Testimony

EDWARD PARKER

The Chinese Industrial Base and Military Deployment of Quantum Technology

Addendum

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Testimony of Edward Parker[1]
RAND[2]

Addendum to testimony before the U.S.-China Economic and Security Review Commission

Submitted March 15, 2024

Following the hearing on February 1, the U.S.-China Economic and Security Review Commission sought additional information and requested an answer to the question in this document. The answer was submitted for the record.

Question

In your oral testimony, you alluded to six or seven distinct technical approaches to quantum that have non-overlapping supply chains, and observed that it is difficult to discern which approach may "win." Please provide an assessment of the mature/near-term quantum technologies that should be updated or clarified within export control regimes.[3]

Answer

The U.S. government has two main mechanisms for administering export controls. The first is the International Traffic in Arms Regulations (ITAR), which are administered by the

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[3] All questions are presented verbatim as they were submitted to RAND.

Department of State and cover military technologies,[4] and the second is the Export Administration Regulations (EAR), which are administered by the Department of Commerce and cover dual-use technologies with both military and civilian uses.[5] All quantum technologies are dual-use, so I believe that the EAR is the most logical mechanism for administering any export controls on quantum technology.

Quantum technology is a complex field with widely varying levels of technology readiness, and I believe it is worth separately discussing its major subfields of quantum sensing, quantum communications, and quantum computing.

Broadly speaking, quantum sensing is the most technically mature of the three subfields of quantum technology. Moreover, quantum sensing technologies have several potential applications that are particularly relevant for defense, such as subsurface sensing and navigation in GPS-denied environments.[6] The Office of the Under Secretary of Defense for Research and Engineering has publicly identified several quantum sensing technologies, such as certain classes of atomic clocks, quantum magnetometers, and quantum inertial sensors, as both being relatively technically mature and having high potential military impact.[7] Any export controls covering these more-mature technologies should reflect the current state-of-the-art understanding of quantum sensing technology.

There are currently no export controls on "quantum sensors" as a category, but there are many existing export controls that would apply to specific quantum sensors. For example, there exist EAR export controls for very high-sensitivity magnetometers, gravimeters, and superconducting electromagnetic sensors that would cover certain types of quantum sensors under development today.[8] These regulations should reflect subject-matter experts' best technical understanding of the capability thresholds for military operational utility—and they should be updated if they do not—but there is no need to completely start from scratch.

In my view, export controls are most effective when applied to end-user systems with operational military capabilities rather than to basic components. For example, if a magnetometer reaches a performance threshold that delivers a useful military capability, then that magnetometer should be export-controlled regardless of whether it uses quantum technology "under the hood." Under this capability-focused approach, U.S. export controls would probably

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[4] U.S. Department of State, "Directorate of Defense Trade Controls," webpage, undated, https://www.state.gov/bureaus-offices/under-secretary-for-arms-control-and-international-security-affairs/bureau-of-political-military-affairs/directorate-of-defense-trade-controls-pm-ddtc/.

[5] International Trade Administration, "U.S. Export Regulations," webpage, undated, https://www.trade.gov/us-export-regulations.

[6] Edward Parker, Richard Silberglitt, Daniel Gonzales, Natalia Henriquez Sanchez, Justin Lee, Lindsay Rand, Jon Schmid, Peter Dortmans, and Christopher A. Eusebi, *An Assessment of U.S.-Allied Nations' Industrial Bases in Quantum Technology*, RAND Corporation, RR-A2055-1, 2023, https://www.rand.org/pubs/research_reports/RRA2055-1.html.

[7] Parker et al., 2023, p. 3, Figure 1.1.

[8] Code of Federal Regulations, Title 15, Subtitle B, Chapter VII, Subchapter C, Part 774, "Part 774 – the Commerce Control List," Sections 6A996–6A997, last updated March 7, 2024.

not require extensive changes until quantum technology becomes capable of delivering *qualitatively* new capabilities, such as decryption.

By contrast, quantum computing and quantum communications technologies are at a lower technical maturity than quantum sensing (with the exception of one application, quantum key distribution, whose likely military impact is low),[9] and their practical applications are probably further out.

As the question mentions, there are currently a wide variety of technical approaches being researched in parallel, which require very different critical components. Some technical approaches are somewhat further along than others: For example, quantum computers based on superconducting, trapped-ion, or neutral-atom qubits are currently somewhat more advanced than quantum computers based on photonic, silicon-spin, or topological qubits.[10] But there is no clear evidence that *any* of these approaches will deliver military operational utility in the near term.

Export controls could impose challenges on U.S. companies whose revenues are still modest, thereby risking their financial health. The administration's goal for its export control policy is to have effective and narrowly targeted controls on critical *military* technologies—a "small yard" with a "high fence."[11] In my judgment, it would be very difficult to impose such export controls on quantum computing or communication systems until experts have a better technical understanding of either (a) their concrete military end-user applications or (b) the most-promising technical pathways and timelines for creating them. Both of these critical data points remain highly uncertain today.

Some experts take a different perspective: They believe that the risk of a competitor nation gaining access to these critical technologies is so high that the highest priority should be to delay competitor nations from gaining these technologies, even if doing so might slow the development of the U.S. commercial industry. Those who take this perspective would endorse a strategy of broadly scoped export controls.[12] But I do not believe that such a strategy is likely to work. I believe that export controls on emerging technologies can reliably set back the targeted nations in the short run, but in the longer run the targeted nations will likely find alternative sources or will develop their own indigenous production capacity. (For example, there is some evidence that China is already mitigating some of the impacts of the 2022 U.S. export controls

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[9] Parker et al., 2023, p. 3, Figure 1.1; National Security Agency, "Quantum Key Distribution (QKD) and Quantum Cryptography (QC)," webpage, undated, https://www.nsa.gov/Cybersecurity/Quantum-Key-Distribution-QKD-and-Quantum-Cryptography-QC/.

[10] Edward Parker, Daniel Gonzales, Ajay K. Kochhar, Sydney Litterer, Kathryn O'Connor, Jon Schmid, Keller Scholl, Richard Silberglitt, Joan Chang, Christopher A. Eusebi, and Scott W. Harold, *An Assessment of the U.S. and Chinese Industrial Bases in Quantum Technology*, RAND Corporation, RR-A869-1, 2022, https://www.rand.org/pubs/research_reports/RRA869-1.html.

[11] The White House, "Remarks by National Security Advisor Jake Sullivan on the Biden-Harris Administration's National Security Strategy," October 13, 2022.

[12] The White House, "Remarks by National Security Advisor Jake Sullivan at the Special Competitive Studies Project Global Emerging Technologies Summit," September 16, 2022.

on advanced semiconductors).[13] I am not confident that any export controls imposed today will necessarily delay the targeted nations from developing quantum computing or communications technologies that are still many years from maturity. Moreover, targeted countries could take several responses to mitigate or retaliate against quantum technology export controls imposed by the United States.[14] For example, the Chinese government already appears to be shoring up China's domestic quantum computing supply chain to reduce its dependence on foreign suppliers.[15] Therefore, I believe that export controls on quantum technology should remain narrowly scoped to concrete and near-term military capabilities.

I will conclude with three cross-cutting suggestions for how any export controls on quantum technology could be designed to be most effective:[16]

1. The export controls should make clear and unambiguous exactly which technologies (and which potential customers) are covered. Those crafting the regulations should consider feedback from industry on publicly proposed rules—not to give those companies a veto but to verify that the affected companies understand exactly how the regulations would apply to them. Two topics in particular should have clear regulations:
    a. When a U.S. person releases certain technical information to a foreign person who is working within the United States, the U.S. government considers this to be a *deemed export* that is subject to control.[17] Foreign nationals form a very important part of the U.S. quantum development ecosystem,[18] so U.S. firms should receive clear guidance on allowed information-sharing with noncitizens.
    b. Many quantum computing companies do not sell hardware but instead operate under a cloud-access model whereby customers submit tasks remotely and the companies perform the actual computations in-house. Any export controls on quantum computing should clearly address the permissibility of selling computing *services* to foreign customers, even if no physical hardware ever leaves the United States.

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[13] Gregory C. Allen, "In Chip Race, China Gives Huawei the Steering Wheel: Huawei's New Smartphone and the Future of Semiconductor Export Controls," Center for Strategic & International Studies, October 6, 2023; Megan Hogan, "Export Controls Are Only a Short-Term Solution to China's Chip Progress," *War on the Rocks*, December 22, 2023.

[14] Kevin Klyman, "The U.S. Wants to Make Sure China Can't Catch Up on Quantum Computing," *Foreign Policy*, March 31, 2023.

[15] "China to step up quantum computing, AI in tech self-sufficiency drive," Reuters, March 5, 2024.

[16] Further discussion of export controls on quantum technology can be found in Edward Parker, *Promoting Strong International Collaboration in Quantum Technology Research and Development*, RAND Corporation, PE-A1874-1, February 2023, pp. 15–18, https://www.rand.org/pubs/perspectives/PEA1874-1.html.

[17] Bureau of Industry and Security, U.S. Department of Commerce, "Deemed Exports," webpage, undated, https://www.bis.doc.gov/index.php/policy-guidance/deemed-exports.

[18] Subcommittee on Economic and Security Implications of Quantum Science, Committee on Homeland and National Security, National Science and Technology Council, *The Role of International Talent in Quantum Information Science*, October 2021.

2. Any licensing requirements should have a minimally burdensome compliance process, because many quantum technology companies are small and do not have legal teams with expertise in export control procedures.
3. Quantum technology is developing rapidly, so export controls should be regularly updated to reflect the current state of the art. The update process should not be a one-way ratchet that always adds new restrictions; it should also remove restrictions on items that are no longer critical.