Appendix B - European Union Quantum Regulation and Policy[1, 2]

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[1] Prepared by Megha Uppal with contributions by Jennifer Westmorland, UNSW Allens Hub for Technology, Law & Innovation.

[2] 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. What has the EU done to date on quantum strategy, policy and legislation?

Twenty-seven EU countries have signed a declaration agreeing to explore how to develop and deploy a quantum communication infrastructure (QCI) within the next ten years. The QCI will be the backbone of Europe's Quantum Internet.[3]

- On 06 December 2023 EU published the **European Declaration on Quantum Technologies**, which outlines the ultimate aim of making Europe the 'quantum valley' of the world.
- In October 2023 European Commission adopted the recommendation to **carry out risk assessments** on four critical technology areas including advanced **semiconductors and quantum**.[4]
- On the 18 April 2023, the European Commission proposed the **EU Cyber Solidarity Act**,[5] to improve the preparedness, detection and response to cybersecurity incidents across the EU. The proposal includes a **European Cybersecurity Shield** to protect, detect, defend and deter cyber threats. Under 'protect' and its 'technological front' they are **'working in particular on the issue of post-quantum encryption'**.[6]
- The **European Chips Act** entered into force in September 2023**.** It will **bolster Europe's competitiveness and resilience in semiconductor technologies and applications**, and help achieve both the digital and green transition. It will do this by strengthening Europe's technological leadership in the field.[7]
- The **European Commission's Quantum Strategy** includes:

1) **Quantum Flagship**.[8] Launched in 2018 for 10 years and a budget of €1 billion, its goal is to consolidate and expand European scientific leadership and excellence in this research area, to kick-start a competitive European industry in Quantum Technologies and to make Europe a dynamic and attractive region for innovative research, business and investments in this field (not only research but also go-to-market).

2) The **European Quantum Communication Infrastructure (EuroQCI) Initiative**.[9] Since June 2019, all 27 EU Member States have signed the EuroQCI Declaration, agreeing to work together, with the Commission and with the support of the European Space Agency, towards the development of a quantum communication infrastructure covering the whole EU (EuroQCI).

3) The **European High Performance Computing Joint Undertaking (EuroHPC JU) regulation** was adopted in 2021 and is a joint initiative between the EU, European countries and private partners to **develop a World Class Supercomputing Ecosystem** in

[3] European Commission, 'The future is quantum: EU countries plan ultra-secure communication network', *News & Views* (Web Page, 13 June 2019) <https://digital-strategy.ec.europa.eu/en/news/future-quantum-eu-countries-plan-ultra-secure-communication-network>.

[4] European Commission, 'Commission recommends carrying out risk assessments on four critical technology areas: advanced semiconductors, artificial intelligence, quantum, biotechnologies', *Press Release* (Web Page, 03 October 2023) < https://ec.europa.eu/commission/presscorner/detail/en/ip_23_4735>.

[5] Regulation of the European Parliament and of the Council laying down measures to strengthen solidarity and capacities in the Union to detect, prepare for and respond to cybersecurity threats and incidents Proposal 2023 (EU) <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52023PC0209>.

[6] European Commission, 'A European Cyber Shield to step up our collective resilience | Opening of the International Cybersecurity Forum | Speech by Commissioner Thierry Breton', *Speech* (Web Page, 05 April 2023) <https://ec.europa.eu/commission/presscorner/detail/en/speech_23_2145>.

[7] European Commission, 'European Chips Act', <https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-chips-act_en#:~:text=The%20Chips%20Act%20proposes%3A,experimentation%20of%20cutting%2Dedge%20chips>.

[8] *Quantum Flagship* (Web Page) <https://qt.eu/about-quantum-flagship/>.

[9] European Commission (n 3).

Europe. To date, **five supercomputers are now fully operational.** EU plans to invest of €7 billion in this till 2033.[10]

- In 2021, **the European Commission published 'European ambitions on Quantum research and innovation'**, which listed these as a part of the **EU quantum technology (QT) ecosystem**: Quantum Flagship, QUANTERA, QTSPACE COST Actions, EURAMET, Digital EU Programme, QKD Testbed, QT in Space, EESA Scylight, and National/Regional initiatives.[11]
- However, in March 2023 it was noted that European Quantum Technologies ecosystem = Quantum Flagship + Quantera +EuroQSM + EuroQCI + EuroQCS + ERC/Marie Skłodowska Curie actions[12]
- **Current funding instruments for EuroQCI** include the **Digital Europe** programme and the **Connecting Europe Facility**, as well as **Horizon Europe**, **ESA**, and **national funds**, including the **Recovery and Resilience Facility**. EuroQCI will be integrated in the proposed Secure Connectivity Programme.

2. **How is the EU approaching quantum technology in strategy and policy?**

- Its aim to be a global leader in quantum technologies is guiding EU's strategy and policy. This means that they are looking at covering all aspects, such as education, research, skill development, industry and economics, and geopolitics. As noted in Q1, several initiatives have been undertaken for this objective.
- EU's **Digital Decade policy:** 2030 targets include 'first computer with quantum acceleration' and Multi-country Projects (MCP) for 'secure quantum communication'.[13]
- The **European Declaration on Quantum Technologies**, outlines the ultimate aim of making Europe the 'quantum valley' of the world.

3. **Does the EU have quantum specific legislation? If so, what does it cover? What does it do?**

Does not seem to be the case, however, it has adopted legislations that are not created specifically for quantum but include quantum due to overlapping concerns.

4. **What technologies are mentioned in the EU's quantum strategy and policy?**

- Quantum computing, quantum communication, quantum sensing and metrology, quantum simulations. The ultimate goal is quantum internet.[14]
- The EU **Competence Framework** (April 2023) 'can be used to facilitate the planning and design of education and training projects in Quantum Technologies and provides an

[10] European Commission, 'The European High Performance Computing Joint Undertaking', *Policies* (Web Page) <https://digital-strategy.ec.europa.eu/en/policies/high-performance-computing-joint-undertaking>.

[11] Pasacal Maillot, 'European ambitions on Quantum research and innovation', *Quantera* (2021) <https://quantera.eu/wp-content/uploads/2021/11/Pascal_MAILLOT.pdf>.

[12] CEN-CENELEC Focus Group on Quantum Technologies, 'Standardization Roadmap on Quantum Technologies', (March 2023) <https://www.cencenelec.eu/media/CEN-CENELEC/AreasOfWork/CEN-CENELEC_Topics/Quantum%20technologies/Documentation%20and%20Materials/fgqt_q04_standardizationroadmapquantumtechnologies_release1.pdf>.

[13] European Commission, 'Europe's Digital Decade: digital targets for 2030', *Strategy and Policy* <https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en>.

[14] European Commission, 'Quantum technologies and the advent of the Quantum Internet in the European Union — Brochure', *Library* (Web Page, 23 September 2019) <https://digital-strategy.ec.europa.eu/en/library/quantum-technologies-and-advent-quantum-internet-european-union-brochure#What>.

instrument to compare different educational approaches'.[15] **The direct inference is that technologies enlisted here will be a part of EU's policy and strategy beyond the education and training stage.** The long list has several categories, such as quantum hardware, quantum computing and simulation, quantum sensors and imaging sensors, quantum communication and networks; and these have their own sub-categories.

5. **What competition/competing interests are mentioned/raised/identified in the EU's quantum strategy and policy?**

- A common ambition across documents, reiterated by Andrus Ansip, Commission Vice-President for the Digital Single Market, 'Europe is determined to lead the development of quantum technologies worldwide'.[16] It is acknowledged across the EU communication that Europe is currently behind the US and China in developing quantum technologies, and it wants not just match, but surpass their development.
- Sensitive and immediate risks related to technology security and technology leakage have often been cited as the possible negative outcomes of quantum technologies.[17] For example, it has been noted that cryptography will be one of the most vulnerable fields, posing risk to how sensitive information is stored today.[18]

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

Yes.

- advances in quantum computing put at risk Europe's cybersecurity by rendering obsolete current encryption systems and creating new cybersecurity challenges[19]

Positive impact:

- Quantum Communication can help to establish highly secure communication channels for information exchange
- QKD would provide highly secure key exchange protocols to protect sensitive communications, data and critical infrastructures
- Quantum sensors and quantum metrology hold substantial promise, offering the potential for transformative applications in the use of measurement devices in forensics, detection and decision making.
- , there are data analysis, machine learning and artificial intelligence, which may benefit from quantum algorithms for more efficient processing, e.g. to process large amounts of data at scale
- Quantum devices may offer new opportunities for digital forensics
- Password guessing can help authorities maintain safety and security

Negative impact:

[15] Quantum technology Education, 'European Competence Framework for Quantum Technologies', (Web Page) <https://qtedu.eu/european-competence-framework-quantum-technologies>.

[16] European Commission, 'Quantum Technologies Flagship kicks off with first 20 projects', *Press Release* (Web Page, 29 October 2018) <https://ec.europa.eu/commission/presscorner/detail/en/IP_18_6205>.

[17] European Commission (n 4).

[18] Europol Innovation Lab, *The Second Quantum Revolution: The impact of quantum computing and quantum technologies on law enforcement* (Report, 2023

[19] Andrea G. Rodríguez, 'A quantum cybersecurity agenda for Europe', (Discussion Paper, European Policy Center, 17 July 2023) <https://www.epc.eu/content/PDF/2023/Cybersecurity_DP.pdf>.

- ‘save now decrypt later’ could lead to new types of ransom demands or a flood of sensitive information being available for crimes such as social engineering and phishing
- Side-channel attacks and fault injection attacks are types of cryptanalysis techniques aiming to weaken or break the security of a cryptosystem
- Parties with malicious intent could make use of quantum communication channels to evade law enforcement detection and prevent criminal prosecution
- Password guessing can pose serious threats if used by parties with malicious intent[20]

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

Yes.

- Q1, Cyber Solidarity Act
- Commission of the European Communities supported ‘Post-Quantum Cryptography for Long-Term Security’, a project focused on developing post-quantum cryptographic techniques.[21]
- As noted in Q5, quantum cryptography has received substantial focus across EU reports due to the vulnerability it will cause for sensitive data, and there is a unanimous call for strengthening cybersecurity to mitigate these risks
- In April 2024, the European Commission published a Recommendation on a Coordinated Implementation Roadmap for the transition to Post-Quantum Cryptography[22]. This paper builds on the policy objectives set out in the EU Cybersecurity Strategy. The key recommendations are that:
  - Europe should switch to Post-Quantum Cryptography as swiftly as possible, to remove the known vulnerabilities of current asymmetric cryptography and enhance robustness against the threats posed by the malicious use of quantum computers.
  - Member States should develop a comprehensive strategy for the adoption of Post-Quantum Cryptography, which should specify clear goals, actions, milestones, and timelines. This should result, within two years, in the definition of a joint Post-Quantum Cryptography Implementation Roadmap.
  - Member States should develop common European standards and develop a framework for identifying and selecting Post-Quantum Cryptography algorithms to be deployed in the digital networks and services across the Union.
  - Member States should continue to cooperate actively with their international strategic partners to develop international standards that will ensure interoperability of communications going forward.

[20] Europol Innovation Lab (n 18).

[21] European Commission, ‘PQCRYPTO: an EU-funded project success story’, *Projects Story* (Web Page, 24 August 2018) <https://digital-strategy.ec.europa.eu/en/news/pqcrypto-eu-funded-project-success-story>.

[22] European Commission, ‘Recommendation on a Coordinated Implementation Roadmap for the transition to Post-Quantum Cryptography’, Policy and Legislation (Web Page, 11 April 2024) < https://digital-strategy.ec.europa.eu/en/library/recommendation-coordinated-implementation-roadmap-transition-post-quantum-cryptography>.

7. **What does the EU's approach to quantum technology say about current encryption practices and processes? Does it mention that quantum will 'break' current encryption?**

- The EU believes that new quantum computers will threaten the current encryption practices. Implementing new crypto algorithms will increase the security of their systems.[23]
- European Policy Center has emphasised the urgent need for a new EU Coordinated Action Plan to facilitate quantum-secured technologies before 'Q-Day' – the point at which quantum computers are able to break existing cryptographic algorithms.[24]
- Also refer to Q5 and Q7.

8. **Does the EU'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?**

Standardisation framework is mentioned in Q10 and Dual-use regulation in Q12. EU's approach does not directly mention any other regulatory or legal frameworks, yet.

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

- Ongoing: no clear results. Likely to follow NIST (US) standards.[25]
- **Rolling Plan for ICT standardisation: Quantum Technologies (RP2023)**[26] suggests nine 'Actions' to be undertaken for creating standards for quantum technologies, from European Committee for Standardization (CEN) & European Committee
- for Electrotechnical Standardization (CENELEC) identifying the most important needs for standardisation to SDOs increasing coordination efforts in Europe and internationally to avoid duplication of efforts.
- CEN-CENELEC released a **Standardization Roadmap on Quantum Technologies** in March 2023.[27]
- ETSI has an industry specification group on quantum key distribution (QKD).[28] Standards ETSI GS QKD 014 (Quantum Key Distribution (QKD); Protocol and data format of REST-based key delivery API) and GS QKD 004 (Quantum Key Distribution (QKD); Application Interface) are emerging as de facto standards for how to interface quantum key distribution systems with new and legacy hardware and software[29]

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

Yes.

[23] European Commission – ENISA Telecom Security Forum Slide Deck

[24] Rodríguez (n 19).

[25] Ibid.

[26] European Commission, 'Quantum Technologies (RP2023)', *Rolling Plan for ICT standardisation* (Web Page) <https://joinup.ec.europa.eu/collection/rolling-plan-ict-standardisation/quantum-technologies-rp2023#:~:text=Quantum%20Technologies%20(QT)%20include%20a,quantum%20communication%20and%20quantum%20computing>.

[27] CEN-CENELEC Focus Group on Quantum Technologies (n 12).

[28] ETSI, 'Industry Specification Group (ISG) on Quantum Key Distribution (QKD)' *QKD* https://www.etsi.org/committee/1430-qkd.

[29] Email from Dr Warren Armstrong, Director of Engineering, Quintessence Labs, email to authors, 'SOCRATES WP8 - Request for feedback – DRAFT quantum policy brief' 16 January 2024, 3:28 PM.

- **Quantum computers will break the most used cryptographic systems:** Research suggests that by 2026, there is a 1 in 7 chance that, which will go as high as 50% by 2031. However, research published in early 2023 by Chinese scholars suggests that it could happen even before.[30] For example, current-use cryptographic standards for webpages of all European Institutions, financial transactions, e-passports, VPNs have been broken at the post-quantum security level.
- Cyberattacks, known as **'harvest attacks'** or **'download now-decrypt later':** cybercriminals and geopolitical adversaries are rushing to obtain sensitive encrypted information that cannot be read today to be de-coded once quantum computers are available.
- Quantum computers will increase the probability of intellectual property theft or data breaches
- Cryptography attacks can also negatively impact the European economy and the competitiveness of European companies. + Cyberattacks on critical infrastructure can have far reaching consequences, with spillover effects on other economic sectors and international security
- Financing is one of the most critical chokepoints for the EU's quantum ambitions[31]

11. Does the EU's approach to quantum technology discuss critical technology and dual-use regulatory and legal frameworks?

- EU introduced a **dual-use regulation in 2021**, Regulation (EU) 2021/821.[32] It sets out rules throughout the EU to control exports, brokering, technical assistance, transit and transfer of dual-use items.
- Compilation of national control lists under Article 9(4) of Regulation (EU) 2021/821[33] **includes quantum computers and related electronic assemblies and components, qubit devices and qubit circuits containing or supporting arrays of physical qubits, quantum control components and quantum measurement devices**; as well as the technology for their development or production.

12. Are there any gaps identified in the EU's approach to quantum technology? Are there any barriers and challenges identified in the EU's approach? Are there any advantages to the EU's approach?

Few gaps/barriers/challenges identified:

- In recognising challenges and/or risks of quantum technologies, EU has focussed significantly on cryptography. Comparatively, focus on any other challenges and risks is negligible
- Lack of quantum-specific legislation despite multiple policies and initiatives already underway

Advantage: EU has recognised the significance of quantum technologies across sectors – research, economic, political – and plans to advance in all at the same pace. This would

[30] Rodríguez (n 19).

[31] Georg E. Riekeles, 'Quantum technologies and value chains: Why and how Europe must act now', (Discussion Paper, European Policy Center, 23 March 2023) < <https://www.epc.eu/content/PDF/2023/Quantum_Technologies_DP.pdf>.

[32] *Regulation (EU) 2021/821 of the European Parliament and of the Council of 20 May 2021 setting up a Union regime for the control of exports, brokering, technical assistance, transit and transfer of dual-use items (recast)* [2021] OJ L 206 11.6.2021/1.

[33] Ibid art 9(4).

ensure that their development of quantum technology progresses in a balanced manner, without any sector lagging and slowing down the others.

Notes

- The European Quantum Communication Infrastructure Initiative has a space component.

13. Summary

- **To recap, EU has strong policies in place for its quantum strategy. However, in terms of regulation it has only instated dual-use regulation and standardisation framework is underway, there is no quantum-specific regulation yet. There is a strong focus on quantum technologies making current cryptography practices vulnerable. EU aims to be a global leader in quantum technologies, and channel its research manpower for the same, and to eventually achieve economic gains from the application of these technologies.**
- The latest **European Declaration on Quantum Technologies** provides a good overview of EU's approach. The 11 signatory member states 'recognise the strategic importance of quantum technologies for the scientific and industrial competitiveness of the EU and commit to collaborating on the development of a world-class quantum technology ecosystem across Europe, with the ultimate aim of making Europe the 'quantum valley' of the world, the leading region globally for quantum excellence and innovation'. [34]
- EU seeks to 'maintain a leading global position, safeguard its strategic assets, interests, autonomy, and security, and avoid a situation of strategic dependency on non-EU sources…and build its own capacity to research and develop quantum technologies and produce devices and systems based on them, while at the same time investing in the whole quantum stack, from hardware to software and to applications and standards'.
- **Briefly, it has recognised the following in relation to quantum technologies:** economic significance, develop a world-class ecosystem in supercomputing and quantum computing, industrial exploitation, a secure quantum communication infrastructure, being at the cutting edge of quantum capabilities by 2030.
- At the same time, it is looking at international cooperation, such as the Trade and Technology Councils (TTCs) with the US and India.

[34] European Commission, 'European Declaration on Quantum Technologies', *Policy and Legislation* (Web Page, 06 December 2023) <https://digital-strategy.ec.europa.eu/en/library/european-declaration-quantum-technologies>.