

# Appendix D – UK’S quantum policy and regulation<sup>1, 2</sup>

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<sup>2</sup> Appended to Lloyd-Jones, Susanne and Kayleen Manwaring, ‘[Quantum Resilience in the Australian National Security Legislative Framework](#)’ (Policy Brief, Cyber Security Cooperative Research Centre, UNSW Faculty of Law & Justice, September 2024)

## 1. Legislation/Framework Summary

- **National Security Investment Act 2021:** Requires sensitive business acquisitions to be approved by the government before they are completed. This includes for quantum technologies.
- **Export Control Order 2008:** regulation of dual use goods – applies to some quantum technologies

Possible frameworks

- **Online Safety Act 2023:** gives the law enforcement investigatory powers over 'regulated services' e.g. internet services, social media sites etc., has the potential to impact encryption<sup>3</sup>
- **Investigatory Powers Act 2016:** allows UK government to compel communications providers to remove electronic protection applied to any communications or data
- **Regulation of Investigatory Powers Act 2000:** gives the UK power to authorities to compel the disclosure of encryption keys or decryption of encrypted data

## 2. What has the UK done to date on Quantum strategy, policy and legislation?

Strategies

- National Quantum Technologies Programme 2014 (NQTP)
- National Quantum Strategy 2023 (NQS)<sup>4</sup>

Notable Programs

- Innovate UK – Commercialising quantum technologies challenge<sup>5</sup>
  - **Budget:** Total of £174 million, supported by £390 million from industry
  - **Duration:** 2018 to 2025

Legislation

- National Security Investment Act 2021

The 2023 UK Integrated Review identified quantum technologies as one of five priority areas of focus for UK Science and Technology.

## 3. How is the UK approaching quantum technology in strategy and policy?

The UK seem to be approaching their QT strategy in a collaborative fashion with plans for industry, researchers, and academia. They had released one of the earliest quantum policies in the world, the National Quantum Technologies Programme (NQTP) in 2014. The NQTP is

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<sup>3</sup> Stewart Room, 'Will U.K. Online Safety Bill Break Encryption For Mass Surveillance?', *Forbes* (21 September 2023) <<https://www.forbes.com/sites/stewartroom/2023/09/21/will-uk-online-safety-bill-break-encryption-for-mass-surveillance/>>.

<sup>4</sup> Department for Science, Innovation and Technology, *National Quantum Strategy* (Mar 2023) <https://www.gov.uk/government/publications/national-quantum-strategy#:~:text=A%2010%2Dyear%20vision%20and,the%20UK's%20prosperity%20and%20security> ('NQS').

<sup>5</sup> UK Research and Innovation (UKRI), 'Commercialising quantum technologies challenge' <https://www.ukri.org/what-we-do/our-main-funds-and-areas-of-support/browse-our-areas-of-investment-and-support/commercialising-quantum-technologies-challenge/#:~:text=The%20challenge%20provides%20funding%20for,%2C%20telecommunications%2C%20cyber security%20and%20defence>.

a ten-year program that is approaching its end and it's really interesting to see what the UK were able to achieve with 10 years of a quantum strategy.

#### National Quantum Technologies Programme 2014

- A ten-year program (2014-2024) representing £1bn of public and private investment to accelerate quantum technologies into the marketplace.
- Delivered in two 5-year phases.
- Phase 1 Achievements: brought 4 products to market:
- Programme is currently in Phase 2

As the NQTP is wrapping up, the UK released another quantum strategy, the NQS, that will take the UK to 2033.

#### National Quantum Strategy 2023

- Further 10-year programme building off the NQTP
- Investment of £2.5B in government funding, aims to generate additional £1B in private funding.
- Vision: UK to be a leading quantum-enabled economy by 2033

The UK's strategy leans heavily on funding education and research. They are also actively courting private investment by 'leading by example through government signalling and procurement'. The UK's Ministry of Defence was a key stakeholder in the NQTP, they have identified quantum applications for defence.

#### **4. Does the UK have quantum specific legislation? If so, what does it cover? What does it do?**

The UK *does not* have quantum specific legislation. However, they have quantum related legislation. The following Acts refer to quantum technology:

- National Security Investment Act 2021: Requires sensitive business acquisitions to be approved by the government before they are completed. This includes for quantum technologies.
- Export Control Order 2008: regulation of dual use goods – applies to some quantum technologies

#### **5. What technologies are mentioned in the UK's quantum strategy and policy?**

**The UK's quantum strategy mentions five technologies, they are quantum computing, quantum communications, quantum sensing, quantum imaging, and quantum timing.**<sup>6</sup> The UK seem to have a more granular definition of their quantum technologies than the US and Australia. The US and Australia usually define three types (computing, sensing, communications); they would class the UK's two extra classifications under the umbrella of quantum sensing.

The UK strategy often mentioned "Position Navigation & Timing" technology alongside in its quantum discussion, this is likely why they specifically define quantum imaging and timing.

"For quantum sensing, timing and imaging, our ambition is to develop the technology so that the UK is in a strong position to play an important role globally in the next generation of

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<sup>6</sup> NQS (n 4) 13.

sensors and position, navigation and timing (PNT) capabilities, working with international partners.”<sup>7</sup>

**6. What competition/competing interests are mentioned/raised/identified in the UK’s quantum strategy and policy?**

- Competition from other sectors for packaging and fabrication capabilities for the commercialisation of QT.
- Competition for quantum enabled workforce.
- Innovation vs security and ethical use policy
- Goal 4: “Create a national and international regulatory framework that supports innovation and the ethical use of quantum technologies and protects UK capabilities and national security.”<sup>8</sup>

**7. Is there consideration of the impact of quantum computing and quantum communications?**

Impact mainly discussed terms of economic gain from commercialisation of QT.

**8. Does the UK’s approach to quantum consider/mention quantum-safe encryption, quantum cryptography?**

Yes, the UK’s strategy briefly mentions quantum safe encryption. The National Cyber Security Centre has published a guidance on the transition to quantum-safe cryptography. (see Q9)

“Quantum technologies also pose potential national security challenges, not least the expectation that quantum computers will be capable of undermining the cryptography used to secure internet data.”<sup>9</sup>

**9. What does the UK’s approach to quantum technology say about current encryption practices and processes? Does it mention that quantum will ‘break’ current encryption?**

Yes, the UK states that quantum has the potential to break current encryption in the future.

“One of the most well documented is the risk quantum computing will pose to national cyber security in the future by threatening the security of much of the existing public-key cryptography, upon which the information sharing and trust mechanisms of most modern systems depend.”<sup>10</sup>

The NCSC has identified that the key threat is that encrypted data could be collected *now*, stored, and then decrypted in the future once a CRQC has been developed. They state that quantum computers that exist today are not a threat to public key cryptography.

Quantum Key Distribution (QKD) is one method for mitigating the quantum threat however, the NCSC does not endorse QKD for any government or military applications due to its specialist hardware requirements. Rather, they believe that Quantum Safe Cryptography (QSC) will provide the most effective mitigation. QSC will algorithm, a standard for which have not been finalised. The NCSC’s advice is that users should “follow normal cyber security best practice and wait for the development of standards-compliant QSC products.” (Preparing for Quantum-Safe Cryptography, NSCS). Early adoption of non-standardised QSC is not recommended.

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<sup>7</sup> UKRI (n 5).

<sup>8</sup> NQS (n 4) 47.

<sup>9</sup> NQS (n 4) 15.

<sup>10</sup> NQS (n 4) 50.

This indicates that UK's current encryption practices and processes are inadequate to deal with CRQCs. However, they do not seem to have a concrete plan for transition to new standards, this likely has to do with the fact that they are most likely to adopt non-national standards from bodies such as NIST (US) and the European Telecommunications Standards Institute and only have estimates of when their standards will be published. Shortcomings discussed in Q14.

Note: as at Nov 2023, NIST has only published a *draft* of their quantum resistant algorithms.

**10. Does the UK's approach to quantum mention any specific regulatory or legal frameworks? If so, which frameworks? If so, what is the predicted impact of quantum on those frameworks? If so, does the approach outline any possible solutions?**

The UK's strategy explicitly mentions the following key regulatory frameworks:

- Trusted Research Guidance for Academia: Advice produced in consultation with research and university community, particularly relevant to research in STEM subjects, dual-use technologies, emerging technologies and commercially sensitive research areas.
- If any research is derived from the US, it could be subject to US export control laws i.e. Export Administration Regulations
- Secure Innovation: NPSA company guidance for security in innovation areas. Secure innovation principles: know the threats, secure your environment, secure your products, secure your partnerships, secure your growth.
- Academic Technology Approval Scheme:
- National Security and Investment Act: Requires sensitive business acquisitions to be approved by the government before they are completed. This includes for quantum technologies.
- Export Controls: see Q13

The regulations mentioned in the UK strategy deal with either tech development processes e.g. research integrity, OR export. There is no mention of frameworks for the application of quantum technologies.

The following acts could have relevance to quantum:

- Regulation of Investigatory Powers Act 2000: gives the UK power to authorities to compel the disclosure of encryption keys or decryption of encrypted data
- Online Safety Act 2023: gives the law enforcement investigatory powers over 'regulated services' e.g. internet services, social media sites etc., has the potential to impact encryption<sup>11</sup>
- Investigatory Powers Act 2016: allows UK government to compel communications providers to remove electronic protection applied to any communications or data

See Q13 for dual use frameworks.

In February 2024, the Regulatory Horizons Council published an independent report to the UK Government titled "Regulating Quantum Technology Applications".<sup>[1]</sup> The recommendations in this report are aligned with the strategic objectives set out in the UK's National Quantum Strategy, The report makes 14 recommendations categorised into three broad themes:

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<sup>11</sup> Room (n 2).

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[https://assets.publishing.service.gov.uk/media/65ddc83bcf7eb10015f57f9f/RHC\\_regulation\\_of\\_quantum\\_technology\\_applications.pdf](https://assets.publishing.service.gov.uk/media/65ddc83bcf7eb10015f57f9f/RHC_regulation_of_quantum_technology_applications.pdf)

### **1. Regulatory frameworks and governance**

To develop a regulatory framework that is adaptable and proportionate to quantum innovation.

To establish a Quantum Regulatory Forum

To implement foresight methods for regulatory requirements

To implement awareness training

### **2. Standards and international collaboration**

To enhance the UK Quantum Standards Pilot Network

To advocate for the UK's strategic involvement in international regulatory forums

To develop interoperability standards in quantum communications

To address security concerns related to quantum communication

To advocate a balanced approach based on standards and responsible innovation

### **3. Innovation funding and market development.**

To establish testbeds and sandboxes with regulatory components

To leverage procurement strategies to create markets for quantum technologies

To tailor the translational funding environment to support quantum innovation

To stress the importance of regulatory policies and funding for mature quantum applications

To ensure compliance with legal frameworks such as the Online Safety Act

### **11. Are there any international or national standards identified in the UK's approach to quantum technology? If so, what are they and where do they come from?**

- The UK has established the Quantum Standards Network Pilot<sup>12</sup>
  - They will encourage direct involvement in standards development; comment on proposals and draft standards, discuss UK standards policy and strategy.
  - Will develop roadmaps for standards requirements for QT
  - Enable UK to coordinate strategic priorities and drive engagement with international standards systems.

Note: does not seem that the Quantum Standards Network Pilot will be developing their own standards for the UK

The NCSC has mentioned waiting on NIST (US) and the European Telecommunications Standards Institute post quantum standards.

- UK is engaging in conversations on technical standards with organisations such as the Institute of Electrical and Electronics Engineers Standards Association, International Organization for Standardization and International Electrotechnical Commission.<sup>13</sup>

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<sup>12</sup> NPL (National Physical Laboratory), 'Quantum standards network pilot' <https://www.npl.co.uk/quantum-programme/standards/network-pilot> accessed 24 April 2024.

<sup>13</sup> NQS (n 4) 30.

**12. Does the UK's approach to quantum technology discuss barriers or challenges of quantum technology? If so, what are they? What will be affected?**

The UK strategy has identified the following challenges:

- QT is an emerging technology and there is uncertainty around how it can best be brought to market.
- Commercialising QT will require sustained investment (commercialisation valley of death).
- Quantum sector must compete with more established sectors to access packaging and fabrication capabilities.
- Despite investment, the demand for quantum skills is greater than supply. Global competition for skills is increasing. Salaries for top quantum professionals are more than double the UK average in the US.
- Growing international competition, the US, China, and EU are all ramping up funding for quantum.
- Potential risks for technology transfer and trade restrictions as quantum corporations establish HQs overseas.

**13. Does the UK's approach to quantum technology discuss critical technology and dual-use regulatory and legal frameworks?**

Neither the NQTP nor the NQS have discussed quantum technology as dual use.

Dual-use regulatory frameworks

- Export Control Order 2008: The UK's main export legislation.
  - Dual-Use List [Annex IV]: quantum cryptography is mentioned

Following the UK's departure from the EU, broader measures were introduced including activities related to restricted goods (critical-industry goods, dual-use goods, military goods, aviation and space goods, oil refining goods, quantum computing and advanced materials goods, defence and security goods, and maritime goods), and energy related goods and technology. In 2022, 14 OITALs were issued covering technical assistance for energy related goods under the Russia sanctions, none were refused and one was revoked.<sup>14</sup>

**14. Are there any gaps identified in the UK's approach to quantum technology? Are there any barriers and challenges identified in the UK's approach? Are there any advantages to the UK's approach?**

**Gaps**

- There is limited discussion of quantum's cryptography breaking abilities compared to the US strategy. There is limited discussion of how UK agencies will use quantum technologies. Seems to be a greater focus on education and industry.

**Barriers**

See Q12

**Advantages**

- The UK's early movement in the quantum field is likely building private industry's confidence in the field. The Innovate UK – Commercialising quantum technologies

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<sup>14</sup> Department for Business and Trade and Export Control Joint Unit, *UK Strategic Export Controls Annual Report 2022* (19 July 2023) <https://www.gov.uk/government/publications/uk-strategic-export-controls-annual-report-2022>, 24

challenge was supported by £390 million from industry. The UK expected an additional £1B of industry investment over the span of the NQS.

- The UK invested in quantum hubs and now have four quantum hubs:
  1. Quantum Hub for sensors and metrology
  2. Quantum Communications Hub
  3. NQIT: Quantum hub for Networked Quantum Information Technologies
  4. QuantIC: Quantum hub for quantum enhanced imaging

### **15. What is UK's commitment to international collaboration?**

The UK has issued statements of cooperation with Australia, the US and Canada.

- Joint Statement of the United Kingdom and Australia on Cooperation in Quantum Technologies
- Joint Statement of the United States of America and the United Kingdom of Great Britain and Northern Ireland on Cooperation in Quantum Information Sciences and Technologies
- Joint Statement of Canada and the United Kingdom of Great Britain and Northern Ireland on cooperation in Quantum Science and Technologies

### **16. What are the UK's considerations as they attempt to regulate quantum technologies?**

"Quantum regulation will need to be:

- Stable, coherent and predictable
- Agile enough to move quickly with technological development • Simple to understand and inexpensive to implement • Where possible, co-designed with industry
- Focussed on innovation and industry-needs
- Champion the transparent and ethical use of quantum technologies."<sup>15</sup>

### **17. Comparison with USA**

UK approach is wholistic – hubs, private companies, broader strategy, private investment, R&D outside of government agencies, started quantum transformation in 2014 (just coming to an end) 10 year strategy. What their goals were – focused on building up 4 Hubs. Launched another 10 year plan – national quantum strategy, next 10 year plan. More funding. Looking at funding education and research, private investment and government procurement. Contracting out. Defence (but not as much as US). UK defines quantum technology differently. Quantum imaging and timing in addition to communications, cryptography and computing. Navigation and timing – Position, Navigation and Timing (clustered). Leadership in PNT sector. Timing & Imaging is usually grouped with sensing (Australia and the US group it with sensing).

UK Standards – deferring to NIST and possibly EU. Post-Quantum Encryption standards. But a week ago (Nov 2023) created 'Quantum Standards Network Pilot' and that's to engage with standards bodies and other countries on quantum standards.

USA is more closed. Government focused – department of Energy and defence. Defence heavy, encryption heavy.

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<sup>15</sup> NQS (n 4) 48.



## 18. UK Quantum Acronyms

Acronym	Body	Description
EPSRC	Engineering and Physical Sciences Research Council	The Engineering and Physical Sciences Research Council is a British Research Council that provides government funding for grants to undertake research and postgraduate degrees in engineering and the physical sciences, mainly to universities in the United Kingdom
NCSC	National Cyber Security Centre	The NCSC acts as a bridge between industry and government, providing a unified source of advice, guidance and support on cyber security, including the management of cyber security incidents. NCSC is part of the Government Communications Headquarters.
NPL	National Physical Laboratory	The National Physical Laboratory (NPL) is a world-leading centre of excellence that provides cutting-edge measurement science, engineering and technology to underpin prosperity and quality of life in the UK.
NPSA	National Protective Security Authority	The National Protective Security Authority, formerly the Centre for the Protection of National Infrastructure, is the national technical authority in the United Kingdom for physical and personnel protective security, maintaining expertise in counter terrorism as well as state threats.
NQCC	National Quantum Computing Centre	The NQCC is the UK's national lab for quantum computing. We work with businesses, government and the research community to deliver quantum computing capabilities for the UK.
NQTP	National Quantum Technologies Programme	The UK National Quantum Technologies Programme is a programme set up by the UK government to translate academic work on quantum mechanics, and the effects of quantum superposition and quantum entanglement into new products and services.
NSSIF	National Security Strategic Investment Fund	The UK Government's corporate venture capital arm for dual-use advanced technologies. NSSIF invests commercially in advanced technology firms, alongside other investors, to support long-term equity investment.
QSNP	Quantum Standards Network Pilot	Network Pilot that provides a focal point for quantum standards in the UK.

QTFP	Quantum Technologies for Fundamental Physics	Quantum technologies for fundamental physics' (QTFP) is a £40 million Strategic Priorities Fund (SPF) programme part of the NQTP.
UKRI	United Kingdom Research and Investment	Launched in April 2018, UK Research and Innovation (UKRI) is a non-departmental public body sponsored by the Department for Science, Innovation and Technology (DSIT).