FULL COMMITTEE

HEARING CHARTER

"From Policy to Progress: How the National Quantum Initiative Shapes U.S. Quantum Technology Leadership"

Wednesday, May 7, 2025
10:00 a.m.
2318 Rayburn House Office Building

PURPOSE

The purpose of this hearing is to evaluate the state of quantum research, development, and technology (RD&T) in the United States. The hearing will also assess the current position of the American quantum industry in the global landscape. The hearing will serve as an opportunity to review and discuss the first seven years of the National Quantum Initiative Act (NQIA), the economic value of quantum science and its applications, the national security importance of developing quantum capabilities, and what policies should be considered for the reauthorization of the NQIA.

WITNESSES

- **Dr. Celia Merzbacher**, Executive Director, Quantum Economic Development Consortium
- **Dr. Charina Chou**, Chief Operating Officer and Director, Google Quantum AI
- **Dr. Pete Shadbolt**, Chief Scientific Officer and Co-Founder, PsiQuantum
- **Dr. Charles Tahan**, Partner, Microsoft Quantum

KEY QUESTIONS

- How has quantum science advanced during the first seven years of the National Quantum Initiative Act?
- What are the primary factors driving the global race in quantum technologies, and how can the U.S. maintain its leadership?
- Is the U.S. keeping pace with China in developing quantum capabilities?
- What programs and activities authorized under the National Quantum Initiative Act have been the most successful in advancing the state of quantum science? What has been the most challenging or least successful?
- What areas or policies should Congress focus on as it looks to reauthorize the National Quantum Initiative Act?
- How can the federal government work with industry to meet the quantum industry's current and future workforce and educational needs?

BACKGROUND

Basics of Quantum Physics and Mechanics: Quantum theory is the theoretical basis of modern physics that explains the nature and behavior of matter and energy on the atomic and subatomic level. The nature and behavior of matter and energy at that level are sometimes referred to as quantum physics and quantum mechanics.

Quantum physics explains the workings of atomic and subatomic particles and the tiniest packets of energy, such as photons. Quantum mechanics helps provide explanations for what happens at atomic scales. A few key properties of quantum mechanics have enabled technological breakthroughs:

- Superposition – the ability for subatomic particles to exist in one of two states, or both states simultaneously.
- Entanglement – the ability for subatomic particles that have been separated to instantaneously respond to each other.
- Uncertainty – the fact that we cannot know the precise location and state of a quantum particle at any time.

Quantum technology research has guided the development of technologies like lasers, magnetic resonating imaging (MRI), superconducting magnets, light emitting diodes, transistors and semiconductors/microprocessors, and electron microscopy. Quantum mechanics also creates the potential for enormous leaps in crucial areas like computing, precise measurement, cryptography, and impenetrable communications.

Quantum Information Science (QIS): Quantum information science is the marriage of information theory and quantum physics to develop new and powerful ways of processing information.

Quantum information science has many possible applications, some already in use or the early/mid testing phases, such as satellite communications and highly sensitive sensors. Others have the potential to mature in the next 5-10 years. Some potential applications include quantum sensors that can discover new underground oil and mineral deposits or detect seismic signals from nuclear explosions that traditional devices are not sensitive enough to discern. New portable quantum navigation devices, already undergoing rigorous testing, would enable soldiers and weapons platforms to navigate even when GPS networks are jammed or disabled.[1] QIS can also help develop communications systems that are impenetrable to quantum and traditional cryptographic methods. China is already operating a secure quantum communications network in the southern hemisphere, linking Beijing and South Africa, and has demonstrated its operations.[2]

Quantum Computing: The computer's basic architecture has remained essentially the same for more than 75 years. Research in advanced materials and computer science continues to push the envelope of classical computing speed and power. Nevertheless, it has been apparent for some time that the physical limits of classic computing are within view.

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[1] Swayne, Matt, Boeing's Quantum-based Navigation System Takes Flight in Historic Test, August 9, 2024, available at https://thequantuminsider.com/2024/08/09/boeings-quantum-based-navigation-system-takes-flight-in-historic-test/

[2] Swayne, Matt. China Establishes Quantum-Secure Communication Links With South Africa, 14 March 2025, available at https://spacenews.com/china-is-developing-a-quantum-communications-satellite-network/

Today, quantum computing is in its pre-market stage, but its maturation promises extraordinary improvements in computing speeds and performance over conventional computing for certain very important classes of problems.

For example, three important areas of science and technology could certainly be affected:

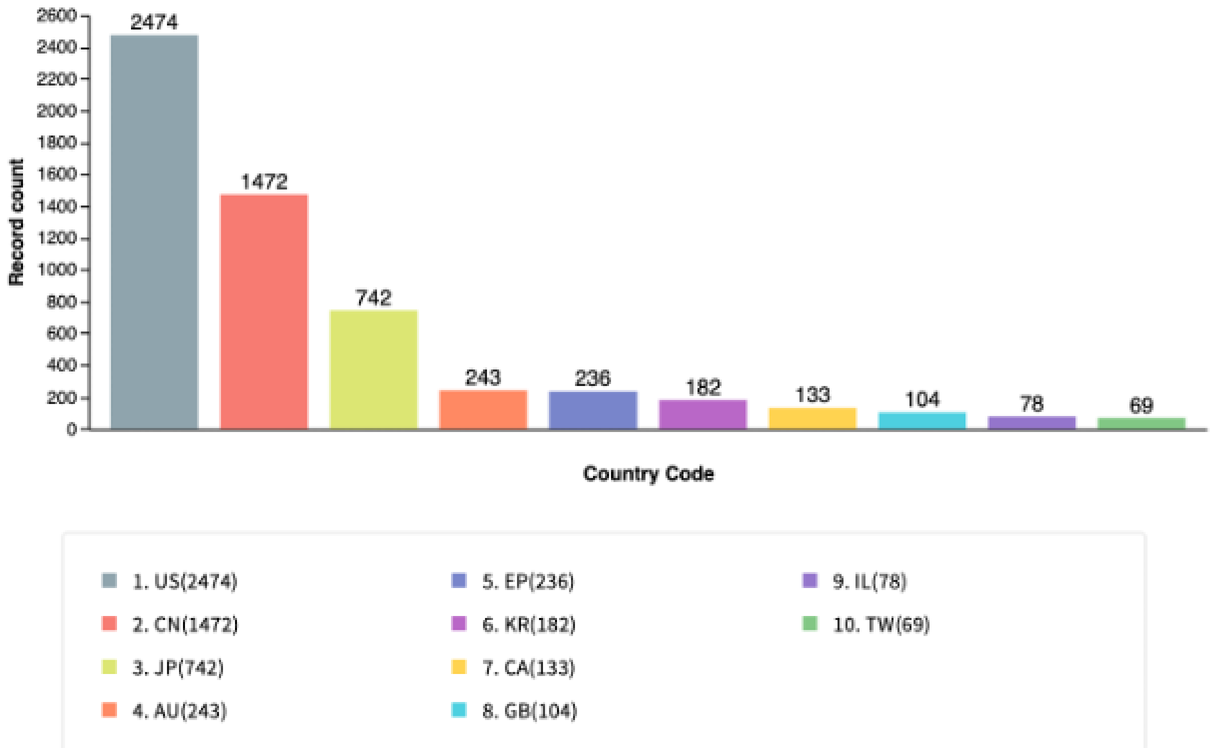
- Cryptography – Current encryption of electronic information is based on mathematical complexities that overwhelm the capabilities of the most powerful supercomputers. With a quantum computer, however, it is believed that every bit of electronic information, from credit card transactions to national security secrets, could be decrypted instantly.[3] Conversely, quantum-encrypted communications could be 100 percent secure for the foreseeable future.
- Chemistry and physics research – By modeling the electronic structure of large molecules, quantum computers could eliminate time-consuming and expensive trial-and-error methods for developing new advanced materials for aeronautics, pharmaceuticals, and much more.[4] Hypothesizing and verifying the performance characteristics of new materials using quantum computing capabilities could be much faster and cheaper.
- Complex data analytics – In every area of data analytics, a quantum computer would possess a significant (orders of magnitude) speed advantage. Analyzing and managing trillions of bits of information moment-by-moment could be feasible.[5]

Quantum computers are not expected to replace classical computers, but their radically different way of operating enables them to perform calculations that are impossible on classical computers.[6] Classical computers encode information in bits. Each bit can represent a zero or a one. These zeroes and ones act as on/off switches that ultimately translate into computing functions. Instead of bits, quantum computers use "qubits," which can represent a zero, a one, or both simultaneously. This enables a quantum computer to solve certain problems more quickly and efficiently.

The United States remains the frontrunner in quantum computing, mostly thanks to a robust private sector research and development community. The U.S. also has the most active quantum startup community, with dozens of innovators pushing the bounds of quantum applications across a range of use cases.[7] This ecosystem is why our nation holds a significant lead in quantum computing patent filings (see graphic below), though China is working to close that gap each year.[8]

[3] Caltech Science Exchange, How Will Quantum Technologies Change Cryptography?, available at https://scienceexchange.caltech.edu/topics/quantum-science-explained/quantum-cryptography
[4] IEEE Spectrum, Quantum Computers Getting Smarter at Simulating Chemistry, available at https://spectrum.ieee.org/quantum-chemistry-largest
[5] MIT, Inspiring Quantum Data Analysts, available at https://hdsr.mitpress.mit.edu/pub/eyywouav/release/3
[6] Department of Energy, DOE Explains…Quantum Computing, available at https://www.energy.gov/science/doe-explainsquantum-computing
[7] Tracxn, Quantum Computing Startups in the United States, April 5, 2025, available at Top Companies in Superconducting Quantum Computer (Apr, 2025) - Tracxn
[8] QED-C, State of Quantum Industry Innovation – What Patents Tell Us, December 11, 2024, available at https://quantumconsortium.org/blog/state-of-quantum-industry-innovation-what-patents-tell-us/#:~:text=The%20U.S.%20patent%20office%20has,Japanese%20patent%20office%20is%20third.

Quantum Computing Patents – Top 10 Offices
2010 through 2023



Quantum Sensing: Quantum sensors exploit the fundamental properties of atoms and light to measure the world.[9] In 2025, the Defense Advanced Research Projects Agency (DARPA) launched its Robust Quantum Sensors (RoQS) program.[10] The RoQS program aims to revolutionize defense sensing capabilities by developing quantum sensors that maintain high sensitivity while withstanding real-world deployments and harsh environments. More work on developing and hardening these sensors is needed to fully realize these technologies' potential, but they demonstrate how quantum technologies are already being deployed.

Quantum sensors are also making waves in the biomedical industry. Their accuracy and atomic length scale of quantum sensors enable them to detect even microscopic phenomena.[11] From detecting changes in electromagnetic fields, which can be used to accurately image brain activity, to microscopic measurement and imaging, which can be used for highly technical single-cell spectroscopy, quantum sensors have vast unrealized potential to improve health care practices.[12]

[9] Nature, Quantum sensors will start a revolution — if we deploy them right, May 24, 2023, available at https://www.nature.com/articles/d41586-023-01663-0#:~:text=Quantum%20sensors%20exploit%20the%20fundamental,for%20making%20a%20quantum%20computer.
[10] Defense Advanced Research Projects Agency (DARPA), Taking quantum sensors out of the lab and into defense platforms, available at https://www.darpa.mil/news/2025/quantum-sensors-defense-platforms
[11] Aslam, N., Zhou, H., Urbach, E.K. *et al.* Quantum sensors for biomedical applications, February 3, 2023, available at https://www.nature.com/articles/s42254-023-00558-3#citeas
[12] Id.

Quantum Networking and Communications: Quantum networks use the quantum properties of photons to encode information. These same properties not only enable communication but also make it uniquely secure against interception.[13] This technology could also facilitate communication across vast distances. Through entanglement, two quantum units exhibit correlated behavior regardless of the distance between them. To extend the reach of these networks, the Department of Energy and others are developing quantum network repeaters that leverage entanglement for long-distance connectivity.[14]

THE GLOBAL RACE FOR QUANTUM LEADERSHIP

Summary: Quantum technologies will be transformative across the scientific, economic, and defense realms. As a result, a global race is underway among great powers to develop operational quantum platforms for a variety of applications. While the United States maintains its global leadership in theoretical physics that underpins quantum computing and related technologies, adversarial nations like China have taken the lead in developing quantum applications and advancing the programming expertise to operationalize them.[15] China's government investment in applied quantum science is double that of the European Union and triple that of the United States government.[16] However, in 2023, private investment in quantum startups in the U.S. was roughly 10 times larger than in China.[17]

China: The Chinese Communist Party (CCP) identified quantum capabilities as one of several mission-critical technologies for its economic and national security. In 2016, China launched a massive quantum initiative to surpass the United States by 2030. In the nation's 14th five-year plan, China announced it would fund an estimated $15.3 billion in quantum research and development activities.[18] Since then, China has claimed major breakthroughs in quantum capabilities, including unveiling the Zuchongzhi-3, a 105-qubit superconducting quantum processor that reportedly operates ten to fifteen times faster than the world's most powerful classical computer.[19] Additionally, China has made other claims that it has reached major milestones in defense applications of quantum science that have not been verified or peer reviewed. Still, the increase in frequency of such claims highlights the CCP's interest in gaining an advantage over its challengers.

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[13] Department of Energy, DOE Explains…Quantum Networks, available at https://www.energy.gov/science/doe-explainsquantum-networks
[14] Id.
[15] Swayne, Matt, Report: China is Challenging U.S. Leadership in Quantum, September 9, 2024, available at https://thequantuminsider.com/2024/09/09/report-china-is-challenging-u-s-leadership-in-quantum/
[16] Ivezic, Marvin, China's Quantum Computing and Quantum Technology Initiatives, December 30, 2024, available at https://postquantum.com/quantum-computing/china-quantum/
[17] Omaar, Hodan and Makaryan, Martin, How Innovative is China in Quantum?, September 9, 2024, The Information Technology and Innovation Foundation, available at https://itif.org/publications/2024/09/09/how-innovative-is-china-in-quantum/
[18] Mateusz Masiowski et al., "Quantum Computing Funding Remains Strong, But Talent Gap Raises Concern," McKinsey Digital, June 2022, https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/quantum-computing-funding-remains-strong-but-talent-gap-raises-concern
[19] Romero, Romero. Quantum Singularity Ahead? China's Zuchongzhi-3 Reshapes Quantum Race, Forbes, 10 March 2025, available at https://www.forbes.com/sites/luisromero/2025/03/10/quantum-singularity-ahead-chinas-zuchongzhi-3-reshapes-quantum-race/

Russia: Russia established its National Quantum Laboratory under Rosatom[20] and integrated quantum technologies into its strategic technology roadmaps. Russia developed multiple 50-qubit quantum computers and plans to scale to 75 qubits by 2025, with a long-term goal of surpassing classical supercomputers by 2030.[21] Despite early successes, such as developing low-qubit quantum computers, international sanctions on Russia and the resource demands of the Ukraine war have likely hindered Russia's quantum advancements.[22] The conflict has also disrupted global supply chains, including restricted access to critical resources like helium.[23]

Europe: In 2018, the European Union (EU) launched Quantum Flagship, a 10-year research initiative with an approximate $1.06 billion budget.[24] This initiative funds research in quantum computing, simulation, communications, basic quantum physics, quantum metrology, and quantum sensing. It also includes efforts to modernize communications networks to use quantum key distribution cryptography.[25] In December 2023, the EU released a European Declaration on Quantum Technologies, with key objectives including developing a quantum ecosystem aligning European, national, and regional research and development programs to accelerate progress in quantum technologies, fast-tracking the transition of quantum innovations from laboratory research to commercial applications, and establishing quantum infrastructures to support research, testing, and deployment across Europe.[26] The EU Digital Decade strategy aims to have its first computer with quantum acceleration by 2025, enabling cutting-edge quantum capabilities by 2030.[27]

LEGISLATIVE HISTORY AND GOVERNMENT'S ROLE IN QUANTUM SCIENCE

National Quantum Initiative Act: The National Quantum Initiative Act[28] (NQIA) was signed into law by President Trump on December 21, 2018, "to accelerate quantum research and development for the economic and national security of the United States." The NQIA authorizes the National Institute of Standards and Technology (NIST), the National Science Foundation (NSF), and the Department of Energy (DOE) to strengthen QIS Programs, Centers, and Consortia. The NQIA also calls for a coordinated approach to QIS Research and Development (R&D) efforts across the United States Government, including the civilian, defense, and intelligence sectors.

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[20] Swayne, Matt, Russia sets up National Quantum Lab, January 28, 2022, available at https://thequantuminsider.com/2022/01/28/russia-sets-up-national-quantum-lab/

[21] Swayne, Matt, Russian Quantum Center Co-Founder Details Navigating Challenges in Quantum Computing Quest, Offers Glimpse at Future Roadmap, 2 January 2025, available at https://thequantuminsider.com/2025/01/02/russian-quantum-center-founder-details-navigating-challenges-in-quantum-computing-quest-offers-glimpse-at-future-roadmap/

[22] Beating China in the Race for Quantum Supremacy | The Heritage Foundation

[23] Swayne, Matt. "How Will the Ukraine–Russia Crisis Affect Quantum?" The Quantum Insider, March 10, 2022, https://thequantuminsider.com/2022/03/10/how-will-the-ukraine-russia-crisis-affect-quantum/

[24] Quantum Flagship, Introduction to the Quantum Flagship, available at https://qt.eu/about-quantum-flagship/

[25] News release, "The Launch of the Quantum Flagship," Quantum Flagship, October 29, 2018, https://qt.eu/about-quantum-flagship/newsroom/quantum-flagship-launch-press-release/

[26] European Quantum Act | European Declaration on Quantum Technologies, available at https://www.european-quantum-act.com/European_Declaration_on_Quantum_Technologies.html?utm_source=chatgpt.com

[27] Id.

[28] Public Law 115-368, National Quantum Initiative Act, available at https://www.european-quantum-act.com/European_Declaration_on_Quantum_Technologies.html?utm_source=chatgpt.com https://www.congress.gov/115/plaws/publ368/PLAW-115publ368.pdf

To guide these actions, the NQIA legislates some responsibilities for the National Science and Technology Council (NSTC) Subcommittee on Quantum Information Science (SCQIS), the NSTC Subcommittee on the Economic and Security Implications of Quantum Science (ESIX), the National Quantum Coordination Office (NQCO), and the National Quantum Initiative Advisory Committee (NQIAC).

In the 117th Congress, bipartisan leaders of the Committee on Science, Space, and Technology introduced H.R. 6213, the National Quantum Initiative Reauthorization Act.[29] The NQIA reauthorization bill was favorably reported out of the Full Committee on November 29, 2023, but was not considered on the House floor. The Committee intends to move a reauthorization bill this Congress.

NDAA and Defense Legislation in Quantum: QIS technologies have commercial and defense applications and authorizes additional QIS R&D. Civilian, defense, and intelligence agencies all have a long history of investments in QIS and have a stake in future QIS discoveries and technology development. The NDAA for FY 2019,[30] the NDAA for FY 2020,[31] and the NDAA for FY 2024,[32] direct the Department of Defense (DOD) to carry out and support quantum information science and technology research and development. These provisions authorized the DOD to increase the technology readiness level of quantum information science technologies under development in the United States, support the development of a quantum information science and technology workforce, and enhance awareness of quantum information science and technology.[33] One provision also provided direction to coordinate all quantum information science and technology research and development within the DOD, including through consultation with the NQCO, the SCQIS, and other appropriate Federal entities and private sector entities. Specifically, the NDAA for FY 2020 further authorizes the establishment of Quantum Information Science Research Centers.[34] The NDAA for FY 2022 amended the National Quantum Initiative Act to include the NSTC Subcommittee on the Economic and Security Implications of Quantum Science (ESIX).[35]

CHIPS and Science Act: The CHIPS and Science Act of 2022[36] amended the NQIA to authorize, the development of standards in quantum networking and communication at NIST; R&D in quantum networking infrastructure and the establishment of a Quantum User Expansion for Science and Technology (QUEST) program to facilitate a competitive, merit-reviewed base process for access to U.S.-based quantum computing resources for research purposes at DOE; and the integration of quantum information science and engineering into the STEM curriculum at all education levels at NSF. It also explicitly includes quantum information science in the new NSF Directorate for Technology, Innovation, and Partnerships and in existing Federal scholarship programs.[37]

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[29] https://www.congress.gov/bill/118th-congress/house-bill/6213
[30] Public Law 115-232, John S. McCain National Defense Authorization Act for Fiscal Year 2019, available at https://www.congress.gov/115/bills/hr5515/BILLS-115hr5515enr.pdf
[31] Public Law 116-92, National Defense Authorization Act for Fiscal Year 2020, available at https://www.congress.gov/116/plaws/publ92/PLAW-116publ92.pdf
[32] Public Law 118-31, National Defense Authorization Act for Fiscal Year 2024, available at https://www.congress.gov/118/plaws/publ31/PLAW-118publ31.pdf
[33] Id.
[34] Id.
[35] Id.
[36] Public Law 117-168, Chips and Science Act, available at https://www.congress.gov/117/plaws/publ167/PLAW-117publ167.pdf
[37] Id.

Quantum Coordinating Bodies: The National Quantum Initiative is carried out by federal agencies, and the NQIA, as amended, calls for interagency coordination through the National Science and Technology Council Subcommittee on Quantum Information Science and the NSTC Subcommittee on Economic and Security Implications of Quantum Science.

The NQIA also established the National Quantum Initiative Advisory Committee (NQIAC) to provide independent assessments and recommendations about the National Quantum Initiative. The NQIAC consists of 15 individuals across government, academia, and industry appointed by the President.[38] In September 2024, the NQIAC released a report presenting findings and recommendations for the U.S. government to promote U.S. leadership in quantum networking for U.S. national security and economic growth.[39] The NQIAC made the following recommendations:

- To continue to support fundamental research in quantum networking, its applications, and their enabling technologies.
- To encourage the definition, development, and use of metrics to measure progress on quantum networking technologies and their applications.
- To support the development of a coordination model for describing the functional layers of quantum networks.
- Federal funding for quantum networking testbeds should be allocated when testbeds are both "right-sized" and "properly-timed."
- To support and facilitate industry participation in quantum networking testbeds.
- To prioritize new funding appropriations and the development of new mechanisms to promote collaboration with international allies and like-minded partners for quantum networking R&D.
- To leverage quantum networking testbeds to enable and train a diverse quantum workforce.

Finally, the NQIA established the National Quantum Coordination Office to oversee the interagency coordination of the NQI Program, carry out the daily activities needed to coordinate and support the NQI, and provide technical and administrative support to the committees.[40]

National Institute of Standards and Technology (NIST): NIST is one of the world's leaders in quantum information research. Its expertise in measurement science, quantum physics, and information technology has produced discoveries and breakthroughs since the birth of the field in the mid-1990s. NIST researchers created the first component of a quantum computer, known as a quantum logic gate. They have developed many of the world's best single-photon detectors and transmitters for sending and receiving quantum data. They have made quantum logic clocks, which could potentially provide the world's best timekeeping and lead to discoveries in physics, such as detecting dark matter. NIST is also actively developing post-quantum encryption algorithms.

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[38] National Quantum Initiative Advisory Committee, available at https://www.quantum.gov/about/nqiac/

[39] National Quantum Initiative Advisory Committee, Quantum Networking: Findings and Recommendations for Growing American Leadership, available at https://www.quantum.gov/wp-content/uploads/2024/09/NQIAC-Report-Quantum-Networking.pdf

[40] National Quantum Initiative, available at https://www.quantum.gov/about/

Some of the most fundamental quantum research in the world is carried out in partnerships between NIST and top universities, such as the Joint Institute for Laboratory Astrophysics (JILA),[41] the Joint Quantum Institute (JQI),[42] and the Joint Center for Quantum Information and Computer Science (QuICS).[43] Scientists in these institutes leverage the combined resources of the partners to advance research in the control of atoms and molecules and the development of ultrafast lasers capable of manipulating states of matter. The discoveries made in these institutes continue to be applied to meeting new measurement challenges, such as the development of the world's best atomic clocks and lasers.

An emerging research focus at NIST is understanding the potential for quantum-based technology to transform security, computing, and communications, as well as developing the measurement and standards infrastructure necessary to exploit this potential. In August 2024, NIST published its first set of post-quantum cryptography standards.[44] These encryption tools are designed to withstand the attack of a quantum computer, securing a wide range of electronic information, from confidential email messages to e-commerce transactions. NIST is also developing technology to harness the power of quantum computing in the everyday world through nanotechnology.[45]

<u>Quantum Economic Development Consortium (QED-C):</u> NIST founded and supports the QED-C, which was authorized in the National Quantum Initiative Act. The QED-C aims to expand U.S. leadership in global quantum research and development and the emerging quantum industry in computing, communications, and sensing. The QED-C is run by SRI International, a nonprofit, independent R&D center headquartered in Menlo Park, California.[46] Corporations, academic and research institutions, and quantum industry supporting businesses across the supply chain are eligible for membership.[47] QED-C convenes both government and private-sector member organizations to:

- Determine workforce needs essential to the development of quantum technologies;
- Provide efficient public-private sector coordination;
- Identify technology solutions for filling gaps in research or infrastructure;
- Highlight use cases and grand challenges to accelerate development efforts; and
- Foster sharing of intellectual property, efficient supply chains, technology forecasting, and quantum literacy.

QED-C members collaborate on precompetitive R&D, such as device design and prototyping, increase efficiencies while sharing resources, and leverage private capital with government funding. Facilitating these activities enables access to quantum engineering capabilities to efficiently create, test, and validate potential technology platforms and processes.

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[41] Joint Institute for Laboratory Astrophysics, available at https://jila.colorado.edu/
[42] Joint Quantum Institute, available at https://jqi.umd.edu/
[43] Joint Center for Quantum Information and Computer Science, available at https://quics.umd.edu/
[44]National Institute of Standards and Technology, NIST Releases First 3 Finalized Post-Quantum Encryption Standards, available at https://www.nist.gov/news-events/news/2024/08/nist-releases-first-3-finalized-post-quantum-encryption-standards
[45] National Institute of Standards and Technology, Quantum Information Science, available at https://www.nist.gov/quantum-information-science
[46] National Institute of Standards and Technology, NIST Launches Consortium to Support Development of Quantum Industry, available at https://www.nist.gov/news-events/news/2018/09/nist-launches-consortium-support-development-quantum-industry
[47]QED-C, available at https://quantumconsortium.org/membership/

National Science Foundation (NSF): NSF has a long history of investment in research that has helped lay the groundwork for the quantum-based technologies that are on the horizon for rapid development over the next few years. NSF's decades of sustained investments have supported the foundational technology behind quantum sensors, computing, and communications,[48] and are a key component of the NQI.[49] Since the passage of the NQIA, NSF has prioritized the development of partnerships that link academia, industry, government, philanthropy, private investors, and civil society. This shift focuses on developing proof-of-concept devices, tools, systems, and applications that can be used for information processing, transmission, and measurement in more efficient ways than classical approaches.[50] Recent agency investments have been influenced by the analyses and recommendations in NSTC reports, including:

- *National Strategic Overview for QIS*[51]
- *Quantum Frontiers Report*[52]
- *A Coordinated Approach to Quantum Networking Research*[53]
- *The Role of International Talent in Quantum Information Science*[54]
- *QIST Workforce Development National Strategic Plan*[55]
- *Bringing Quantum Sensors to Fruition*[56]

In 2020, NSF funded the first of its Quantum Leap Challenge Institutes (QLCI), investing in large-scale interdisciplinary research projects motivated by challenges at the frontiers of quantum information science and technology.[57] These institutes coordinate research approaches across scientific disciplines and institutions to promote discovery and provide education, training, and workforce development. For example, the QLCI for Robust Quantum Simulation, hosted by the University of Maryland at College Park, combines expertise in computer science, engineering, and physics to develop the methods and tools for large-scale quantum simulators.[58] The QLCI for Hybrid Quantum Architectures and Networks at the University of Illinois Urbana-Champaign focuses on developing robust, interconnected networks of quantum processors and features three quantum testbeds that will collaboratively develop the technology needed to assemble a hybrid quantum processor and network.[59] NSF has awarded over $245 million in the QLCI initiative since 2020.[60]

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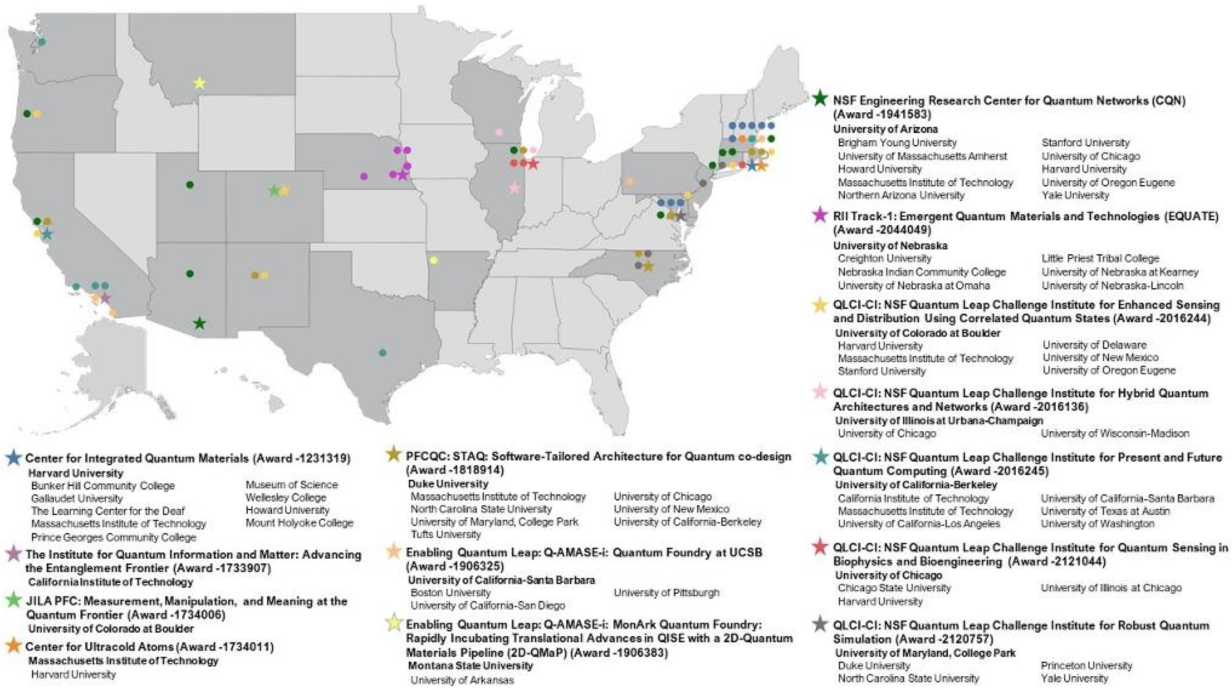
[48] National Science Foundation, Quantum Information Science, available at https://www.nsf.gov/focus-areas/quantum
[49] National Science Foundation, *FY 2025 Budget Request to Congress*, March 11, 2024, available at https://nsf-gov-resources.nsf.gov/files/00_NSF_FY25_CJ_Entire%20Rollup_web.pdf?VersionId=cbkdqD_UMweHEIsZwPjtVgcQRwMccgvu
[50] *Id.*
[51] National Science and Technology Council, National Strategic Overview for Quantum Information Science, available at https://www.quantum.gov/wp-content/uploads/2020/10/2018_NSTC_National_Strategic_Overview_QIS.pdf
[52] National Quantum Coordination Office, Quantum Frontiers: Report on Community Input to the Nation's strategy for quantum information science, available at https://www.quantum.gov/wp-content/uploads/2020/10/QuantumFrontiers.pdf
[53] National Science and Technology Council, A Coordinated Approach to Quantum Networking Research, available at https://www.quantum.gov/wp-content/uploads/2021/01/A-Coordinated-Approach-to-Quantum-Networking.pdf
[54] National Science and Technology Council, The Role of International Talent in Quantum Information Science, available at https://www.quantum.gov/wp-content/uploads/2021/10/2021_NSTC_ESIX_INTL_TALENT_QIS.pdf
[55] National Science and Technology Council, Quantum Information Science and Technology Workforce Development Strategic Plan, available at https://www.quantum.gov/wp-content/uploads/2022/02/QIST-Natl-Workforce-Plan.pdf
[56] National Science and Technology Council, Bringing Quantum Sensors to Fruition, available at https://www.quantum.gov/wp-content/uploads/2022/03/BringingQuantumSensorstoFruition.pdf
[57] National Science Foundation, NSF Quantum Leap Challenge Institutes, available at https://www.nsf.gov/mps/osi/quantum-leap-challenge-institutes
[58] Institute for Robust Quantum Simulation, available at https://rqs.umd.edu/about
[59] Hybrid Quantum Architectures and Networks, available at https://hqan.illinois.edu/
[60] National Science Foundation, Quantum Leap Challenge Institutes (QLCI) Active Awards, available at https://www.nsf.gov/awards/award_visualization.jsp?org=NSF&pims_id=505634&ProgEleCode=105Y00&from=fund

NSF's center-scale investments in QIS research centers



In 2024, NSF selected eleven pilot projects to bridge scientific gaps between current quantum technological capabilities and those needed to fully harness quantum properties for practical applications. These projects combine to support the National Quantum Virtual Laboratory initiative, which seeks to accelerate the development of quantum technologies by giving researchers specialized resources that can be accessed anywhere in the United States.[61] This initiative directly addresses the strategy outlined in the NQI to democratize access and build capacity for quantum information science research domestically. Each program was awarded $1 million to use over one year to create real-world testing environments for quantum-related technologies.

National Space and Aeronautics Administration (NASA): While not an official member of NQIA, NASA does have some representation on the various advisory committees and has made investments in quantum RD&T. NASA established the Quantum Science and Technology Laboratories under its Jet Propulsion Laboratory to support the research and development of advanced technologies and precision instruments enabled by quantum mechanical and photonic processes. Basic research activities include laser cooling and trapping of atomic particles, ultra-cold atom physics, nonlinear optics and quantum optics, frequency control, and precision measurements.[62] The focus areas are high-performance atomic clocks, atom interferometer sensors, microresonator devices, laser interferometers, and their applications for fundamental physics measurements in space.

#showAwardDollars=true

[61] National Science Foundation, Final 6 pilot projects selected for NSF National Quantum Virtual Laboratory, December 16, 2024, available at https://www.nsf.gov/news/final-6-pilot-projects-selected-nsf-national-quantum-virtual

[62] NASA Jet Propulsion Lab, Science and Research and NASA JPL, available at https://scienceandtechnology.jpl.nasa.gov/quantum-sciences-and-technology-laboratories

NASA also runs the Quantum Artificial Intelligence Laboratory (QuAIL) under its Intelligent Systems Division.[63] QuAIL is the space agency's hub for assessing the potential of quantum computers to impact computational challenges the agency faces in the decades to come. NASA's QuAIL team aims to demonstrate that quantum computing and quantum algorithms may someday dramatically improve the agency's ability to address difficult optimization and machine learning problems arising in NASA's aeronautics, Earth and space sciences, and space exploration missions.

Department of Energy (DOE): DOE's Office of Science supports robust Quantum Information Science (QIS) research and development activities across its core program areas. Some Office of Science research program activities include:

- Advanced Scientific Computing Research (ASCR): driving innovation in quantum computing by developing new algorithms and supporting the development of quantum testbeds.
- Basic Energy Sciences (BES): leveraging the BES Nanoscale Science Research Centers to advance materials and chemistry research that will help tackle high-priority QIS challenges in areas like quantum coherence.
- High Energy Physics (HEP): analyzing quantum sensors and related opportunities for new areas of HEP research.
- Nuclear Physics (NP): exploring quantum chromodynamics, nuclei, nuclear astrophysics, and fundamental nuclear symmetries.

- Fusion Energy Sciences (FES): developing quantum sensors uniquely capable of monitoring fusion plasma and providing new data for researchers.
- Biological and Environmental Research (BER): supporting QIS applications in bioimaging.
- Isotope Research and Production.

As part of the NQIA, DOE was tasked with creating up to five National QIS Research Centers with unique missions and capabilities that will help maintain U.S. leadership in QIS.

Q-NEXT: Next Generation Quantum Science and Engineering: Based at Argonne National Laboratory, Q-NEXT is focused on quantum communications and the ability to reliably control, store, and transmit quantum information across long distances. This work will be instrumental in developing more complex quantum networks.[64]

C^2QA: Co-design Center for Quantum Advantage: Located at Brookhaven National Laboratory, C^2QA conducts basic physics research that will allow quantum computers to be more accurate and efficient. This research into materials and software simultaneously will enable quantum computers to be developed much more quickly.[65]

SQMS: Superconducting Quantum Materials and Systems Center: Situated at Fermi National Accelerator Laboratory, SQMS is developing quantum devices to test and improve their capabilities. This work is unique to the high-energy physics research conducted at Fermi, where they are leveraging superconducting radio-frequency cavities to increase the knowledge of how these systems operate.[66]

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[63] NASA Quantum Artificial Intelligence Laboratory (QuAIL), available at https://www.nasa.gov/content/nasa-quantum-artificial-intelligence-laboratory-quail

[64] Q-NEXT, available at https://q-next.org/about/

[65] Brookhaven National Laboratory, Co-design Center for Quantum Advantage, available at https://www.bnl.gov/quantumcenter/

[66] Fermi National Accelerator Laboratory, SQMS Center, available at https://sqmscenter.fnal.gov/

QSA: Quantum Systems Accelerator: Lawrence Berkeley National Laboratory is home to QSA, which is developing algorithms to further optimize quantum systems. This research on basic quantum systems will accelerate the development and eventual commercialization of the technology.[67]

QSC: The Quantum Science Center: At Oak Ridge National Laboratory, QSC is researching key challenges for QIS in controllability and the maintainability of quantum states. The center is also focused on the workforce and creating a pipeline of skilled individuals needed as the field develops.[68]

Department of Defense (DoD): DoD engages in basic research, defined as the 'systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and observable facts without specific applications towards processes or products in mind.' DOD has supported fundamental QIS research for three decades and continues to invest in basic QIS R&D activities via several DOD offices, agencies, and laboratories. These include: the Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E)), the Defense Advanced Research Projects Agency (DARPA), the Air Force Research Laboratory (AFRL), the Air Force Office of Scientific Research (AFOSR), the Army Research Laboratory (ARL), the Army Research Office (ARO), the Naval Research Laboratory (NRL), and the Office of Naval Research (ONR).

FURTHER READING:

CRS:

1. CRS - Quantum Computing: Concepts, Current State, and Considerations for Congress
2. CRS – Defense Primer: Quantum Technology
3. CRS - Preparing Secrets for a Post-Quantum World – National Security Memorandum 10

Competitiveness and National Security:

4. CSIS – CSIS Commission on U.S. Quantum Leadership
5. Heritage Foundation - Beating China in the Race for Quantum Supremacy
6. AEI – Quantum Computing: A National Security Primer
7. ITI - ITI_QuantumPolicyGuide_042025.pdf

Quantum Basics:

8. QED-C – State of the Global Quantum Industry Report 2025
9. QED-C – Quantum Sensing Use Cases
10. NIST - Quantum information science | NIST

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[67] Lawrence Berkeley National Laboratory, Quantum Systems Accelerator, available at https://crd.lbl.gov/centers/qsa/

[68] Quantum Science Center, available at https://www.qscience.org/