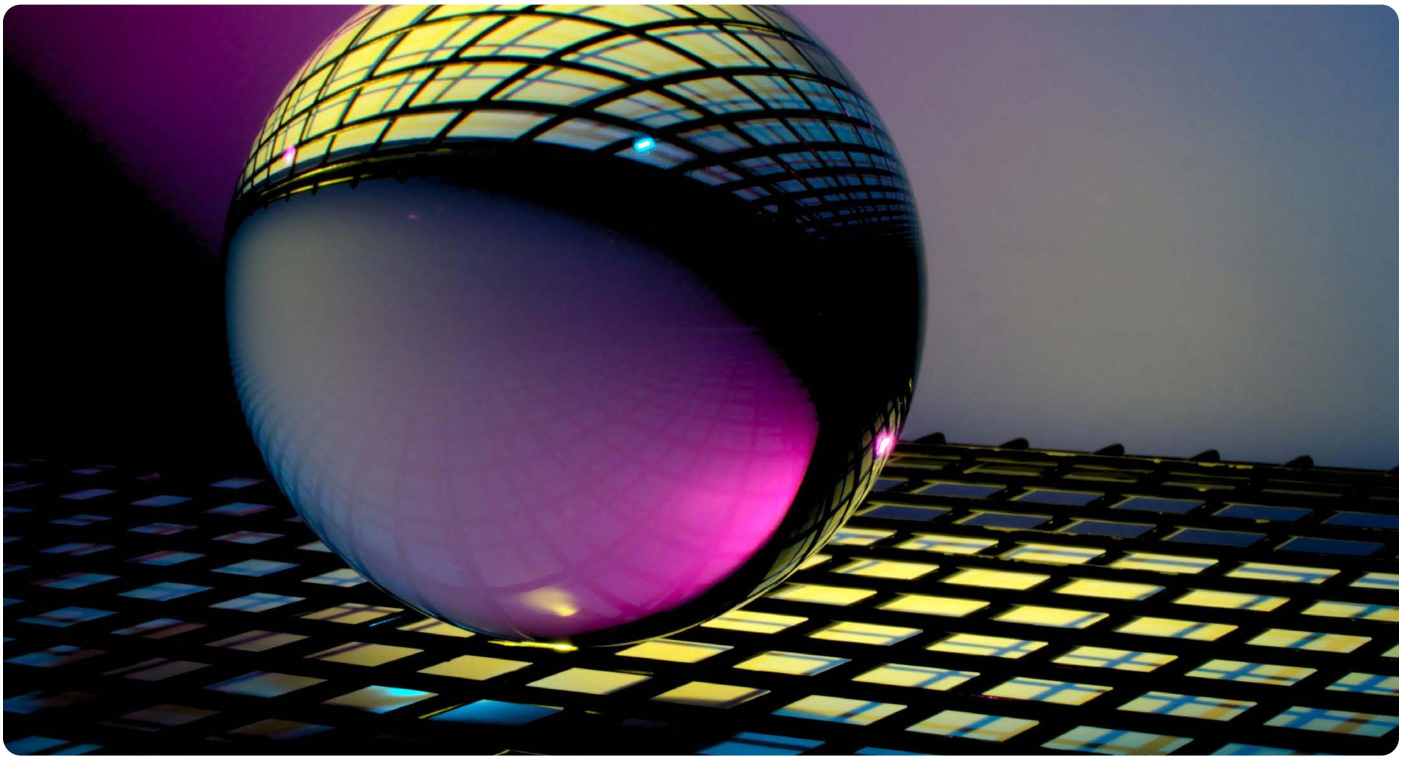
This disconnect is a **missed opportunity** for innovation, growth, and leadership in emerging tech. Moreover, negative media hype around AI and job displacement, coupled with real misuse by malicious actors, has created a climate of **fear and mistrust.** This must be addressed before similar reactions develop around quantum technologies.

Policy Recommendations

To foster a vibrant, cross-sector ecosystem of **quantum-ready creatives, developers, and entrepreneurs,** the UK should:

- Launch ring-fenced creative quantum innovation grants
(e.g., through UKRI or Innovate UK) for projects in quantum music applications like encryption, generative composition, sound design, and streaming optimisation.
- Fund interdisciplinary research hubs
Involving quantum computing scientists, music technologists, and industry stakeholders.
- Facilitate incubator programmes
For startups exploring quantum applications in music, with matched incentives.
- Support public education and outreach
To demystify quantum and AI technologies within the music industry.
- Invest in education and training
Including courses on quantum computing for the creative industries, conferences, hackathons, and joint innovation labs.
- Brand the UK as a global leader in Quantum Creative Tech
And promote the export of British expertise in this emerging space.

With the right investments and imagination, the UK can lead the way in combining two of its most powerful exports: **music and science.** Let's turn up the volume—before someone else does.



From Turing to Tomorrow: A Labour Strategy for Quantum Sovereignty

Don't just fund the research—own the outcomes. Before it's too late.

Simon Muskett
President & CEO,
Mountain Quantum

Quantum computing is one of the most transformative technological revolutions of our time, with profound implications for national security, energy, healthcare, climate modelling, logistics, and artificial intelligence. The underlying science—based on the principles of quantum mechanics—is fundamentally different from classical computing. It enables powerful new ways to simulate nature, solve complex optimisation problems, and analyse massive datasets.

While technically complex and often misunderstood, quantum computing represents a new computational paradigm that could vastly outperform traditional approaches—particularly in the near term when combined with existing technology in hybrid systems.

The UK has already demonstrated a financial and policy commitment to quantum computing, including the establishment of the National Quantum Computing Centre (NQCC) and the Quantum Missions strategy. Coupled with our world-leading scientific institutions, Britain is uniquely positioned to shape the future of this industry—**but only if it acts now to bring these technologies out of the lab and into industry.**

UK Quantum Strengths: A Research Powerhouse

The UK is home to globally recognised academic leadership in quantum science:

- **Oxford University:** Pioneering quantum theory and algorithms
- **Durham University:** Leading development of neutral-atom quantum systems
- **Glasgow University:** Advancing superconducting qubit technologies and quantum metrology
- **Nottingham University:** Focused on sensing, atomic-scale fabrication, and nanoengineering
- **Edinburgh University:** Integrating quantum error correction with high-performance computing
- **NQCC & Quantum Hubs:** Supporting collaboration, engagement, and technology transfer

Despite these centres of excellence, the UK's quantum commercialisation lags behind. Many businesses must look overseas for revenue, as domestic conditions remain underdeveloped.

- Few companies are building scalable full-stack quantum computers: *Oxford Quantum Circuits, TreQ, Universal Quantum, Oxford Ionics, ORCA Computing*
- Supporting vendors like *Riverlane* and *NuQuantum* build hardware/software layers
- Strong ecosystems exist across *Cambridge, London, Oxford, Bristol, East Anglia,* and *Scotland,* yet lack national integration
- Many early-stage quantum startups remain under-supported and under-capitalised

Strategic Risks: Commercialisation and Foreign Dependency

The gap between research and deployment remains wide:

- Fragmented investment and limited industrial collaboration
- Heavy reliance on overseas suppliers for lasers, cryogenics, photonic chips
- Minimal support for non-university-affiliated startups
- Weak sovereign control over key infrastructure and knowledge

Meanwhile, global competitors are accelerating:

- **USA:** *Google, IBM, Microsoft (Azure Quantum), AWS (Braket),* and startups like *Strangeworks*
- **China:** Rapid sovereign infrastructure buildout
- **Canada:** Leading photonic and annealing systems (*Xanadu, D-Wave*)
- **Germany, France:** Strong government grants and industrial partnerships
- **Denmark, Singapore, ASEAN:** Strategic hubs, commercial missions, and defence partnerships

UK Opportunity: A Quantum Leadership Playbook

The UK has critical strengths it must now scale:

- **Neutral Atom Systems:** Naturally scalable architecture with active UK research
- **Ion Trap Systems:** Mature research and commercial development
- **Superconducting Systems:** Notable players using off-the-shelf components
- **Quantum Sensing & Navigation:** Defence, aerospace, and infrastructure applications
- **Photonics & Networks:** Modular systems and quantum-secure communication
- **Error Correction & Hybrid Algorithms:** Critical for early real-world advantage

The story of *PsiQuantum*—a UK spinout now headquartered in Palo Alto and funded by US capital—serves as a warning: Britain builds the science but loses the upside.

Quantum Isn't Magic: Focus on Education & Engineering

Quantum's complexity excludes the public and even many professionals. We must:

- Introduce quantum concepts in early education using nature-based metaphors
- Fund school–university education partnerships
- Offer short courses and apprenticeships for industry professionals
- Train systems integrators, control engineers, and software developers—not just physicists

Historical Lessons: Don't Repeat ARM and Turing

From *Colossus* to *ARM,* the UK has pioneered world-changing technologies—only to see them sold abroad. We must now:

- Maintain sovereign control of quantum IP and systems
- Build application hubs connecting research to real-world needs
- Adapt grant funding and procurement to support commercial scale
- Keep spinouts rooted and growing in the UK

Policy Recommendations: A Six-Pillar Strategy

1. **Build Sovereign Supply Chains**
    a. Fund UK-based production of lasers, cryogenics, vacuum systems, and photonic chips
    b. Develop foundries, tooling, and testbeds for domestic use
2. **Create a Quantum Growth Fund**
    a. Establish a public-private fund to scale UK startups
    b. Offer milestone-based grants, equity matching, and procurement incentives
3. **Deploy UK-Built Quantum Systems**
    a. Prioritise public-sector procurement of domestic systems
    b. Expand the NQCC to host live industry testbeds and user demonstrations
4. **Accelerate Industry Adoption**
    a. Require commercialisation roadmaps in funded R&D
    b. Appoint a National Quantum Commercialisation Champion
    c. Launch "Quantum Challenge Vouchers" to subsidise SME adoption
5. **Safeguard IP and Talent**
    a. Create a UK-first IP framework and extend the Patent Box to quantum
    b. Develop streamlined visa and relocation schemes for global quantum talent
6. **Maximise Global Economic Impact**
    a. The global quantum market will exceed $1 trillion by 2030
    b. The UK risks dependency, missed growth, and talent loss without urgent action

Conclusion: Make Britain Quantum-Ready

Quantum computing is not a far-off fantasy. It's already here. The UK has the talent and infrastructure—but not yet the commercial momentum. With strategic investment, strong policy, and public leadership, Britain can become a quantum superpower.

We urge the Labour Party to:

- Establish a national commercialisation strategy
- Incentivise domestic capability and talent retention
- Champion early industry adoption
- Make quantum accessible and real for every region

The time to lead is now.

A Signal Boost for Quantum Britain

Keeping the UK connected, competitive, and quantum-secure.

Dr. Ryan Parker
Quantum Research Lead,
Vodafone R&D

The UK is a global leader in the development of quantum computing hardware and software. To maintain and strengthen this position, the industry requires clear national policy, resilient supply chains, robust regulation, and sustained investment.

As a major telecoms operator, Vodafone recognises quantum computing's transformative potential—particularly in network optimisation, cybersecurity, spectrum management, and beyond.

This contribution outlines Vodafone's key policy recommendations to enable scalable, secure, and inclusive adoption of quantum technologies across the UK.

Ensure Supply Chain Resilience and Diversity

Quantum computing hardware spans multiple paradigms—superconducting qubits, trapped ions, photonics, and more. Each of these depends on distinct and often fragile global supply chains. Focusing investment too narrowly risks unintentionally undermining alternative architectures.

Recommendation:

Develop policies that support a diverse quantum ecosystem and reinforce the resilience of all hardware supply chains.

Secure the Supply Chain Against Adversarial Access

Quantum systems are composed of complex, multi-component architectures. If components are compromised, they can become vectors for data leakage—posing a critical national security threat.

Recommendation:

Establish stringent security standards and certification pathways to prevent trapdoors and unauthorised backdoors in quantum hardware.

Develop Regulatory Frameworks for Safe Deployment

Quantum computing brings with it novel regulatory challenges. Guidelines must address everything from secure manufacturing to responsible algorithm deployment.

Recommendation:

Introduce comprehensive regulatory frameworks tailored to the unique risks and characteristics of quantum hardware and its integration into sensitive infrastructure.

Standardise and Secure Cloud Access for End Users

Quantum computing will largely be accessed remotely via cloud platforms, rather than housed on-site.

Recommendation:

Promote international standards for secure, interoperable cloud-based access to quantum computers, ensuring trusted and scalable deployment.

Prevent the Misuse of Quantum Algorithms

Algorithms such as Shor's Algorithm present real threats to deployed cryptographic systems. Preventing malicious use without stifling legitimate research requires careful policy calibration.

Recommendation:

Invest in responsible innovation initiatives, and explore mechanisms to detect and mitigate misuse (e.g. restricted algorithm access policies or sandboxed environments).

Strengthen International Collaboration

Quantum technology development is increasingly international. Without robust collaboration, the UK risks losing access to critical infrastructure, knowledge-sharing, and testbeds.

Recommendation:

Encourage and fund international quantum collaborations, including joint testbeds, academic partnerships, and research integration for a future Quantum Internet.

Increase Support for Sovereign Quantum Projects

The UK has made commendable investments via UKRI and similar bodies, but increased funding is needed for both R&D and end-user application development.

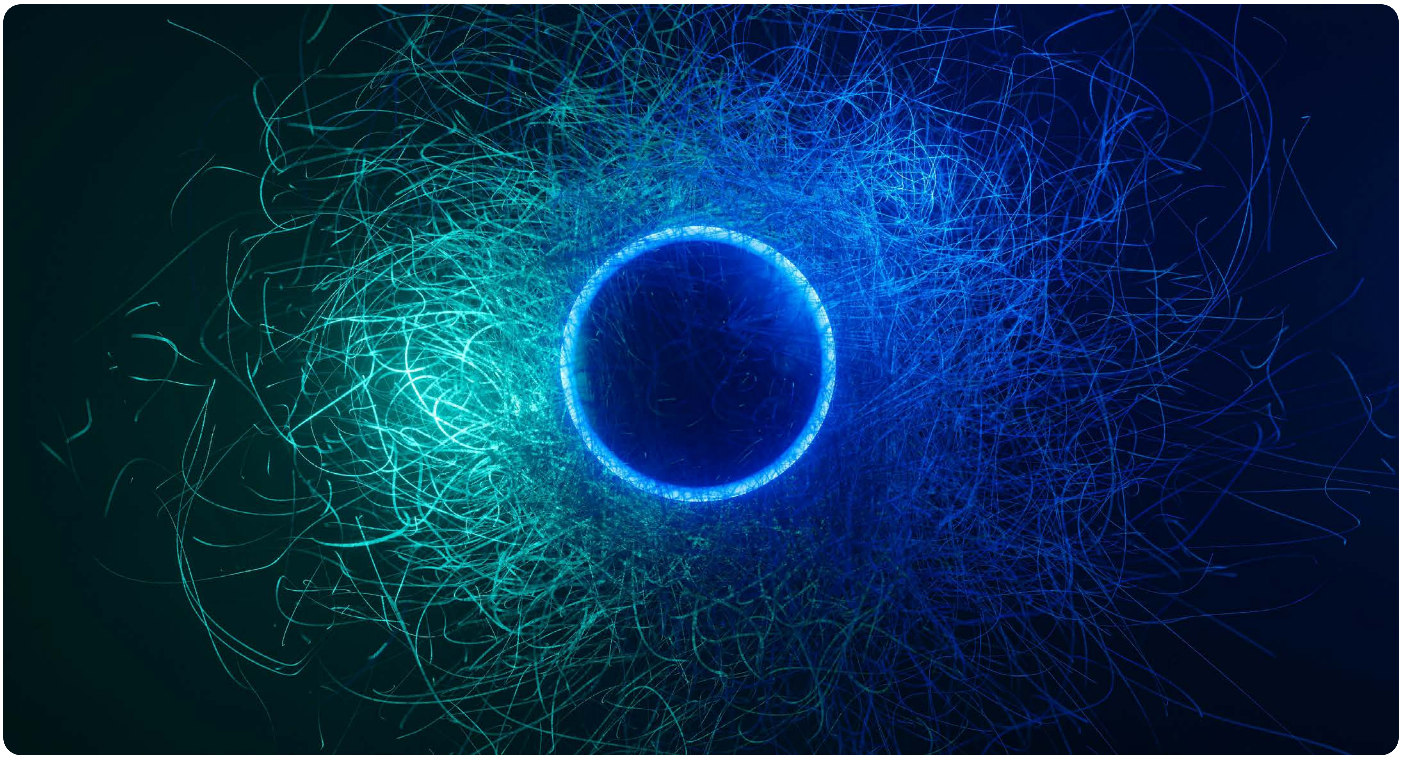
Recommendation:

Expand funding for UK-based, sovereign collaborative projects, ensuring both hardware vendors and industry end-users benefit from long-term, fault-tolerant quantum computing efforts.

Conclusion

The UK has the expertise, research strength, and industry appetite to lead globally in quantum computing. But this leadership is not guaranteed. Only with comprehensive, forward-looking policy can the UK bridge the gap between scientific potential and economic impact.

Vodafone urges policymakers to support a resilient, ethical, and internationally integrated quantum ecosystem that unlocks innovation while protecting national security and global competitiveness.



The Digital Bomb Beneath Whitehall

Quantum is coming for our codes—Britain must detonate its complacency first.

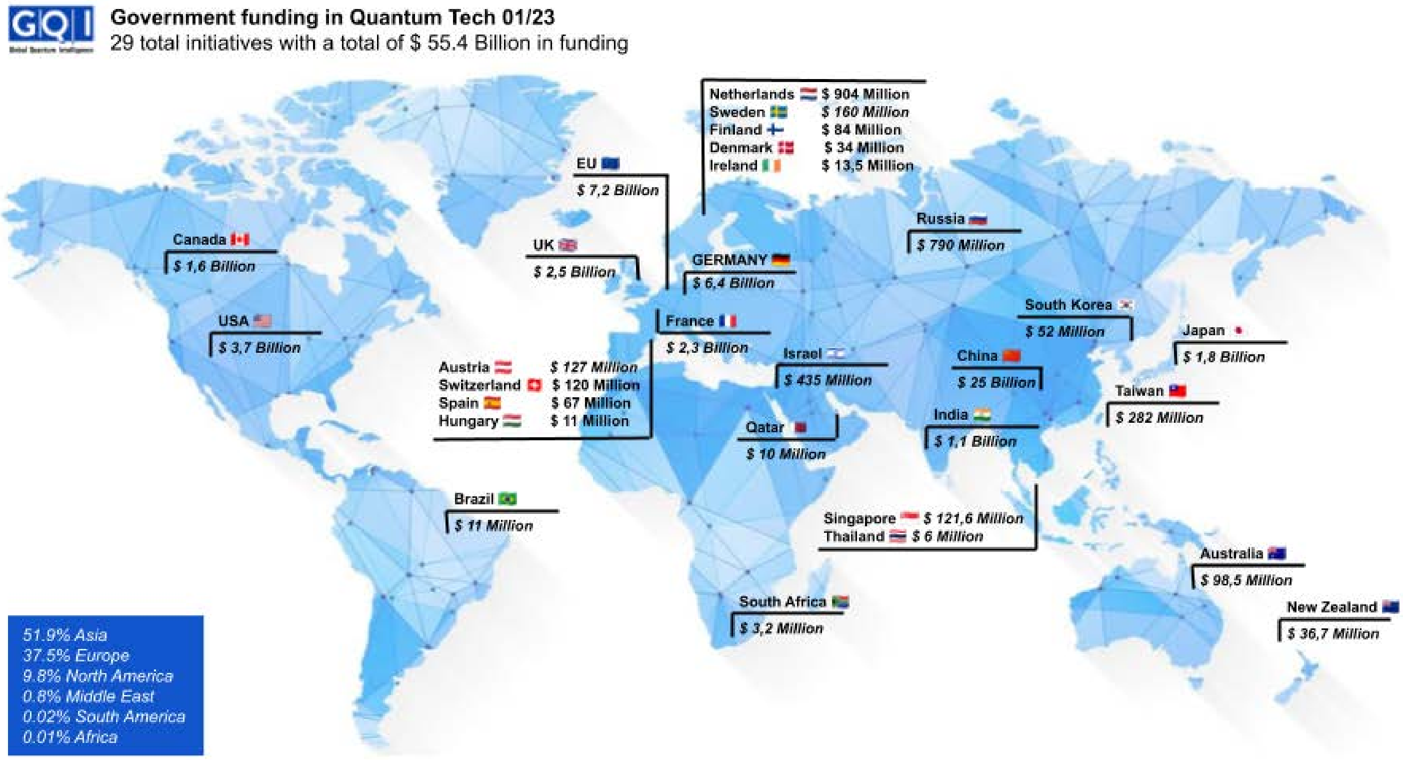
Dr. Joe Spencer
Global Quantum Intelligence LLC

In 2018, U.S. Congressman Mike McCaul described quantum technology as "the digital nuclear bomb." His warning wasn't hyperbole. Quantum computing has the potential to be as disruptive as the nuclear age—except this time, the battlefield is not just physical, but digital, and the stakes involve national security at an unprecedented level.

The UK now stands at a crossroads. Nations such as the United States and China are investing billions in quantum research, recognising its potential to break encryption, revolutionise intelligence analysis, and transform military logistics.

Meanwhile, Britain's early investment through the **National Quantum Technologies Programme (NQTP)**—launched in 2014—placed it in a globally competitive position. But to maintain that lead, **strategic reinvestment and deployment are now essential.**

And while the UK continues to position itself as a global leader, **are we at risk of falling behind to either massive venture capital from overseas or heavily state-funded efforts abroad?**



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Britain's Strategic Advantage — And the Growing Need for Investment

The UK is not starting from scratch. The NQTP has helped establish Britain as a frontrunner in quantum research. Government–industry–academic collaborations have led to world-class expertise in areas such as **trapped-ion quantum computing,** known for its precision and scalability.

However, the global landscape is shifting rapidly. The US, China, and the EU are dramatically scaling their efforts. If the UK is to stay in the race, it must expand its ambition and resources.

The Government's recent pledge of **£2.5 billion over the next decade** is a welcome step. Yet more is needed. We propose:

- **Sustained Investment:** Support not just for basic research, but for defence-specific applications that translate breakthroughs into operational capabilities.
- **Defence–Industry Collaboration:** MoD, quantum startups, and universities must co-develop practical use cases through faster tech transfer and procurement channels.
- **Quantum Workforce Development:** Education and training initiatives must scale to build the next generation of quantum scientists and engineers.
- **A Clear National Strategy:** A dedicated quantum defence roadmap should align ethical guidelines, security priorities, and mission objectives.

What is Quantum Technology? (And Why it Matters)

Let's skip the standard explanation that "a qubit is a superposition of a 0 and 1." These analogies don't actually help most people understand why quantum computing is revolutionary.

Instead, let's put it simply:

The universe itself behaves according to quantum mechanics.

So when we try to simulate systems that are quantum in nature—like how a protein folds or how a drug molecule interacts—we're using **classical computers** to model **quantum systems.** That's like trying to capture the richness of a colour photograph with a black-and-white camera.

Wouldn't it make more sense to use quantum tools to study quantum phenomena?

That's exactly what quantum computers promise. They don't just simulate—they process quantum information natively, unlocking answers to questions we previously couldn't even ask, either due to computational limitations or sheer complexity.

"Deep Thought took millennia to answer one question in The Hitchhiker's Guide to the Galaxy—quantum computers could do it in moments."

Not Just Computers — Quantum Sensors Are a Game-Changer

It's not just computing power that gives us an edge. Quantum sensing will transform how we see, diagnose, and secure the world around us.

- **Medical Diagnostics:** Imagine an MRI-like scanner—without the radiation or the machine—that detects diseases by sensing minute magnetic changes at the cellular level. The UK is already prototyping this.
- **Underground Mapping & Threat Detection:** Quantum gravimeters can detect tiny changes in underground density—ideal for finding sinkholes, locating buried explosives (IEDs), or mapping infrastructure.

Why It Matters for Defence: Quantum is Coming — Whether We Like It or Not

Right now, state actors and cybercriminals may be **stockpiling encrypted data,** waiting. Military secrets and classified data don't expire. The moment a sufficiently powerful quantum computer becomes viable, **today's strongest encryption will be obsolete.**

Sound alarming? It is.

But quantum isn't just a threat. It's also a shield—**quantum-secure cryptography** can protect future communications and safeguard critical systems. But we need to act **now.**

Without **urgent investment in quantum-safe systems,** the UK risks losing decades of sensitive data to adversaries. This is **not science fiction**—this is a ticking clock. With many experts predicting commercially relevant quantum systems within a decade, preparation is no longer optional.

Conclusion: A New Digital Arms Race

Quantum computing is not just another technological advance. It's a once-in-a-generation leap—**akin to the discovery of nuclear fission or the invention of the transistor.** It will disrupt encryption, reshape warfare, and redefine intelligence.

The UK has the expertise. It has the infrastructure. And it has the head start. But without **rapid and sustained action,** we risk squandering it all. Quantum is coming.

The only question is:

Will Britain lead—or be left behind?

From Lab Coats to Leases: Britain's Quantum Infrastructure Bottleneck

We've invested in world-class quantum minds. Now we must build the facilities to keep them here.

Dr. Aditya Jain
Postdoctoral Research Associate,
University of Cambridge

Quantum computing represents a radical departure from traditional computational paradigms. Rooted in the counterintuitive principles of quantum physics, this emerging technology challenges long-standing notions of how information can be processed. Unlike classical computers that encode data in binary bits—strictly 0s or 1s—quantum computers leverage **qubits,** which can exist in a superposition of both states simultaneously.

This foundational shift sets quantum computing apart not only from conventional computing but also from other advanced digital technologies such as artificial intelligence (AI), machine learning (ML), cloud computing, and biologically inspired computing systems. While these technologies build upon and extend the capabilities of classical computers, quantum computing introduces a fundamentally new architecture—one that manipulates the behaviour of particles at the smallest scales to perform calculations.

The promise of quantum computing lies in its ability to accelerate solutions to certain complex problems that are currently intractable using classical methods. These include simulating quantum materials for drug discovery, optimizing vast logistical networks, and enhancing cryptographic systems. However, it is important to note that this speedup is not universal. Quantum computing excels only in specific domains where quantum phenomena such as **entanglement** and **interference** can be effectively harnessed.

Despite being in the early stages of development, quantum computing is poised to reshape entire industries. From pharmaceuticals and finance to energy and defence, its potential to redefine what is computationally possible continues to attract significant research investment and industrial interest.

In the following sections, we explore how quantum computing is expected to impact real-world challenges and transform sector-specific problem-solving. We also outline the key technical challenges in building scalable quantum systems, emphasize the urgency for strategic investment, and offer policy recommendations.

Industrial Impact of Quantum Computing

Quantum computing is beginning to demonstrate real promise in industries where classical computing struggles with complexity, scale, or precision. The most compelling early applications appear in quantum chemistry, cryptography, logistics, and finance—fields where quantum algorithms can significantly outperform classical approaches for specific tasks.

In quantum chemistry, quantum computers could revolutionize the simulation of molecular systems, enabling breakthroughs in **drug discovery, materials design,** and **energy efficiency.** By modelling electron and atomic behaviour at the quantum level, researchers may uncover new compounds or optimize chemical reactions currently beyond the reach of supercomputers.

In cryptography, quantum computing presents both a risk and an opportunity. Algorithms such as **Shor's** could break widely used encryption schemes, prompting urgent efforts to develop **quantum-resistant cryptographic methods.** Conversely, **quantum key distribution (QKD)** offers a promising path toward unbreakable communication systems.

In logistics, quantum computers could optimize **supply chain routing, delivery scheduling,** and **resource allocation.** In finance, quantum algorithms are being tested to improve **portfolio optimization, risk analysis,** and **fraud detection**—tasks that involve high-dimensional data and complex modelling.

Although fault-tolerant quantum computing is still under development, progress in early-stage applications signals a significant paradigm shift. As quantum hardware and algorithms evolve, their implications will be profound and far-reaching.

Key Challenges in Building Quantum Computers

Despite its transformative potential, quantum computing is in a nascent stage. Several formidable challenges must be addressed to realize its full potential:

- **Hardware Limitations:** Current quantum devices are small and contain noisy, error-prone qubits. Maintaining **quantum coherence**—the delicate state in which qubits can perform computation—is a significant technical challenge.
- **Error Correction Requirements:** Quantum systems require complex **error correction** methods to function reliably. These come with high resource overheads, making scalability a major hurdle.
- **Infrastructure Demands:** Quantum computers require highly specialized infrastructure, such as **ultra-low temperatures, vacuum systems, and electromagnetic shielding**—all expensive and technically demanding.

The Time to Act is Now

Quantum computing is transitioning rapidly from theoretical exploration to practical application. While large-scale fault-tolerant systems are not yet commercially available, we are at a critical inflection point. Here's why immediate action is necessary:

- **Security & Infrastructure Preparedness:** Quantum computers threaten to break current cryptographic standards. Governments must invest in **post-quantum cryptography** and secure digital infrastructure now—before adversaries acquire decryption capabilities.
- **First-Mover Advantage:** Early investment in quantum enables strategic leadership in setting standards, developing intellectual property, and attracting top talent.
- **Accelerating Momentum:** Industry leaders such as IBM, Google, and global startups are progressing rapidly. Achieving **quantum advantage** in narrow applications is within reach, and early adopters can realize real-world benefits.
- **Ecosystem Shaping:** Investment today can shape the architecture of the global quantum ecosystem—ensuring openness, interoperability, and fair access—rather than leaving it in the hands of a few dominant players.

Policy Recommendations

To remain competitive and capitalize on the quantum revolution, policymakers should:

- **Increase Strategic Funding and Long-Term Investment**
  Expand public R&D funding for fault-tolerant hardware, scalable algorithms, and quantum networking. De-risk early innovation and incentivize private sector involvement.
- **Build National and International Quantum Infrastructure**
  Establish testbeds, labs, and shared facilities. Promote cross-disciplinary research by creating quantum centres that unite Physics, Mathematics, and Computer Science departments (e.g., modeled on IQC at University of Waterloo or QuICS at University of Maryland).
- **Develop a Skilled Quantum Workforce**
  Integrate quantum concepts into university and secondary STEM curricula. Fund scholarships, fellowships, and retraining programs. Offer internationally competitive compensation to attract and retain top talent.

Conclusion

Quantum computing is approaching a critical tipping point. Nations investing today are not merely preparing for the future—they are actively shaping it. To secure its place as a global leader in quantum science and technology, the UK must act now by investing strategically, building robust infrastructure, and nurturing a quantum-ready workforce.

Britannia Does Not Code the Waves

Christopher Worrall

A call to rewire Britain's defence strategy with quantum military superiority.

Quantum computing is no longer the distant dream of theoretical physicists—it is fast becoming the defining technological frontier of 21st-century statecraft. For middle powers like South Korea and the UK, mastering quantum technology is not merely a question of economic competitiveness, but of national survival and sovereign security.

South Korea, positioned precariously between nuclear-armed adversaries and under constant threat from a volatile North, has internalised a strategic imperative: invest now, or be technologically outpaced and geopolitically exposed. It is a nation that grasps the stakes of digital supremacy. In response, Seoul has executed an all-of-state approach to quantum development, treating it not as a scientific curiosity but as a core pillar of national defence.

Britain, by contrast, has pursued a broader and more diffuse route—commendable in ambition, but lacking military specificity. As geopolitical tensions intensify—from the Indo-Pacific to Eastern Europe—quantum computing is poised to reshape not only economic paradigms but military doctrine. This paper outlines why the UK must learn from South Korea's model and embed defence-focused quantum innovation at the heart of its national strategy.

Cryptographic Caution Vs. Defence-First Boldness

The UK has made progress in post-quantum cryptography (PQC) and Quantum Key Distribution (QKD)—both essential for safeguarding future communications. These efforts protect intelligence, financial systems, and military channels against emerging quantum threats.

However, South Korea aims not just to defend but to dominate. With an explicit state-backed target of 50 qubits by 2026 and 1,000 by 2032, Seoul is developing battlefield simulations, missile defence optimisation, and quantum-enhanced electronic warfare capabilities—far beyond cryptographic safety.

The UK's £1bn National Quantum Technologies Programme (2014–2024) yielded civilian-focused results. In contrast, South Korea's £1.7bn (₩3 trillion) strategic fund is unapologetically militarised. At least £11.6m annually is dedicated to startups working on quantum radar evasion, secure drone networks, and SIGINT applications—coordinated directly with the Ministry of Defence.

Quantum Demonstrations and Dual-Use Dominance

South Korea is not just theorising quantum advantage—it is proving it. One such example is the Quantum Supremacy Demonstration Project for Aerospace, launched by Norma and Gyeongsang National University.

The initiative applies quantum simulations to aerospace engineering challenges—modelling hypersonic vehicles, reusable launch systems, and next-generation fighter jets. These simulations solve equations like the Navier-Stokes and Burgers models, which are prohibitively complex for classical computing.

Such projects not only refine hardware but create software libraries with direct military utility. These are the dual-use advantages of quantum: quantum fluid dynamics for flight, quantum machine learning for threat detection, and quantum chemistry for advanced materials in armour and propulsion.

The UK's National Quantum Computing Centre (NQCC) is promising but lacks a defence-specific roadmap or testbed portfolio with strategic alignment comparable to Korea's.

Quantum Advantage or Technological Subjugation in the Theatre of Drones

The age of drones has transformed modern warfare—but also exposed our vulnerabilities. From Ukraine to Syria, unmanned aerial systems (UAS) have shifted from surveillance tools to battlefield hunters. In the most sinister cases, we've witnessed near-dystopian use cases, where drones are deployed in ways disturbingly akin to "human safaris": automated systems seeking and engaging targets with ruthless efficiency, often with minimal human oversight.

The UK must not only guard against this new era of algorithmic atrocity—it must lead the charge in building ethical, sovereign quantum infrastructure capable of controlling, countering, and outclassing it.

Quantum computing offers precisely this potential. Its application to drone technology—whether through quantum-enhanced navigation, swarm optimisation, electromagnetic signal countermeasures, or adversarial detection through quantum machine learning—will define whether Britain retains strategic edge or cedes it to actors with looser rules of engagement and darker ambitions.

South Korea has recognised this. Its investments in quantum-enhanced electromagnetic counter-drone systems, funded through its defence budget and tied directly to geopolitical instability in the region, are a warning shot to Western complacency.

The UK, for all its technical brilliance, risks losing the race not from lack of talent—but from lack of strategic clarity. Quantum computing cannot remain an academic curiosity or a City-backed commercial asset. It must be seen—and funded—as a critical sovereign capability, essential to our national security, our moral leadership, and our technological sovereignty in a world where drones no longer patrol battlefields—they define them.

If we do not control the future of quantum and autonomous systems, we may soon find ourselves not fighting to win, but fighting to keep our citizens off the menu from Russian human safaris.

Israel's Startup Model Meet's Korea's Mission Clarity

Israel's $219m injection into over 100 defence startups—primarily focused on drone applications—offers a complementary model. Through vehicles like the Technological Incubators Programme and Yozma 2.0, Israel has created agile pathways from lab to battlefield.

But South Korea goes further. It embeds national sovereignty directly into its quantum roadmap. Sovereign hardware targets, a focus on military applications, and export orientation mean South Korea is not merely incubating innovation—it is building quantum infrastructure into its strategic deterrence posture.

If the UK wishes to apply quantum to drone systems—swarm control, battlefield comms, targeting, and stealth—it must fuse Israel's entrepreneurial ecosystem with South Korea's strategic doctrine.

The UK, by contrast, risks scattering its quantum ambitions across civil, commercial, and academic silos—without a clear, coordinated strategy to translate this innovation into sovereign defence capability.

In a world where unmanned systems may be deployed in contested theatres like Ukraine or the Taiwan Strait, quantum-enhanced drones could mean the difference between strategic advantage and national exposure. Britain must act—before it falls behind not just in qubits, but in control of the skies.

Policy Recommendations for the UK Government

Establish a Dedicated Quantum Defence Office (QDO)

Create a joint taskforce within the Ministry of Defence and Department for Science, Innovation and Technology, including space agencies, dedicated to applying quantum computing to national security objectives. This body should act as a national accelerator for dual-use and military-aligned projects. In turn, emulating the Korea Quantum Computing (KQC) initiative and its Ministry of Defence to simulate missile defence scenarios using quantum-based algorithms.

Militarise Quantum for Drone Sovereignty

The UK currently lacks targeted drone sovereignty integration into quantum computing. It should establish a Defence Quantum Innovation Fund of at least £150 million over five years, specifically targeting quantum-enhanced drone technologies.

Drawing from Israel's agile startup incubation and South Korea's defence-first quantum roadmap, this fund should focus on real-time battlefield applications—such as quantum-optimised swarm coordination, encrypted drone communication, and threat-detection algorithms.

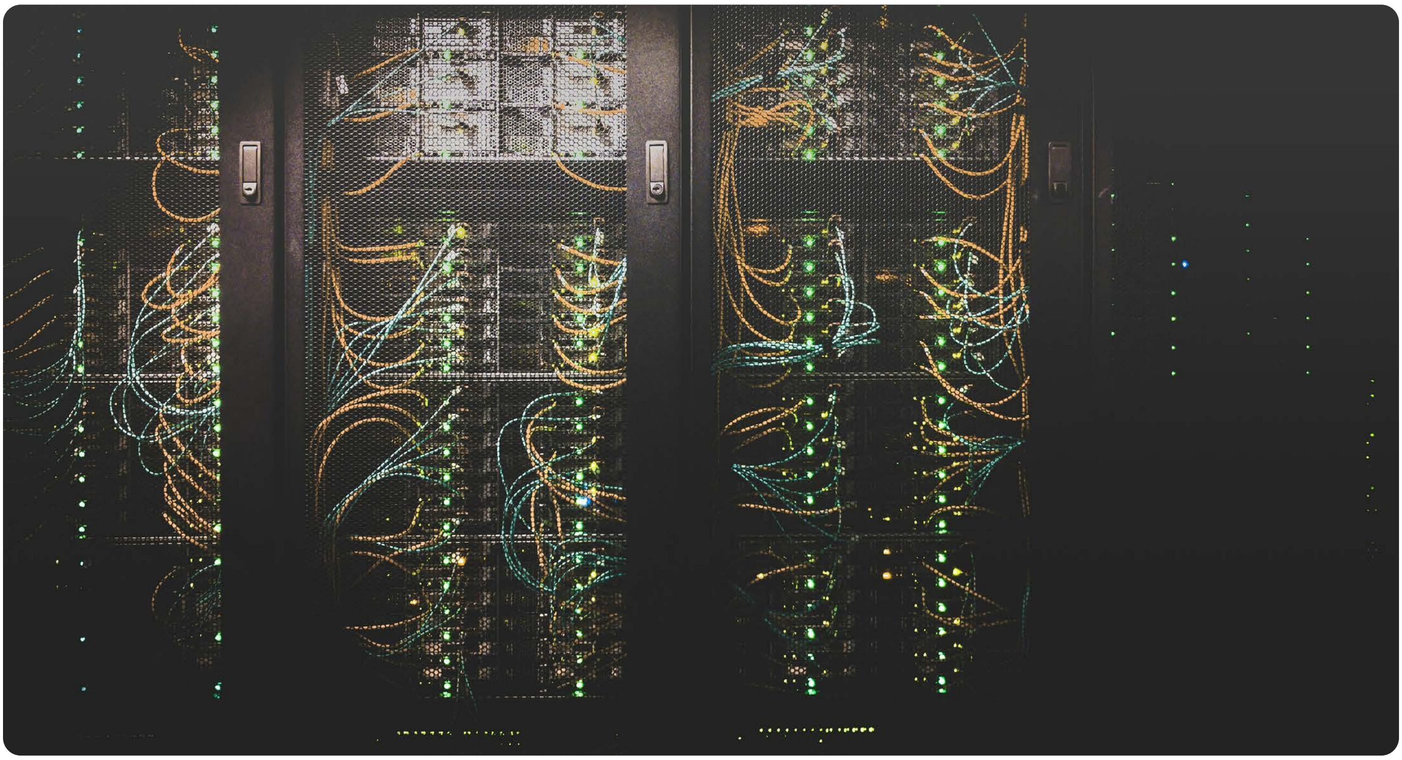
The NQCC must be mandated to align one of its testbeds with defence-specific use cases, integrating SMEs, MoD partners, and aerospace primes to ensure sovereign technological control of future airspace.

Simulate and Demonstrate: Quantum Testbeds for Combat Scenarios

Launch specific demonstration projects tied to battlefield relevance. Potential applications include quantum-assisted command-and-control systems, adaptive threat modelling, and quantum-optimised drone swarm control. Norma and Gyeosang National University launched its Quantum Supremacy Demonstration Project for Aerospace in computational fluid dynamics, simulations for aerospace applications relevant to hypersonic vehicles, reusable launch vehicles, and unmanned aerial vehicles. UK needs to specify projects for combat scenarios as a matter of priority.

Set a National Quantum Hardware Target

The UK should establish a sovereign quantum hardware target of 1,000 error-corrected qubits by 2035, with an interim milestone of 500 qubits by 2032, focused on defence applications such as battlefield simulation, hypersonic modelling, and quantum drone navigation. This aligns UK ambition with South Korea's targets and ensures readiness for the next generation of military capabilities. The target would catalyse domestic



manufacturing, supply chain diversification, and attract global investment in UK hardware ventures.

Establish a Sovereign Defence Quantum Data Centre (SDQDC)

The UK should establish a Sovereign Defence Quantum Data Centre (SDQDC) to host and scale British-built quantum hardware for military and intelligence use.

While the National Quantum Computing Centre (NQCC) drives research, it lacks a deployable, defence-ready quantum system. As nations like South Korea target 1,000 qubits by 2035 for missile defence and electronic warfare, the UK must not fall behind.

This centre would:

- Securely host operational quantum machines for defence simulation, cryptography, and drone coordination.
- Accelerate scaling of domestic qubit platforms from companies with potential to support defence applications, including quantum-enhanced drone systems, like Oxford Quantum Circuits and Quantum Motion.
- Ensure sovereign control of strategic quantum capabilities.

Investment required: £250 million to £300 million over 5 years, jointly led by MoD and DSIT.

Conclusion: Quantum or Prey

In a world where AI-guided drones can be dispatched with chilling autonomy, where human life can be calculated into target coordinates, and where the very physics of information can determine strategic outcomes, the stakes of quantum superiority are existential. If Britain wishes to uphold its democratic ideals and preserve the sanctity of international law, it must embed quantum computing at the heart of its defence innovation.

South Korea saw the warning signs—regional threats, technological disruption, and a volatile world order—and responded with bold statecraft. Britain, too, must make that leap. Quantum isn't just a technology. It is sovereignty. It is safety. And in the age of algorithmic war, it may be the last guarantee of peace.

Penny Wise, Quantum Foolish?

How underfunding PhDs and testbeds could cost Britain its digital sovereignty.

Dr. Jonte R Hance
School of Computing,
Newcastle University

Across the globe, a race is underway to develop transformative quantum technologies. All such innovations stem from fundamental quantum research. Quantum Key Distribution (QKD), for instance, arose from principles like the uncertainty principle and the no-cloning theorem. Quantum computing, as credited by David Deutsch, was built upon quantum parallelism and interference, while quantum sensing emerged from our understanding of quantum measurement, entanglement, and squeezing..

This illustrates how critically important quantum foundational research is, and why foundational work is necessary if we want to develop truly new quantum technologies, as opposed to making short-term minor enhancements to current technologies.

The Algorithmic Bottleneck: Thirty Years of Waiting

It is becoming increasingly apparent that we are facing difficulties developing new algorithms and approaches which provide quantum advantage. For instance, aside from classically inspired and energy-minimisation algorithms, we only have two real useful quantum algorithms, Shor's and Grover's, both of which were found nearly thirty years ago.

A reason for this thirty-year lack of progress in quantum algorithm development is that we do not yet understand well enough the fundamental aspects of quantum mechanics, such as contextuality, which underpin behaviours useful algorithms could leverage. Therefore, understanding peculiar quantum properties like contextuality seems essential for us to harness quantum computing's full potential.

Quantum Competition: China's Strategic Acceleration

At the same time, progress in developing quantum technologies in key competitor countries like China has begun to outstrip that in the UK. Despite the UK building a good initial lead with the National Quantum Technologies Programme, as championed by Sir Peter Knight, investing over £1 billion so far, this pales in comparison to the roughly $15 billion that China has already invested. And this investment is paying dividends.

After its successful 2016 satellite QKD experiments, China has already announced plans to set up a satellite QKD network later this year, allowing theoretically un-hackable communication. They also recently demonstrated a 105-qubit quantum computer, Zuchongzhi 3.0, giving similar performance to Google's Willow processor, and have announced testing of a 500-qubit device, which would be far in advance of anything in the West.

Given such a rate of development, it is only a matter of years before China can create a quantum computer which could use Shor's Algorithm to break key security protocol RSA-2048, the world's most commonly used public-key cryptography scheme, while communicating using a QKD network to protect themselves from all currently known quantum computer-based attacks.

Investment in both fundamentals, to develop the next generation of quantum technologies, and in applications, to implement and use the current generation of quantum technologies, must obviously therefore increase. But how would such investment best be spent?

Quantum Must Leave the Lab: Invest in Scaleable Infrastructure

For applied work, the answer is simple – infrastructure. Establishing QKD networks, developing quantum computing testbeds, such as at the NQCC, and undertaking real-world tests of quantum sensing and metrology. As seen in recent demonstrations of quantum gravimetry for identifying and tracking tunnels underground– without having to dig anything up. This seems the best way to implement the good work we've already developed, and demonstrate just how useful quantum technologies can be in the world outside the lab.

The PhD Pipeline Problem: A Narrow Route to Innovation

On the theory side, things are more complex. To develop new and interesting quantum technologies, a key resource is freshly minted quantum PhDs. However, recent decisions at UKRI have meant most quantum PhD funding is now passing through Centres for Doctoral Training, freezing out academics unaffiliated with these centres from proposing projects or supervising students.

Given most research groups catalyse around one specific sub-topic, this means the vast majority of quantum PhDs in the UK will, for the next 5-10 years at least, only have experience in one of five small specialisms.

To do truly innovative discovery science, we obviously need students exposed to a far wider range of topics, and this is before we even begin to consider how best to integrate quantum technologies into interdisciplinary science.

Ensuring that the relatively small number of quantum academics in the UK have reliable access to PhD funding is essential if we are to maximise their ability to conduct innovative discovery research and train the next generation of quantum theorists and engineers. This is particularly important given the UK's ambition to scale up quantum research over the coming decade—and to avoid the current trend of PhD students being concentrated within just one or two narrowly focused research groups.

Conclusion: Invest to Lead, or RIsk Falling Behind

The UK is in a strong position in the global quantum landscape due to early investment and a vibrant research culture. However, without further and more focused investment—both in PhD training and quantum infrastructure—we risk ceding our lead to more strategically aggressive competitors.

To remain at the cutting edge:

- PhD funding must be diversified, enabling a broader range of researchers to train students and conduct discovery science.
- Quantum infrastructure must be expanded, especially in secure communications, testbed computing, and sensing trials, specifically into QKD networks, quantum computing testbeds, and practical quantum sensing trials.
- Strategic alignment is essential, framing quantum not merely as a science policy issue, but a cornerstone of national security and economic resilience.

All of the above will be critical to leverage the amazing work we have already pioneered in the area, and ultimately to ensure the future of communications security in the UK.

FOLLOWER OR FRONTRUNNER?

Managed decline or Quantum growth? The choice is ours.

LABOUR TECH

THE YIMBY INITIATIVE

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