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Quantum Information Science: Congressional Activity and Federal Policy Recommendations

Quantum Information Science Technologies and Applications

Combining elements of mathematics, computer science, engineering, and physical sciences, quantum information science (QIS) is believed to have the potential to provide capabilities far beyond what is possible with the most advanced sciences available today. Quantum science, generally, is the study of the smallest particles of matter and energy; QIS builds on quantum science principles to obtain and process information in ways that cannot be achieved through classical physics. QIS is based on the premise that information science depends on quantum effects in physics.

Although much of the press coverage of QIS is on quantum computing, experts generally divide QIS into four categories: sensing and metrology, communications, simulation, and computing (some combine simulation and computing). Each can be used for a variety of applications. For example:

- Sensing and metrology—navigation, precise timekeeping, locating subterranean mineral deposits;
- Communications—generating quantum keys for encryption and enabling quantum-secure communications (interception destroys the communication and exposes the interceptor);
- Simulation—calculating the properties of materials such as high-temperature superconductors and modeling nuclear and particle physics; and
- Computing—performing some computations much faster, in some cases exponentially faster, than is possible using conventional high-performance computers.

In a February 11, 2020, memorandum, the White House stated that it intends to double non-defense QIS funding by 2022. The memorandum notes that the FY2021 budget recommendation would provide the National Science Foundation with a budget of $230 million and the Department of Energy Office of Science with $237 million for QIS, and an additional $25 million to DOE specifically to support quantum internet research.

Congressional Activity: 116th Congress

The following QIS-related activity has taken place in the 116th Congress.

General QIS Legislation

The National Defense Authorization Act for Fiscal Year 2020 (P.L. 116-92) modified the Department of Defense (DOD) QIS research and development (R&D) program. The law specifies which organizations must be consulted in developing an R&D plan; requires the DOD to classify QIS activities and requirements for relevant technology and standards; and establishes QIS research centers to enhance and accelerate the research, development, and deployment of quantum information sciences and quantum information science-enabled technologies and systems.

The Global Leadership in Advanced Manufacturing Act of 2019 (S. 1427) encourages research in a number of emerging technologies, including QIS. Among other provisions, the bill would expand the definition of a center for manufacturing innovation to make eligible for inclusion (and funding) a center that has a predominant focus on innovative sectors, including QIS. The Senate Committee on Commerce, Science, and Transportation ordered the bill to be reported favorably with an amendment in the nature of a substitute.

"Industries of the Future"

Two bills have been introduced—S. 3191 and H.R. 6145—and Congress has held a hearing focused on "Industries of the Future." The bills would require the White House Office of Science and Technology Policy (OSTP) to report on R&D investments, infrastructure, and workforce development by the federal government. Specifically, the report would be required to include (1) an assessment of current federal civilian R&D investments in the industries of the future (IotF); (2) a plan to double current investments in artificial intelligence and QIS by FY2022; (3) a detailed plan to increase investments in IotF R&D to $10 billion per year by FY2025; (4) a plan to leverage federal IotF investments through complementary investments by non-federal entities; and (5) proposed implementation legislation. The bills would also require the creation of an Industries of the Future Coordination Council to advise the OSTP Director. Council membership would be composed of members from the federal government as stipulated in the legislation.

On January 15, 2020, the Senate held a hearing on Industries of the Future. The hearing examined how the United States can maintain its global economic edge in a variety of disciplines, including QIS. Witnesses from the Department of Commerce, National Science Foundation, OSTP, and the Federal Communications Commission discussed R&D investments, potential regulatory changes, and workforce training requirements.

Quantum Computing Legislation

S. 1534 would require the Secretary of Defense to conduct an assessment of quantum computing technology to address problems associated with exposure to "PFAS"—a class of more than 3,500 dangerous compounds found in ground and drinking water. After referral to the Senate Armed Services Committee, no further action has been taken.

Legislation Limiting QIS Transfer to China

A number of bills have been introduced that would impose limits on the export of quantum technologies to China, including those related to QIS computing and simulation:

- China Technology Transfer Control Act of 2019, S. 1459, H.R. 3532;
- Fair Trade with China Enforcement Act, S. 2, H.R. 704;
- Uighur Intervention and Global Humanitarian Unified Response (UIGHUR) Act of 2019, H.R. 1025; and
- United States Export Finance Agency Act of 2019, H.R. 3407.

Federal Policy Recommendations

Some analysts believe that policies to boost the QIS industry in general would also boost the quantum computing industry. In a September 2018 report, *National Strategic Overview for Quantum Information Science* ("*National Strategy*"), the President's National Science and Technology Council (NSTC) asserted that creating a cohesive and effective U.S. QIS R&D policy would require a collaborative effort among government, academia, and the private sector. It cited six key areas, discussed below, that need to be addressed to craft an effective quantum policy.

Choosing a science-first approach to QIS

QIS is a rapidly evolving discipline with substantial opportunities for further discovery. According to the *National Strategy*, this will require strengthening core research programs and finding new methods for collaboration. It recommends the federal government

- strengthen federally-funded research programs to support long-term QIS research;
- foster cross-discipline collaboration among researchers;
- use the NSTC Subcommittee on Quantum Information Science (SCQIS) to coordinate federal policy; and
- identify "grand challenges" to encourage investment in both basic and applied QIS research.

Creating a future quantum-smart workforce

The U.S. educational system typically focuses on discrete disciplinary tracks rather than emphasizing cross-disciplinary study. To change this, the *National Strategy* recommends the federal government

- encourage industry and academia to create convergent, cross-sector educational approaches;
- use and enhance existing programs to increase the QIS-ready workforce;
- encourage academia to consider quantum science and engineering as its own discipline;
- address education in quantum science at an early stage, including elementary, middle, and high school levels;
- reach out to broader audiences by working with relevant agencies and industry to highlight their investments; and
- encourage the QIS community to track and estimate the future industry workforce needs.

Deepening engagement with the quantum industry

Some see a reliable supply of supporting technologies that are not in themselves intrinsically quantum as a critical element in a robust quantum ecosystem. In September 2019, the National Institute for Standards and Technology created a Quantum Economic Development Consortium to establish consensus on requirements and challenges, coordinate pre-competitive research, address intellectual property issues, and streamline technology-transfer mechanisms. Formation of such an organization was recommended in the *National Strategy* and mandated by the National Quantum Initiative Act (P.L. 115-368). The *National Strategy* also recommends the federal government

- increase investment in joint research centers created by industry, academia, and government partnerships; and
- maintain awareness of how quantum advances may affect agency missions and how agencies can encourage the adoption of quantum technologies.

Providing critical infrastructure

The successful development of technologies based on QIS is expected to enable increasingly more advanced quantum research, but such advances hinge on the availability of suitable tools, facilities, and other infrastructure. The *National Strategy* recommends the federal government

- identify needed infrastructure and encourage necessary investments by working with government experts and stakeholders, as well as industry and academia;
- encourage agencies to provide the QIS research community with increased access to needed facilities;
- establish testbed facilities to allow federal agencies to explore mission-relevant applications; and
- repurpose existing infrastructure (e.g., manufacturing facilities) to advance quantum technology development.

Maintaining national security and economic growth

National security needs often drive advancements in new science and technology and enable economic development. The *National Strategy* recommends the federal government

- maintain an understanding of the security implications of advances in QIS science and technology;
- promote mechanisms, such as the SCQIS, to educate government agencies of the defense implications of QIS and to help balance the benefits of economic growth with potential risks created by the technology; and
- ensure consistent use of classification and export control mechanisms to provide the best information possible to U.S. universities and industry about QIS research to encourage economic opportunities, protect intellectual property, and protect national security.

Advancing international cooperation

QIS research and development is designed to support U.S. prosperity and economic competitiveness in a highly interconnected world characterized by transnational flows of goods and information and international collaboration among scientists and engineers. The *National Strategy* recommends the federal government

- seek to increase international industry and government cooperation;
- ensure the United States continues to attract and retain the best talent, and has access to international technologies, research facilities, and expertise; and
- identify strengths and opportunities of international actors to better understand the international QIS landscape from both technical and policy perspectives.

Related CRS Products

CRS Report R45409, *Quantum Information Science: Applications, Global Research and Development, and Policy Considerations*, by Patricia Moloney Figliola

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