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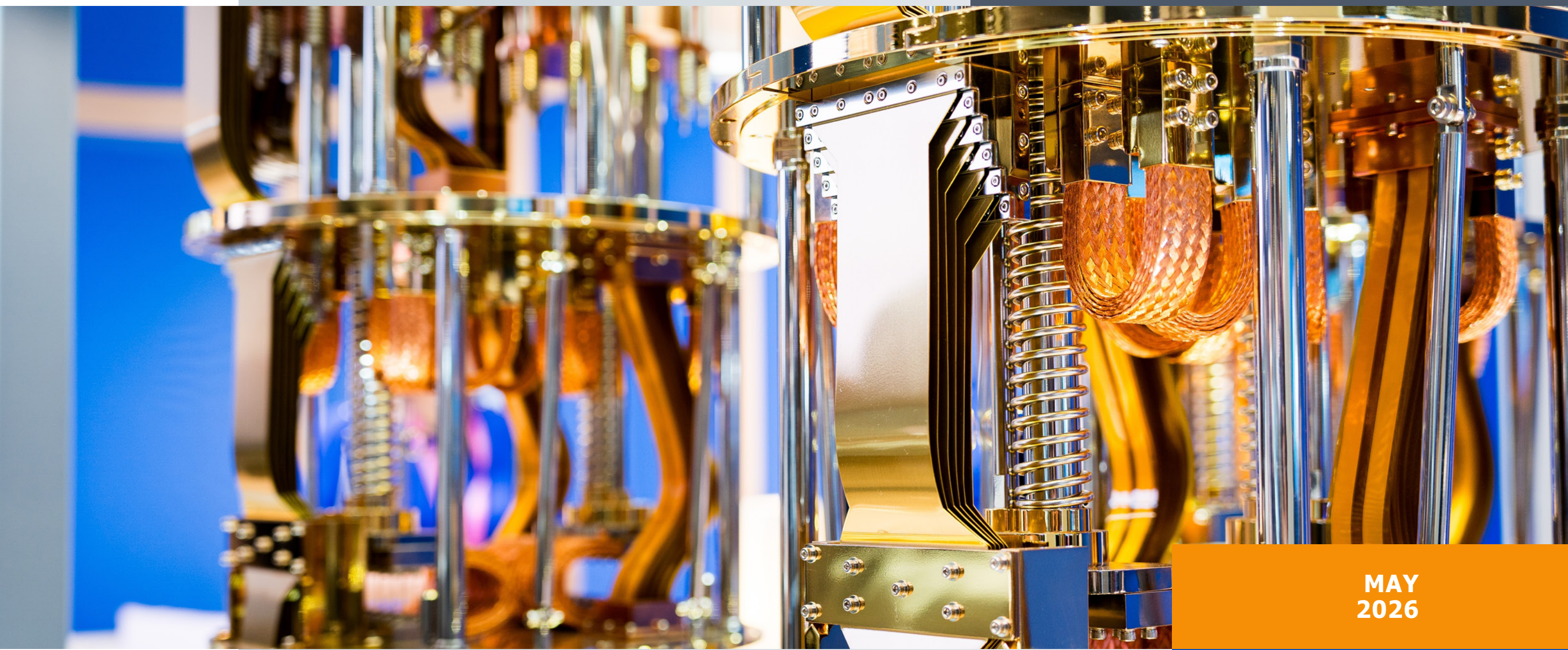

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Geopolitics of Technology Center

Europe Facing the Quantum Challenge: From Ambitions to Action

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Résumé

Malgré l'excellence de sa recherche dans le quantique, l'Europe accuse un retard structurel en financements privés et brevets, et reste exposée à des risques de prédation – prises de participation étrangères, dépendances d'approvisionnement, imposition de standards – qui fragilisent son autonomie stratégique.

Le modèle « tout start-up », soumis aux pressions du marché et aux appétits d'investisseurs extra-européens, ne peut garantir seul la maîtrise des technologies quantiques stratégiques, ouvrant la voie à une capture progressive par les rivaux sino-américains.

Sur le modèle du Conseil européen pour la recherche nucléaire (CERN), l'articulation d'un centre de recherche commun, d'un incubateur public-privé et de commandes publiques mutualisées pourrait constituer une voie pour ouvrir un marché de lancement sur les segments stratégiques et protéger les innovations européennes d'une absorption extérieure.

Grâce à son futur *Quantum Act* et à des coopérations sélectives avec des pays affinitaires, l'Union européenne pourrait s'imposer progressivement comme un acteur de la gouvernance internationale des normes quantiques, avant que la fragmentation technologique mondiale ne limite durablement ses marges de manœuvre.

Abstract

Despite the excellence of its research in the quantum sector, Europe lags behind in terms of private funding and patents, and remains vulnerable to predatory risks—foreign equity investments, supply dependencies, and the imposition of standards—that undermine its strategic autonomy.

The "all-startup" model, subject to market pressures and the appetites of non-European investors, cannot alone guarantee mastery of strategic quantum technologies, paving the way for a gradual takeover by Chinese and American rivals.

Following the model of the European Organization for Nuclear Research (CERN), the establishment of a joint research center, a public-private incubator, and pooled public procurement could provide a pathway to opening up an initial market in strategic segments and protecting European innovations from being absorbed by external players.

Through its future Quantum Act and selective cooperation with like-minded countries, the European Union (EU) could gradually establish itself as a key player in the international governance of quantum standards, before global technological fragmentation permanently limits its room for maneuver.

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Introduction

The nomination of researchers Alain Aspect and Michel Devoret for the 2022 and 2025 Nobel Prizes in Physics, for their work in quantum physics, attests to the enduring vitality of French and European research in this field. While the deployment of technologies stemming from the second quantum revolution is still in its infancy, one might think that strategic patience is called for, and that we must wait for the proliferation of basic research to give way to innovations ready for deployment. That would be a serious mistake, given that the potential for profound transformation inherent in the quantum sector is directly linked to states and organizations' strategic autonomy.

Europe has grasped this well and is gradually addressing the many challenges associated with this technological evolution. Its ambition, set out in the dedicated strategy of July 2025, is to position itself by 2030 as one of the world leaders alongside the United States and China, backed by member states with established capabilities (France, Germany, the Netherlands, Denmark, Austria, and Finland). The European Union (EU) nevertheless faces significant challenges, ranging from protecting its quantum ecosystem against internal and external competition to the necessary but slow development of shared infrastructure, and the establishment of an unprecedented regulatory framework.

At a time when the rapid growth of U.S. players is raising fears of new monopolies, when China's sectoral advances serve its civil-military agenda, and when the "all-startup" model is showing its limits in the EU, European quantum development must be viewed over the long term and take into account the enduring nature of current geopolitical upheavals. This will likely involve establishing preferential partnerships with like-minded countries and leading pioneering efforts in the international governance of these technologies deemed to be of strategic importance.

Europe in the global quantum race

Quantum technology: a source of technological and strategic potential

Based on fundamental physical principles such as superposition and entanglement—which underpin the second quantum revolution—, quantum technologies span computing and simulation, communications and cryptography, sensors, and metrology. They thus offer tremendous benefits in many sectors, both in the civilian sphere (chemistry and materials science, logistics, Earth observation) and the military sphere (submarine detection, aircraft stealth, decryption, autonomous systems).

However, these technologies carry risks, particularly in terms of cybersecurity. A sufficiently powerful quantum computer, equipped with a large number of high-quality qubits, would be capable of rendering obsolete the cryptographic algorithms based on the Rivest-Shamir-Adleman (RSA) and Diffie-Hellman protocols, which have secured a large portion of our communications since the late 1970s. Even though the prospect of such a machine emerging may seem distant, it already poses a threat to the most sensitive data, since it is already possible today to collect and store it, while waiting for the arrival of a quantum machine powerful enough to exploit it later. We must therefore anticipate this threat now. To address it, two solutions exist:

- quantum cryptography, whose security is based on quantum physics;
- post-quantum cryptography, based on new computational problems, which is already being deployed.[1]

Although still in its early stages, the quantum sector is experiencing rapid innovation, which raises challenges for governments in terms of research funding and competitiveness, the establishment of norms and standards, and economic security (regarding supply chains and export controls), calling for medium and long-term industrial planning strategies.

1. "A Coordinated Implementation Roadmap for the Transition to Post-Quantum Cryptography", European Commission, June 23, 2025, available at: https://digital-strategy.ec.europa.eu.

Europe and its international competitors

According to some estimates, the quantum sector could represent a potential market worth €65 billion by 2030,[2] fueling the adoption of ambitious quantum plans worldwide. The European strategy is no exception to this trend: following an initial phase through the 2016 Quantum Manifesto,[3] then the 2018 Quantum Flagship (an initiative with a budget of €1 billion over ten years to support research and innovation),[4] a second, more ambitious phase was announced in July 2025 via the Quantum Europe Strategy. Paving the way for the implementation of a future Quantum Act in late 2026 or during 2027,[5] it aims to strengthen fundamental research, training, and innovation, and to accelerate the development of infrastructure and the industrial ecosystem, with a focus on dual-use, space, and defense applications. Driven by a strategic roadmap currently under development, the future €2 billion framework program is expected to strengthen Europe's position in the field, with the goal of "positioning Europe as a global leader" by 2030.

Initiatives are multiplying at both member states and EU levels, and European investment in quantum technologies—starting with computing[6]—has increased significantly in recent years, now reaching $10 billion, ranking second globally behind China.[7] However, despite the dynamism of its ecosystem, the EU suffers from a fragmented industrial landscape that struggles to scale up, due to limited access to private financing and the redundancy caused by the proliferation of national strategies.[8]

The sector has so far been dominated by the United States and China, both in terms of funding and patents filed. Between 2005 and 2024, Europe is estimated to have filed 1,604 patents, compared to 3,300 for the United States.[9] However, it can count on its Finnish and French "champions" of quantum computing, IQM and Pasqal, as well as on rising players (Alice &

2. "Ordinateur quantique et secteurs financiers", Deloitte, May 2, 2022, available at: www.deloitte.com.
3. A. de Touzalin *et al.*, "Quantum Manifesto for Quantum Technologies", European Commission, May 17, 2016, available at: https://ec.europa.eu.
4. "Quantum Flagship", available at: https://qt.eu.
5. While its details remain unclear, the goal of the future Quantum Act will be to stimulate research and innovation, expand industrial capacity through pilot production lines (to encourage scaling up), and strengthen the resilience and governance of supply chains. Beyond that, it will also be necessary to establish a harmonized financial and regulatory framework to prevent the fragmentation of national industrial policies.
6. A. Pannier, "Strategic Calculation: High-Performance Computing and Quantum Computing in Europe's Quest for Technological Power", *Ifri Studies*, Ifri, October 6, 2021, available at: www.ifri.org.
7. F. Erixon *et al.*, "Benchmarking Quantum Technology Performance: Governments, Industry, Academia and Their Role in Shaping Our Technological Future", *ECIPE Policy Brief*, European Centre for International Political Economy, June 2025, available at: https://ecipe.org.
8. F. Schmidt, "Ces technologies vont révolutionner notre économie : l'Union européenne à l'assaut du quantique", *Les Échos*, July 2, 2025, available at: www.lesechos.fr.
9. "Mapping the Global Quantum Ecosystem: A Comprehensive Analysis Based on Innovation, Firm, Investment, Skills, Trade and Policy Data", European Patent Office (EPO) and Organisation for Economic Co-operation and Development (OECD), available at: www.oecd.org.

Bob, Planqc, QuantWare, Multiverse Computing…), and is closing the gap with China in terms of the number of companies deploying radical innovations.[10] While Europe collectively leads the United States in terms of public funding—with Washington having disbursed $5 billion to date and planning to allocate $2.5 billion over the next five years—,[11] it remains far behind in private funding. The U.S. ecosystem's ability to raise funds (44% of the global total) remains far superior to that of Europe (12%).[12] U.S. startups Quantinuum, PsiQuantum, and IonQ are projected to have raised $600 million, $1 billion, and $2 billion, respectively, by 2025—far ahead of all their competitors.[13] As of late January 2026, IonQ's market capitalization stood at $16 billion, Rigetti Computing's at nearly $8 billion, and D-Wave Quantum's at nearly $10 billion, despite very modest operational results to date. Added to these startups is the firepower of major corporations such as International Business Machines Corporation (IBM), Google, and Amazon, which are also making even more significant efforts, thanks to their financial and technological capabilities.

For its part, China has been making long-term investments in a sector identified as a national priority since the 13th Five-Year Plan (2016). It is now estimated to account for nearly 50% of global public funding, potentially amounting to $15 billion.[14] Recently, China has further increased its financial and political support for quantum technologies through its $138 billion fund dedicated to emerging technologies.[15] Private investment, however, remains difficult to quantify, both due to a lack of reliable data and because of the intertwined nature of public and private funding in China. Beijing is mainly focusing its efforts on quantum communications,[16] where it excels, and on quantum computing[17].

Beyond the Sino-American duopoly, the United Arab Emirates, Qatar, and Saudi Arabia are each expanding their academic collaborations and economic partnerships with foreign industry leaders (Quantinuum, QuEra,

10. A. García-Herrero and M. Krystyanczuk, "Les innovations radicales de la Chine dans l'IA et les semi-conducteurs : une enquête comparative", Le Grand Continent, November 12, 2025, available at: https://legrandcontinent.eu.

11. F. Erixon *et al.*, "Benchmarking Quantum Technology Performance", *op. cit.* ; « Quantum Computing Report », Global Quantum Intelligence, 2025, available at: https://quantumcomputingreport.com.

12. *Ibid.*

13. "Honeywell Announces $600 Million Capital Raise for Quantinuum at $10B Pre-Money Equity Valuation to Advance Quantum Computing at Scale", Honeywell, September 4, 2025, available at: www.honeywell.com ; "PsiQuantum Raises $1 Billion to Build Million-Qubit Scale, Fault-Tolerant Quantum Computers", PsiQuantum, available at: www.psiquantum.com ; "IonQ Announces Pricing of $2.0 Billion Equity Offering", IonQ, October 10, 2025, available at: www.ionq.com.

14. M. Serie, "Les technologies quantiques : un levier stratégique de souveraineté européenne", Institut national des affaires stratégiques, available at: https://inas-france.fr.

15. M. Swayne, "China Launches $138 Billion Government-Backed Venture Fund, Includes Quantum Startups", Quantum Insider, March 7, 2025, available at: https://thequantuminsider.com.

16. M. Julienne, "China's Quantum Dream: A Giant's Aspirations in the Infinitely Small", *Ifri Studies*, Ifri, February 14, 2022, available at: www.ifri.org.

17. M. Julienne, "China's Quest for a Quantum Leap", *Policy Brief,* No. 15, Reconnect China, October 2024, available at: www.reconnect-china.ugent.be.

Pasqal, etc.), with the aim of fostering a local ecosystem that remains modest for now.[18] They can also rely on the unparalleled resources of their sovereign wealth funds and national companies (Mubadala, ADQ, Qatar Investment Authority, Aramco) to finance their ambition to become regional hubs. In Asia, Singapore has been implementing a quantum strategy for several years across the entire value chain—with investments expected to reach $550 million by 2029—[19] and hosts a promising local research ecosystem. Japan has also committed $855 million to investments focused on the development of quantum computing and chips.[20] South Korea, for its part, aims to mobilize more than $1.5 billion in public investment and $500 million in private investment to set the country on the path to quantum computing, in order to mitigate its initial lag in infrastructure. On the other side of the globe, with over $700 million invested through 2022 and more than $200 million to come, Canada is a serious contender, capable of fostering the creation of numerous startups (ranked 4th globally in 2023).[21]

France, among Europe's top three

In France, initiatives have been organized since 2021 through the national strategy for quantum technologies, centered on five priorities: research support, training programs, infrastructure development, incentives for startups and industry, and an investment of one billion euros over five years.[22] This strategy is also complemented by the PROQCIMA program led by the Armed Forces Ministry, with a budget of 500 million euros to build a quantum computer capable of solving industrial problems.[23] France can rely on a dynamic ecosystem of quantum computing startups (Pasqal, Quandela, Alice & Bob, Quobly, C12, Welinq…) and prioritizes the development of quantum computers, sensors, and memories, as well as enabling technologies and post-quantum cryptography.[24]

With the support of the National Center for Scientific Research (CNRS), the French Alternative Energies and Atomic Energy Commission (CEA), and the National Institute for Research in Computer Science and Control, the country ranks third in Europe for quantum patent filings, behind Germany

18. Investments from the United Arab Emirates and Qatar are estimated at $1.6 billion. Cf. K. Priyadarshi, "$1.6 Billion Vision: How UAE and Qatar Are Converting Oil Wealth Into Quantum Power", Techodevas, September 9, 2025, available at: www.linkedin.com.
19. "Singapore to Invest About S$300 Million in Quantum Tech Research and Talent", Singapore Economic Development Board, May 30, 2024, available at: www.edb.gov.sg.
20. M. Swayne, "Japan Channels Almost $900 Million (U.S.) Into Quantum Push", Quantum Insider, November 28, 2025, available at: https://thequantuminsider.com.
21. C. Jurczak, "Investing in the Quantum Future – State of Play and Way Forward for Quantum Venture Capital", ArXiv, November 28, 2023, available at: https://arxiv.org.
22. "France 2030 : stratégie nationale pour les technologies quantiques", July 6, 2023, available at: www.entreprises.gouv.fr.
23. "Programme PROQCIMA", Quantique France 2030, available at: https://quantique.france2030.gouv.fr.
24. A. Sternchuss, "Marché de la technologie quantique : les chiffres à connaître", Bpifrance, August 19, 2024, available at: https://lehub.bpifrance.fr.

and the United Kingdom.[25] Nevertheless, it lags behind its international competitors in terms of public funding (2.2 billion over the past ten years, compared to 5.3 billion for Germany and 4.3 billion for the United Kingdom), as well as in attracting private capital, deploying industrial capacity, and generating economic value from its ecosystem. The challenge of scaling up therefore remains significant.

25. « Mapping the Global Quantum Ecosystem », *op. cit.*

A European ecosystem to be protected, enhanced and strengthened

Vulnerabilities to predation risks

The challenge for Europe is to prevent its innovations and the emerging market that accompanies them from being concentrated or captured by its strategic rivals. The pursuit of European strategic autonomy requires mastery of quantum technologies, which means the EU must be able to manage its dependencies and identify its vulnerabilities. However, various risks of predatory behavior already loom over the European ecosystem.

The first one deals with the acquisition of significant or majority stakes by American and/or Chinese funds or companies, which are poised to take advantage of the modest valuations of European startups seeking funding and the weak patent protection of their innovations. The example of the American company IonQ is illustrative in this regard: its 2021 initial public offering (IPO), carried out through a SPAC mechanism,[26] valued the company at over €2 billion, subsequently enabling its continuous growth, but also its diversification through external or major stakes acquisitions in competing companies. By centralizing its operations and patiently building vertical integration, IonQ now clearly aims to dominate the sector—if not monopolize it.[27]

A second risk lies in dependence, throughout the value chain, on materials (semiconductors, industrial diamonds, aluminum oxides, metal salts, helium, silicon, erbium, ytterbium, and other critical elements…) or enabling technologies (cloud computing, software, components for optical systems or lasers, ion pumps, photodetectors, pulse tubes, etc.) supplied by non-European partners of varying reliability.[28] Strategic autonomy here

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26. SPACs (Special Purpose Acquisition Companies) are financial vehicles that allow companies to raise capital without the need for a business plan or prior operating results. As a result, they enable companies to adopt aggressive strategies and secure future markets by mobilizing available capital in advance.
27. Over the past nine months, IonQ has acquired or taken controlling stakes in no fewer than seven specialized companies: Vector Atomic (quantum GPS), Skyloom (ground-to-ground and ground-to-air telecommunications infrastructure), Capella Space (air-to-ground quantum communications), Lightsynq (quantum interconnects), ID Quantique (quantum cryptography and detection systems), Oxford Ionics (trapped-ion quantum computers), and SkyWater (semiconductor foundry).
28. For a more detailed overview of critical vulnerabilities in the quantum supply chain within North Atlantic Treaty Organization (NATO) countries, read: "Critical Vulnerabilities in the Quantum Computing Supply Chain within the NATO Alliance", NATO Transatlantic Quantum Community, May 12, 2025, available at: www.fheijman.nl.

represents a fine line between accepting inevitable dependencies and asserting an open, partnership-based technological sovereignty.

A third challenge lies in the possibility of unequal partnerships between intra- and extra-European actors in order to gain access to an external market,[29] or to scale up and market technologies more effectively. This increases the risk of other companies—particularly Chinese and American ones—ultimately imposing their platforms and standards.[30] The case of the proprietary programming language Qiskit, developed by IBM and widely adopted as a de facto standard, is emblematic of these structural dependency issues.[31] In this regard, American tech giants pose a threat, given that their propensity for systematic concentration of technological innovations is now well established, and while historical precedents call for the utmost vigilance.[32]

Intellectual property issues also represent a short-term vulnerability. Patent filing is, in fact, a key component of the policies implemented by the United States and China. It helps them secure long-term returns on research investments, control market access, and steer innovation in line with their diplomatic interests and priorities. Serving as tools for economic attractiveness and security as well as levers of influence at both the regulatory and political levels, these patents are currently underutilized by European players compared to the aggressive efforts of their Sino-American competitors. Europe thus ranked second in its own market until 2025, behind the United States, before regaining ground: it now accounts for 41% of patents filed with the European Patent Office, compared to 35.6% for the United States and 5.6% for China.[33] At a time when companies account for 80% of patent filings—a sign of a shift from basic research toward industrialization and commercialization, investing in this field appears essential to avoid any legal or technical preemption of the market.

Such risks call for an increase in both public and private European funding, as well as the implementation of dedicated strategies regarding

29. Just like the Boston offices of Alice & Bob, Qubit Pharmaceuticals, and Pasqal (which also has locations in Chicago and Canada): A. Bécache and J. Nicolaï, "Boston, nouveau hub de l'industrie quantique ?", France Science, June 9, 2023, available at: https://france-science.com.

30. Relying on a proprietary environment can lead to vendor lock-in, forcing developers and organizations to use hardware and software over which they have no control, and ultimately limiting interoperability, competition, and thus innovation. This also paves the way for geopolitical and/or cyber exploitation of this dependency.

31. We can also consider the open-source development platforms Cuda-Q and NVQlink from NVIDIA, the leader in graphics processors, which have won over industry players and led to partnerships with French startups (Alice & Bob, Pasqal).

32. In the 2000s, the Gemplus and Alcatel-Lucent cases highlighted the United States' propensity for economic espionage, which had the effect of permanently weakening these two French technological powerhouses. As tensions with the Trump administration escalate, this issue could take on greater significance.

33. J. Planté-Bordeneuve *et al.*, "A Portrait of the Global Patent Landscape in Quantum Technologies", QuIC Whitepaper, European Quantum Industry Consortium (QuIC), February 2026, available at: www.euroquic.org.

patents and the structuring of intra-EU technology partnerships. Furthermore, without robust mechanisms for economic security, supply chain resilience, and sustainable attractiveness programs to address these threats, the EU will inevitably find itself exposed to the fierce appetite of its competitors, or even to their retaliation in the event of regulatory and/or trade disputes—notably through the U.S. International Traffic in Arms Regulations (ITAR).[34] While France appears to have dedicated tools in this regard (the Strategic Information and Economic Security Service [SISSE], the Protection of the Nation's Scientific and Technical Potential [PPST], and regulations on Foreign Investment in France [IEF]),[35] their effectiveness will likely be put to the test in the coming years.

Technical standardization: a field that requires greater investment

In Europe, two organizations are currently particularly active in the field of quantum technologies: the European Committee for Standardization in Electronics and Electrical Engineering (CEN/CENELEC)—through the CEN-CLC/JTC 22 committee—and the European Telecommunications Standards Institute (ETSI), which recently established a group dedicated to quantum technologies. Both organizations have been mandated by the EU to establish technical standards and specifications applicable within the European Union, but ETSI remains the more attractive option, largely due to its greater openness, which allows non-European stakeholders to participate in its work.

However, like other technology sectors, quantum is suffering from a lack of commitment from relevant European stakeholders (industry, academia, and institutions), who generally constitute a minority within the various ETSI groups, thereby favoring the influence strategies of the Americans or Chinese who lead them. The fragmentation of efforts and the insufficient number of European experts involved can be attributed both to the lack of incentives to participate in these processes and to a lack of training in these topics—particularly in France. Governance is another limiting factor, insofar as, under the current framework, it is nearly impossible to create a joint CEN-ETSI standardization group or to impose EU leadership over an ETSI group,

34. As such, ITAR regulations—which restrict, at the discretion of the authorities, the use and re-export of U.S.-origin military-use components and technologies—apply particularly to the quantum sector, where many of the technologies (quantum computers or simulators, navigation sensors, quantum radars or gravimeters, integrated communication modules) are dual-use (civilian-military). It therefore constitutes a means of exerting pressure and a potential tool for economic predation against European quantum companies, mirroring notable precedents in the space sector or the defense industry. See T. Dublanche, "La réglementation américaine ITAR : une menace pour la souveraineté française ?", Portail de l'intelligence économique, March 14, 2025, available at: https://www.portail-ie.fr.

35. "Sécurité et protection", Quantique France 2030, available at: https://quantique.france2030.gouv.fr.

due to the independence of these organizations, which are bound by their inflexible statutes.

While it is possible to participate in U.S. or even Chinese standardization processes, these are semi-open and guided—in whole or in part—by their national authority, which influences their decisions.[36] This can lead to strategic issues that may be detrimental to European interests[37]. These limitations of European technical standardization are well known and identified in the new dedicated European strategy.[38] They persist, however, as stated ambitions struggle to materialize.

Toward European-scale public quantum infrastructure

Infrastructure development is at the heart of the European strategy, which aims to translate the excellence of European research into practical and accessible devices and applications. This development is currently being carried out primarily through the European High-Performance Computing Joint Undertaking (EuroHPC) and the European Quantum Communication Infrastructure (EuroQCI), which aim, respectively, to deploy quantum computing and communication infrastructures across multiple European sites. At the same time, as part of the Chips Joint Undertaking, pilot production lines covering all the main physical platforms used for quantum technologies are being established with a view to streamlining and accelerating the production capacity of quantum chips.[39]

All these infrastructures are aligned and aim to provide open access to services on a pan-European scale. They play a vital role in bridging the gap between scientific research advances and industrialization efforts. It is therefore crucial to maintain and develop these capabilities across the EU. It

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36. For example, it is easier—even more so than at ETSI—to participate in the work of the American National Standards Institute (ANSI)/X9, a U.S. standards working group focused on the impact of quantum technology on the financial sector. Regarding cryptographic issues, the recent definition of post-quantum standards by the U.S. National Institute of Standards & Technology (NIST), which is open to international participation, is another example.

37. In direct alignment with the recommendations of the National Security Agency (NSA), the Internet Engineering Task Force aims to standardize a non-hybrid, purely post-quantum version of the globally used "HTTPS" protocol. This would pave the way for a reevaluation of hybrid post-quantum migration strategies (combining classical and post-quantum cryptography), advocated by the French and German cyber agencies (the National Agency for the Security of Information Systems and the Federal Office for Information Security) in light of the uncertainties surrounding a one-time transition to "fully post-quantum" systems relying solely on algorithms approved by the U.S. National Institute of Standards and Technology (NIST). See "NSA Pushes for Weaker Post-Quantum Cryptography Standards, Sparking Security Debate", BigGo Finance, October 6, 2025, available at: https://finance.biggo.com.

38. "Une stratégie de l'UE en matière de normalisation – Définir des normes mondiales à l'appui d'un marché unique européen résilient, vert et numérique", European Commission, February 1, 2022, available at: https://ec.europa.eu.

39. "Chips JU Accelerates Quantum Innovation with the Selection of Six Consortia – Chips JU Press Release", Association pour les activités européennes en nanoélectronique, April 28, 2025, available at: https://aeneas-office.org.

is also important to facilitate access to these infrastructures for researchers and industry, as well as to ensure their interoperability and their ability to integrate innovations as they emerge. Their long-term viability cannot be guaranteed without planning and ongoing public commitment, which could take various forms.

The challenges of the coming decade

The need to move beyond the current startup model

In a model where startups are funded by capital raises and investors seeking profitability, maintaining the autonomy of these startups without government intervention or significant public equity stakes seems like an unsolvable puzzle. Given the strategic stakes involved in mastering and controlling certain quantum technologies (computing, quantum cryptography, and post-quantum cryptography), the relevance of an "all-startup" model seems questionable.

Drawing an analogy with the nuclear sector, quantum technologies require strong public support to preserve any hope of strategic autonomy. Since French nuclear expertise has been secured through state oversight via the CEA, the creation of a public entity that would play a similar role for quantum technologies is worth considering. At the European level, the potentially replicable model is that of CERN, as the scale of the scientific challenges and the need to preserve financial flexibility require us to pool our resources.

However, quantum technology differs from nuclear energy in that it has far more applications, for which the involvement of the private sector and startups remains essential, but must be developed in closer coordination with the public sector. The goal would therefore be to devise a hybrid model that goes beyond existing academic hubs and combines a European research center dedicated to the development of quantum platforms (computers, quantum communication networks) with a public-private structure (of the incubator type). The latter's mission would be to develop commercial applications based exclusively on these platforms. The European PIECC (Major Project of Common Interest for Competitiveness and Sovereignty) framework is a potentially suitable tool for launching such an initiative.[40] It would offer the advantage of focusing on technological development while freeing itself from market pressures and constraints and should be structured around a coalition of leading member states, with which Switzerland could be associated.

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40. Designed to support strategic industrial and technological projects, the PIECCs mobilize public and private funding to strengthen European competitiveness and self-reliance in key sectors.

However, such measures will need to be accompanied by both tax incentives and the harmonization of the regulatory and legal framework at the EU level to facilitate market entry for startups that may emerge as a result of these preliminary efforts. While the recent announcement of the "EU-Inc." startup facilitation scheme, scheduled for 2027, appears to move in this direction,[41] the creation of a single European point of contact could also be useful to support these companies more effectively, as well as to encourage simplified and unified patent filings. Finally, intra-European consolidation of the sector also requires more direct support through public procurement, which must be significantly strengthened to provide medium-term stability and visibility for the entire sector. By acting as the primary customer, pooled public procurement policies would circumvent the challenges of the private market absorbing immature technologies, thereby opening a launch market, particularly in strategic segments (defense, infrastructure, healthcare, etc.). In a second phase, mergers and acquisitions will need to take place gradually and could be accompanied by greater involvement from Euronext to facilitate future listings on the European market. This requires first providing better training for both European and national executives on quantum issues and further structuring the relationship between the academic community and decision-making circles. The facilitation of dedicated exchange networks, at the national level (at the initiative of the Foreign Affairs, Economy, and Armed Forces Ministries, in conjunction with the General Secretariat for Investment and the National Coordinator) and at the EU level (via the Directorate-General for Communications Networks, Content, and Technology, DG-CONNECT), would likely foster such acculturation.

The imperative need to build reliable strategic partnerships

As international competition intensifies and the adoption of national strategies increases,[42] there is a high risk that quantum technologies will develop in a fragmented and non-interoperable manner, thereby limiting cooperation among allies and scientific progress, complicating supply chains, and increasing deployment costs.[43] Competing technical standards and misaligned export control regimes risk accelerating global technological decoupling, even before the emergence of the next generation of global communications infrastructure. This calls for fostering selective collaborations among trusted nations starting now.

41. "Discours spécial de la présidente von der Leyen au Forum économique mondial", European Commission, January 20, 2026, available at: https://ec.europa.eu.

42. By November 2025, 18 OECD countries and the European Union had adopted dedicated strategies. See A. Barreneche, M. Benallaoua and D. Valenzuela, "Technologies quantiques : le rôle des gouvernements et de l'action publique pour impulser la seconde révolution", OECD, January 12, 2026, available at: www.oecd.org.

43. A. Ferrazzini, "Quantum, Diplomacy, and Geopolitics", ArXiv, December 5, 2025, available at: https://arxiv.org.

The EU has a stake in the emergence of an open, secure, resilient, and diverse quantum ecosystem that benefits as many people as possible and respects human rights and state sovereignty. The goal is therefore to promote a form of "quantum diplomacy" that engages like-minded states in defining standards and levels of interoperability so that allied systems remain compatible, despite growing strategic competition. While formats for cooperation with the United States exist,[44] these may prove more difficult to maintain in the future given diverging priorities and interests. Europe can nevertheless rely on partners such as Canada, South Korea, Singapore, Japan, and soon India, with whom it maintains significant technological and political ties. This cooperation could take the form of a "Quantum Trade Zone" facilitating trade among like-minded nations, notably by establishing preferential tariffs across the entire sector and reciprocal free trade zones.

The growing challenge of international governance

The wide range of strategic applications promised by the future adoption of these technologies calls for establishing a regulatory framework well in advance. However, while institutional initiatives are on the rise, the fragmentation of international governance makes it necessary to put these efforts in order.

The multilateral framework offers a first possible approach to establishing initial milestones led by key countries: the G7 thus plans to create a future internal working group.[45] The issues it addresses include collective cybersecurity of infrastructure,[46] as well as the harmonization of export control policies, risk assessment frameworks, supply chain security policies, and support for quantum innovation.[47] However, at a time of growing divisions within the G7, and given its greater inclusivity, the G20 appears increasingly well-suited to lead negotiations and the adoption of norms of responsible state behavior in the quantum field, and to strengthen related confidence-building measures. In addition to establishing initial minimum safeguards, the G20 could also serve as a coordinator to align and distribute responsibilities among other organizations working on the issue

44. One example is the Quantum Development Group, whose most recent meeting in September 2025 brought together the United States, Japan, Germany, Australia, Canada, South Korea, Denmark, Finland, France, the United Kingdom, the Netherlands, Sweden, and Switzerland. Another example is the Quantum Without Borders initiative and its multilateral dialogue, the most recent iteration of which took place in Bern in March 2026. See "Multilateral Dialogue on Quantum", Quantum Without Borders, October 2023, available at: www.quantumwithoutborders.org.

45. "Kananaskis Common Vision for the Future of Quantum Technologies", G7, June 17, 2025, available at: www.g7.utoronto.ca.

46. L. Perret and G. Ribordy, "Accelerating the Transition to Quantum-Safe Communication: A Call for Global Collaboration and Action", *Policy Brief*, Center for International Governance Innovation (CIGI) and Think7, April 2025, available at: www.think7.org.

47. T. Dekker *et al.*, "Enabling Quantum Technology Cooperation: A Strategic Priority for the G7 Ecosystem in the Global Race", *Policy Brief*, CIGI et Think7, April 2025, available at: www.think7.org.

(OECD, World Economic Forum, UN agencies), thereby limiting fragmentation and facilitating the adoption of principles that have already been identified.[48]

UN agencies will also have a role to play. Following the example of previous work on other technologies, the United Nations Educational, Scientific and Cultural Organization (UNESCO) could build in the future an "International Code of Conduct for Quantum Technologies" focused on the protection of human rights, security, transparency, and openness, in line with its Global Quantum Initiative launched this year.[49] UNESCO also considers it necessary to establish a global forum on quantum governance under the auspices of the United Nations.[50] The World Summit on the Information Society (WSIS), which operates under the International Telecommunication Union (ITU), has positioned itself as a platform for coordinating such exchanges.[51] Recommended in its 2025 report, the creation of a global network of multi-stakeholder research centers—bringing together government representatives, academics, members of non-governmental organizations, and businesses—is intended to foster the consensus and inclusivity necessary for the adoption of a common, shared, and therefore sustainable governance framework for quantum technology.[52] Ultimately, the creation of a dedicated international agency could also be considered to establish UN authority, potentially modeled after the International Atomic Energy Agency (IAEA).[53]

Multi-stakeholder frameworks, which are more diverse and inclusive, could also facilitate preliminary discussions in a more neutral and potentially less contentious environment, to explore principles (charters, codes of conduct, transparency mechanisms, evaluations, etc.) that could subsequently be adopted by multilateral institutions. Some existing mechanisms are already based on this multi-stakeholder approach, such as the North Atlantic Treaty Organization's (NATO) Transatlantic Quantum Community.[54] Others likely remain to be developed in order to move beyond

48. Similar to those mentioned in the World Economic Forum (WEF) reports, "Quantum Computing Governance Principles", *WEF Insight Report*, WEF, January 2022, available at: www.weforum.org.
49. "Global Quantum Initiative", UNESCO, available at: www.unesco.org.
50. "Projet de rapport de la Commission mondiale d'éthique des connaissances scientifiques et des technologies (COMEST) sur l'éthique de l'informatique quantique", UNESCO, July 16, 2025, available at: https://unesdoc.unesco.org.
51. The WSIS thus aims to develop "a global framework for the governance of quantum technologies that is human rights-centered, ethical, and forward-looking, and serves the public interest". See "Human Rights-Centered Global Governance of Quantum Technologies", SMSI, July 8, 2025, available at: www.itu.int.
52. These objectives also appear to drive the ITU's Quantum for Good initiative. See "Quantum for Good", AI for Good, available at: https://aiforgood.itu.int.
53. M. Kop and T. Forrest, "Global Quantum Governance: From Principles to Practice", *CIGI Policy Brief*, No. 222, CIGI, February 5, 2026, available at: www.cigionline.org.
54. Established in 2024, this Denmark-led network aims to strengthen cooperation among willing Allies and leverage quantum technologies to bolster collective deterrence and defense. See "The United Kingdom Takes the Lead of NATO's Transatlantic Quantum Community", NATO, May 13, 2025, available at: www.nato.int.

limited partnerships between like-minded countries. Modelled on the Franco-Canadian Global Partnership on Artificial Intelligence,[55] a multi-stakeholder structure could thus be created with the aim of bridging the gap between fundamental research and concrete applications that benefit the public good. Such an initiative could also aim to raise public awareness of key quantum technology issues, building on the platform already provided by the Open Quantum Institute.[56] Along the same lines, a global observatory on the post-quantum transition could be considered, with the objectives of raising awareness of related cybersecurity issues, establishing a dedicated roadmap (key performance indicators, compilation of best practices, and a timeline for solution deployment) available to states and international institutions, and to promote the harmonization and interoperability of quantum security standards.[57] In a second phase, it could work toward the adoption of a unified code of conduct. Such an observatory could, in this case as well, draw on sector-specific work conducted elsewhere, notably that of the Quantum Safe Financial Forum, a multi-stakeholder initiative created by Europol.[58]

55. "Lancement du partenariat mondial pour l'intelligence artificielle", Ministry of the Economy, June 16, 2020, available at: www.economie.gouv.fr.

56. The Open Quantum Institute is a science diplomacy initiative launched in 2024 by the Geneva Science and Diplomacy Anticipator, hosted by CERN, that promotes inclusive access to quantum computing and its application to the Sustainable Development Goals. Details are available at: https://open-quantum-institute.cern.

57. L. Perret and G. Ribordy, "Accelerating the Transition to Quantum-Safe Communication", *op. cit.*

58. "Quantum Safe Financial Forum", Europol, May 7, 2024, available at: www.europol.europa.eu.

Conclusion

Achieving long-term European strategic autonomy will necessarily require mastery of quantum technologies, which lie at the intersection of multiple technical and strategic challenges. This mastery is not a zero-sum game and remains within Europe's reach. This requires strengthening intra-European cooperation in the sector and giving serious consideration to the geopolitical landscape that Europe currently faces. As the focus is now on reducing critical dependencies and mitigating material, infrastructural, and legal exposures to any attempt at external destabilization, the EU will have much work to do in the coming years to protect a nascent and still fragile quantum ecosystem, despite its clear strengths.

With its upcoming Quantum Act, the EU will have the opportunity to set a first milestone in the governance of quantum technologies at the EU level. This could potentially influence current and future processes, generating a "Brussels effect" that has been observed in other sectors (digital, artificial intelligence). However, to achieve this, Europe will first need to establish itself as a key player in the quantum field, capable not only of deploying innovative technologies and infrastructure within its borders but also of building reliable partnerships with like-minded countries, in the face of potentially threatening Sino-American competition.

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