

NATIONAL QUANTUM INITIATIVE ACT

SEPTEMBER 13, 2018.—Committed to the Committee of the Whole House on the State of the Union and ordered to be printed

Mr. SMITH of Texas, from the Committee on Science, Space, and Technology, submitted the following

R E P O R T

[To accompany H.R. 6227]

[Including cost estimate of the Congressional Budget Office]

The Committee on Science, Space, and Technology, to whom was referred the bill (H.R. 6227) to provide for a coordinated Federal program to accelerate quantum research and development for the economic and national security of the United States, having considered the same, report favorably thereon with an amendment and recommend that the bill as amended do pass.

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The amendment is as follows:

Strike all after the enacting clause and insert the following:

SECTION 1. SHORT TITLE; TABLE OF CONTENTS.

(a) SHORT TITLE.—This Act may be cited as the “National Quantum Initiative Act”.

(b) TABLE OF CONTENTS.—

- Sec. 1. Short title; table of contents.
 Sec. 2. Definitions.
 Sec. 3. Purposes.

TITLE I—NATIONAL QUANTUM INITIATIVE

- Sec. 101. National Quantum Initiative Program.
 Sec. 102. National Quantum Coordination Office.
 Sec. 103. Subcommittee on Quantum Information Science.
 Sec. 104. National Quantum Initiative Advisory Committee.
 Sec. 105. Sunset.

TITLE II—NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY QUANTUM ACTIVITIES

- Sec. 201. National Institute of Standards and Technology activities and quantum workshop.

TITLE III—NATIONAL SCIENCE FOUNDATION AND MULTIDISCIPLINARY CENTERS FOR QUANTUM RESEARCH AND EDUCATION

- Sec. 301. Quantum information science research and education program.
 Sec. 302. Multidisciplinary Centers for Quantum Research and Education.

TITLE IV—DEPARTMENT OF ENERGY RESEARCH AND NATIONAL QUANTUM INFORMATION SCIENCE RESEARCH CENTERS

- Sec. 401. Quantum Information Science Research program.
 Sec. 402. National Quantum Information Science Research Centers.
 Sec. 403. Spending limitation.

SEC. 2. DEFINITIONS.

In this Act, the following definitions apply:

- (1) **ADVISORY COMMITTEE.**—The term “Advisory Committee” means the National Quantum Initiative Advisory Committee established under section 104(a).
 (2) **COORDINATION OFFICE.**—The term “Coordination Office” means the National Quantum Coordination Office established under section 102(a).
 (3) **INSTITUTIONS OF HIGHER EDUCATION.**—The term “institutions of higher education” has the meaning given the term in section 101(a) of the Higher Education Act of 1965 (20 U.S.C. 1001(a)).
 (4) **PROGRAM.**—The term “Program” means the National Quantum Initiative Program implemented under section 101(a).
 (5) **QUANTUM INFORMATION SCIENCE.**—The term “quantum information science” means the storage, transmission, manipulation, or measurement of information that is encoded in systems that can only be described by the laws of quantum physics.
 (6) **SUBCOMMITTEE.**—The term “Subcommittee” means the Subcommittee on Quantum Information Science of the National Science and Technology Council established under section 103(a).

SEC. 3. PURPOSES.

The purposes of this Act are to ensure the continued leadership of the United States in quantum information science and its technology applications by—

- (1) supporting research, development, demonstration, and application of quantum information science and technology in order to—
 (A) expand the number of researchers, educators, and students with training in quantum information science and technology to develop a workforce pipeline;
 (B) promote the development and inclusion of multidisciplinary curriculum and research opportunities for quantum information science at the undergraduate, graduate, and postdoctoral level;
 (C) address basic research knowledge gaps;
 (D) promote the further development of facilities and centers available for quantum information science and technology research, testing and education; and
 (E) stimulate research on and promote more rapid development of quantum-based technologies;
 (2) improving the interagency planning and coordination of Federal research and development of quantum information science and technology and maximizing the effectiveness of the Federal Government’s quantum information science and technology research and development programs;
 (3) promoting collaboration among government, Federal laboratories, industry, and universities; and
 (4) promoting the development of standards for quantum information science and technology security.

TITLE I—NATIONAL QUANTUM INITIATIVE

SEC. 101. NATIONAL QUANTUM INITIATIVE PROGRAM.

The President shall implement a 10-year National Quantum Initiative Program. In carrying out the Program, the President shall, acting through appropriate Federal agencies, councils, working groups, subcommittees, and the Coordination Office—

- (1) establish the goals, priorities, and metrics for a 10-year plan to accelerate development of quantum information science and technology applications in the United States;
- (2) invest in fundamental Federal quantum information science and technology research, development, demonstration, and other activities to achieve the goals established in paragraph (1);
- (3) invest in activities to develop a quantum information science and technology workforce pipeline;
- (4) provide for interagency coordination of Federal quantum information science and technology research, development, demonstration, and other activities undertaken pursuant to the Program;
- (5) partner with industry and academia to leverage knowledge and resources; and
- (6) leverage existing Federal investments efficiently to advance Program goals and objectives.

SEC. 102. NATIONAL QUANTUM COORDINATION OFFICE.

(a) ESTABLISHMENT.—The President shall establish a National Quantum Coordination Office, which shall have—

- (1) a Director appointed by the Director of the Office of Science and Technology Policy, in consultation with the Secretary of Commerce, the Director of the National Science Foundation, and the Secretary of Energy; and
- (2) staff that shall be comprised of employees detailed from the Federal agencies that are members of the Subcommittee.

(b) RESPONSIBILITIES.—The Coordination Office shall—

- (1) provide technical and administrative support to—
 - (A) the Subcommittee; and
 - (B) the Advisory Committee;
- (2) oversee interagency coordination of the Program, including encouraging and supporting joint agency solicitation and selection of applications for funding of projects under the Program;
- (3) serve as the point of contact on Federal civilian quantum information science and technology activities for Government organizations, academia, industry, professional societies, State governments, and others to exchange technical and programmatic information;
- (4) ensure coordination between the Multidisciplinary Centers for Quantum Research and Education established under section 302(a) and the National Quantum Information Science Research Centers established under section 402(a);
- (5) conduct public outreach, including dissemination of findings and recommendations of the Advisory Committee, as appropriate;
- (6) promote access to and early application of the technologies, innovations, and expertise derived from Program activities to agency missions and systems across the Federal Government, and to United States industry, including start-up companies; and
- (7) promote access, through appropriate Government agencies, to existing quantum computing and communication systems developed by industry, academia, and Federal laboratories to the general user community in pursuit of discovery of the new applications of such systems.

(c) FUNDING.—Funds necessary to carry out the activities of the Coordination Office shall be made available each fiscal year by the participating agencies of the Subcommittee, as determined by the Director of the Office of Science and Technology Policy.

SEC. 103. SUBCOMMITTEE ON QUANTUM INFORMATION SCIENCE.

(a) ESTABLISHMENT.—The President shall establish, through the National Science and Technology Council, a Subcommittee on Quantum Information Science.

(b) MEMBERSHIP.—The Subcommittee shall include—

- (1) the National Institute of Standards and Technology;
- (2) the National Science Foundation;
- (3) the Department of Energy;
- (4) the National Aeronautics and Space Administration;

- (5) the Department of Defense;
 - (6) the Office of the Director of National Intelligence;
 - (7) the Office of Management and Budget;
 - (8) the Office of Science and Technology Policy; and
 - (9) any other Federal agency as considered appropriate by the President.
- (c) CHAIRS.—The Subcommittee shall be jointly chaired by the Director of the National Institute of Standards and Technology, the Director of the National Science Foundation, and the Secretary of Energy.
- (d) RESPONSIBILITIES.—The Subcommittee shall—
- (1) coordinate the quantum information science and technology research and education activities and programs of the Federal agencies;
 - (2) establish goals and priorities of the Program, based on identified knowledge and workforce gaps and other national needs;
 - (3) assess and recommend Federal infrastructure needs to support the Program; and
 - (4) evaluate opportunities for international cooperation with strategic allies on research and development in quantum information science and technology.
- (e) STRATEGIC PLAN.—Not later than 1 year after the date of enactment of this Act, the Subcommittee shall develop a 5-year strategic plan, and 6 years after enactment of the Act develop an additional 5-year strategic plan, with periodic updates as appropriate to guide the activities of the Program, meet the goals, priorities, and anticipated outcomes of the participating agencies.
- (f) REPORTS.—The Chairs of the Subcommittee shall submit to the President, the Advisory Committee, the Committee on Science, Space, and Technology of the House of Representatives, the Committee on Commerce, Science, and Transportation and the Committee on Energy and Natural Resources of the Senate, and other appropriate committees of Congress the strategic plans developed under subsection (e) and any updates to such plans.

SEC. 104. NATIONAL QUANTUM INITIATIVE ADVISORY COMMITTEE.

- (a) IN GENERAL.—The President shall establish a National Quantum Initiative Advisory Committee.
- (b) QUALIFICATIONS.—The Advisory Committee established by the President under subsection (a) shall consist of members from industry, academic institutions, and Federal laboratories. The President shall appoint members to the Advisory Committee who are qualified to provide advice and information on quantum information science and technology research, development, demonstrations, education, technology transfer, commercial application, or national security and economic concerns.
- (c) MEMBERSHIP CONSIDERATION.—In selecting an Advisory Committee, the President may seek and give consideration to recommendations from the Congress, industry, the scientific community (including the National Academy of Sciences, scientific professional societies, and academia), the defense community, and other appropriate organizations.
- (d) DUTIES.—The Advisory Committee shall advise the President and the Subcommittee and make recommendations that shall be considered in reviewing and revising the Program. The Advisory Committee shall provide the President and the Subcommittee with an independent assessment of—
- (1) trends and developments in quantum information science and technology;
 - (2) progress made in implementing the Program;
 - (3) whether the Program activities, priorities, and technical goals developed by the Subcommittee are helping to maintain United States leadership in quantum information science and technology;
 - (4) the management, coordination, implementation, and activities of the Program;
 - (5) the need to revise the Program;
 - (6) whether or not there are opportunities for international cooperation with strategic allies on research and development in quantum information science and technology; and
 - (7) whether national security, societal, economic, legal, and workforce concerns are adequately addressed by the Program.
- (e) REPORTS.—The Advisory Committee shall report, not less frequently than once every 2 years, to the President on the assessments required under subsection (d) and any recommendations to improve the Program. The first report under this subsection shall be submitted not later than 6 months after the date of enactment of this Act. The Director of the Office of Science and Technology Policy shall transmit a copy of each report under this subsection to the Committee on Science, Space, and Technology of the House of Representatives, the Committee on Commerce, Science, and Technology of the Senate, the Committee on Energy and Natural Resources of the Senate, and other appropriate committees of the Congress.

(f) TRAVEL EXPENSES OF NON-FEDERAL MEMBERS.—Non-Federal members of the Advisory Committee, while attending meetings of the Advisory Committee or while otherwise serving at the request of the head of the Advisory Committee away from their homes or regular places of business, may be allowed travel expenses, including per diem in lieu of subsistence, as authorized by section 5703 of title 5, United States Code, for individuals in the Government serving without pay. Nothing in this subsection shall be construed to prohibit members of the Advisory Committee who are officers or employees of the United States from being allowed travel expenses, including per diem in lieu of subsistence, in accordance with existing law.

(g) EXEMPTION.—The Advisory Committee shall be exempt from section 14 of the Federal Advisory Committee Act (5 U.S.C. App.).

SEC. 105. SUNSET.

(a) IN GENERAL.—Except as provided for in subsection (b), the authority to carry out sections 101, 102, 103, and 104 shall terminate on the date that is 11 years after the date of enactment of this Act.

(b) EXTENSION.—The President may continue the activities under such sections if the President determines that such activities are necessary to meet national economic or national security needs.

TITLE II—NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY QUANTUM ACTIVITIES

SEC. 201. NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY ACTIVITIES AND QUANTUM WORKSHOP.

(a) NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY ACTIVITIES.—As part of the Program described in title I, the Director of the National Institute of Standards and Technology shall—

(1) continue to support and expand basic quantum information science and technology research and development of measurement and standards infrastructure necessary to advance commercial development of quantum applications;

(2) use its existing programs, in collaboration with other agencies, as appropriate, to train scientists in quantum information science and technology to increase participation in the quantum fields;

(3) establish or expand collaborative ventures or consortia with other public or private sector entities, including academia, National Laboratories, and industry for the purpose of advancing the field of quantum information science and engineering; and

(4) have the authority to enter into and perform such contracts, including cooperative research and development arrangements and grants and cooperative agreements or other transactions, as may be necessary in the conduct of the work of the Institute and on such terms as the Director considers appropriate, in furtherance of the purposes of this Act.

(b) QUANTUM WORKSHOP.—

(1) IN GENERAL.—Not later than 1 year after the date of enactment of this Act, the Director of the National Institute of Standards and Technology shall convene a workshop of stakeholders to discuss the future measurement, standards, cybersecurity, and other appropriate needs for supporting the development of a robust quantum information science and technology industry in the United States. The goals of the workshop shall be to—

(A) assess the current research on the issues described in this paragraph;

(B) evaluate the research gaps relating to such issues; and

(C) provide recommendations on how the National Institute of Standards and Technology and the Program can address the research needs identified.

(2) REPORT TO CONGRESS.—Not later than 2 years after the date of enactment of this Act, the Director of the National Institute of Standards and Technology shall transmit to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate a summary report containing the findings of the workshop convened under this section.

(c) FUNDING.—The Secretary of Commerce shall devote \$400,000,000 to carry out this section, which shall include \$80,000,000 for each of fiscal years 2019 through 2023, subject to the availability of appropriations, to come from amounts made available for the National Institute of Standards and Technology. This section shall be carried out using funds otherwise appropriated by law after the date of enactment of this Act.

TITLE III—NATIONAL SCIENCE FOUNDATION AND MULTIDISCIPLINARY CENTERS FOR QUANTUM RESEARCH AND EDUCATION

SEC. 301. QUANTUM INFORMATION SCIENCE RESEARCH AND EDUCATION PROGRAM.

(a) **IN GENERAL.**—The Director of the National Science Foundation shall carry out a basic research and education program on quantum information science and engineering.

(b) **PROGRAM COMPONENTS.**—In carrying out the program required under subsection (a), the Director of the National Science Foundation shall carry out activities that continue to support basic interdisciplinary quantum information science and engineering research, and support human resources development in all aspects of quantum information science and engineering. Such activities shall include—

(1) using the existing programs of the National Science Foundation, in collaboration with other Federal agencies, as appropriate, to—

(A) improve the teaching and learning of quantum information science and engineering at the undergraduate, graduate, and postgraduate levels; and

(B) increase participation in the quantum fields, including by individuals identified in sections 33 and 34 of the Science and Engineering Equal Opportunities Act (42 U.S.C. 1885a; 42 U.S.C. 1885b);

(2) formulating goals for quantum information science and engineering research and education activities to be supported by the National Science Foundation;

(3) leveraging the collective body of knowledge from existing quantum information science and engineering research and education activities;

(4) coordinating research efforts funded through existing programs across the directorates of the National Science Foundation; and

(5) engaging with other Federal agencies, research communities, and potential users of information produced under this section.

SEC. 302. MULTIDISCIPLINARY CENTERS FOR QUANTUM RESEARCH AND EDUCATION.

(a) **MULTIDISCIPLINARY CENTERS FOR QUANTUM RESEARCH AND EDUCATION.**—

(1) **IN GENERAL.**—The Director of the National Science Foundation, in consultation with other Federal agencies as appropriate, shall award grants to institutions of higher education or eligible nonprofit organizations (or consortia thereof) to establish up to 5 Multidisciplinary Centers for Quantum Research and Education.

(2) **COLLABORATIONS.**—A collaboration receiving an award under this subsection may include institutions of higher education, eligible nonprofit organizations, and private sector entities.

(3) **PURPOSE.**—The purpose of the Centers shall be to conduct basic research and education activities in support of the goals and priorities of the Program as determined in title I, to—

(A) continue to advance quantum information science and engineering;

(B) support curriculum and workforce development in quantum information science and engineering; and

(C) foster innovation by bringing industry perspectives to quantum research and workforce development, including by leveraging industry resources and research capacity.

(4) **REQUIREMENTS.**—An institution of higher education or an eligible nonprofit organization (or a consortium thereof) seeking funding under this section shall submit an application to the Director at such time, in such manner, and containing such information as the Director may require. The application shall include, at a minimum, a description of—

(A) how the Center will work with other research institutions and industry partners to leverage expertise in quantum science, education and curriculum development, and technology transfer;

(B) how the Center will promote active collaboration among researchers in multiple disciplines involved in quantum research including physics, engineering, mathematics, computer science, chemistry, and material science;

(C) how the Center will support long-term and short-term workforce development in the quantum field;

(D) how the Center can support an innovation ecosystem to work with industry to translate Center research into applications; and

(E) a long-term plan to become self-sustaining after the expiration of Foundation support.

(5) SELECTION AND DURATION.—

(A) IN GENERAL.—The Centers selected and established under this section are authorized to carry out activities for a period of 5 years.

(B) REAPPLICATION.—An awardee may reapply for an additional, subsequent period of 5 years on a competitive, merit-reviewed basis.

(C) TERMINATION.—Consistent with the existing authorities of the Foundation, the Director of the National Science Foundation may terminate an underperforming Center for cause during the performance period.

(6) FUNDING.—The Director of the National Science Foundation shall devote \$250,000,000 to carry out this section, which shall include \$50,000,000 for each of fiscal years 2019 through 2023, subject to the availability of appropriations, to come from amounts made available for Research and Related Activities and Education and Human Resources. This section shall be carried out using funds otherwise appropriated by law after the date of enactment of this Act.

(b) GRADUATE TRAINEESHIPS.—The Director of the National Science Foundation may establish a program to provide traineeships to graduate students at institutions of higher education within the United States who are citizens of the United States and who choose to pursue masters or doctoral degrees in quantum information science.

TITLE IV—DEPARTMENT OF ENERGY RESEARCH AND NATIONAL QUANTUM INFORMATION SCIENCE RESEARCH CENTERS

SEC. 401. QUANTUM INFORMATION SCIENCE RESEARCH PROGRAM.

(a) IN GENERAL.—The Secretary of Energy shall carry out a basic research program on quantum information science.

(b) PROGRAM COMPONENTS.—In carrying out the program required under subsection (a), the Secretary shall—

(1) formulate goals for quantum information science research to be supported by the Department of Energy;

(2) leverage the collective body of knowledge from existing quantum information science research;

(3) coordinate research efforts funded through existing programs across the Office of Science; and

(4) engage with other Federal agencies, research communities, and potential users of information produced under this section.

SEC. 402. NATIONAL QUANTUM INFORMATION SCIENCE RESEARCH CENTERS.

(a) IN GENERAL.—The Secretary of Energy shall ensure that the Office of Science carries out a program, in consultation with other Federal agencies, as appropriate, to establish and operate up to 5 National Quantum Information Science Research Centers to conduct basic research to accelerate scientific breakthroughs in quantum information science and technology and to support research conducted under section 401. Such centers shall be established through a competitive, merit-reviewed process, and consider applications from National Laboratories, institutions of higher education, research centers, multi-institutional collaborations, and other appropriate entities.

(b) COLLABORATIONS.—A collaboration receiving an award under this subsection may include multiple types of research institutions and private sector entities.

(c) REQUIREMENTS.—To the maximum extent practicable, the Centers developed, constructed, operated, or maintained under this section shall serve the needs of the Department of Energy, industry, the academic community, and other relevant entities to create and develop processes for the purpose of advancing basic research in quantum information science and improving the competitiveness of the United States.

(d) COORDINATION.—The Secretary shall ensure the coordination of, and avoid unnecessary duplication of, the activities of each Center with the activities of—

(1) other research entities of the Department, including the Nanoscale Science Research Centers, the Energy Frontier Research Centers, and the Energy Innovation Hubs; and

(2) industry.

(e) SELECTION AND DURATION.—

(1) IN GENERAL.—The centers selected and established under this section are authorized to carry out activities for a period of 5 years.

(2) REAPPLICATION.—An awardee may reapply for an additional, subsequent period of 5 years on a competitive, merit-reviewed basis.

(3) **TERMINATION.**—Consistent with the existing authorities of the Department, the Secretary may terminate an underperforming Center for cause during the performance period.

(f) **FUNDING.**—The Secretary of Energy shall devote \$625,000,000 to carry out this section, which shall include \$125,000,000 for each of fiscal years 2019 through 2023, subject to the availability of appropriations, to come from amounts made available for the Office of Science. This section shall be carried out using funds otherwise appropriated by law after the date of enactment of this Act.

SEC. 403. SPENDING LIMITATION.

No additional funds are authorized to be appropriated to carry out this Act and the amendments made by this Act, and this Act and such amendments shall be carried out using amounts otherwise available for such purpose.

COMMITTEE STATEMENT AND VIEWS

PURPOSE AND SUMMARY

H.R. 6227, the “National Quantum Initiative Act,” was introduced by Chairman Lamar Smith and sponsored by Ranking Minority Member Eddie Bernice Johnson. The purpose of H.R. 6227 is to provide for a coordinated Federal program to accelerate quantum research and development for the economic and national security of the United States. The bill establishes a 10-year program to advance quantum research and technology applications and workforce development. The bill authorizes quantum activities at the National Institute of Standards and Technology (NIST), the National Science Foundation (NSF), and the Department of Energy (DOE) Office of Science.

BACKGROUND AND NEED FOR LEGISLATION

Quantum Information Science (QIS) is a multi-disciplinary field of research that is at an inflection point. Advancing current quantum science into real world applications will create scientific and technological breakthroughs that will stimulate economic growth and enhance American global competitiveness. QIS is also critical to national security, as the nation that develops quantum communications technology first will enable secure networks and possess powerful decoding capabilities.

QIS is based on exploiting subtle aspects of quantum physics, such as “quantum superposition” and “entanglement” for valuable, real-world technologies. These technologies can handle computationally complex problems, provide communication security and enhance navigation, imaging and other sensing technologies in ways that are impossible using conventional hardware.

It is vital that the United States increase and accelerate its quantum efforts to maintain the nation’s scientific and technological leadership. H.R. 6227 meets these challenges by bringing a “whole of government” approach to moving QIS to the next level of research and development through addressing fundamental research gaps, creating a stronger workforce pipeline and taking the lead in developing quantum standards and measures for global use to give U.S. companies and workers an enduring competitive advantage. The bill also encourages private sector companies, which are investing heavily in quantum research, and a wave of quantum technology start-ups, to contribute their knowledge and resources to a national effort.

H.R. 6227 establishes a National Quantum Coordination Office within the White House Office of Science and Technology Policy

(OSTP) to oversee interagency coordination, provide strategic planning support, serve as a central point of contact for stakeholders, conduct outreach and promote commercialization of federal research by the private sector. The bill authorizes research activities at NIST, NSF and DOE. H.R. 6227 also establishes up to five NSF multidisciplinary centers for quantum research and education and up to five DOE National Quantum Information Science Research Centers.

LEGISLATIVE HISTORY

On January 28, 2015, the Subcommittee on Energy held a hearing titled, “Supercomputing and American Technology Leadership.” Witnesses were: Mr. Norman Augustine, Board Member, Bipartisan Policy Center; Dr. Roscoe Giles, Chairman, DOE Advanced Scientific Computing Advisory Committee; Mr. David Turek, Vice President, Technical Computing, IBM; and Dr. James Crowley, Executive Director, Society for Industrial and Applied Mathematics.

On June 28, 2017, the Energy Subcommittee and the Research and Technology Subcommittee held a hearing titled, “Material Science: Building the Future.” Witnesses were: Dr. Matthew Tirrell, Deputy Laboratory Director for Science and Chief Research Officer, Argonne National Laboratory; Dr. Laurie Locascio, Acting Associate Director for Laboratory Programs and Director, Material Measurement Laboratory, National Institute of Standards and Technology; Dr. Adam Schwartz, Director, Ames Laboratory; Dr. Fred Higgs, John and Ann Doerr Professor of Mechanical Engineering, Rice University.

On October 24, 2017, the Energy Subcommittee and the Research and Technology Subcommittee held a hearing titled, “American Leadership in Quantum Technology.” Witnesses were: Dr. Carl J. Williams, Acting Director, Physical Measurement Laboratory, National Institute of Standards and Technology; Dr. Jim Kurose, Assistant Director, Computer and Information Science and Engineering Directorate, National Science Foundation; Dr. John Stephen Binkley, Acting Director of Science, U.S. Department of Energy; Dr. Scott Crowder, Vice President and Chief Technology Officer for Quantum Computing, IBM Systems Group; Dr. Christopher Monroe, Distinguished University Professor & Bice Zorn Professor, Department of Physics, University of Maryland and Founder, and Chief Scientist, IonQ, Inc.; and Dr. Supratik Guha, Director, Nanoscience and Technology Division, Argonne National Laboratory, and Professor, Institute for Molecular Engineering, University of Chicago.

On January 30, 2018, the Committee held a hearing titled, “Department of Energy: Management and Priorities.” Witnesses were: the Honorable Paul Dabbar, Under Secretary for Science, U.S. Department of Energy; and the Honorable Mark Menezes, Under Secretary of Energy, U.S. Department of Energy.

On March 14, 2018, the Committee held a hearing titled, “National Laboratories: World-Leading Innovation in Science.” Witnesses were: Dr. Mark Peters, Director, Idaho National Laboratory; Dr. Susan Seestrom, Advanced Science and Technology Associate Laboratory Director and Chief Research Officer, Sandia National Laboratory; Dr. Mary E. Maxon, Associate Laboratory Director for Biosciences, Lawrence Berkeley National Laboratory; Dr. Chi-

Chang Kao, Director of Stanford Linear Accelerator Center, National Accelerator Laboratory; and Dr. Paul Kearns, Director, Argonne National Laboratory.

On March 15, 2018, the Committee held a hearing titled “An Overview of the National Science Foundation Budget Proposal for Fiscal Year 2019.” Witnesses were: Dr. France Córdova, Director, National Science Foundation; and Dr. Maria T. Zuber, Chair, National Science Board.

On May 9, 2018, the Committee held a hearing titled, “An Overview of the Budget Proposal for the Department of Energy for Fiscal Year 2019.” The witness was the Honorable Rick Perry, Secretary, U.S. Department of Energy.

On June 27, 2018, the full Committee approved by voice vote H.R. 6227, the National Quantum Initiative Act, as amended.

COMMITTEE VIEWS

The potential of Quantum Information Science

The Committee believes that Quantum Information Science—the measurement, manipulation, transmission, and storage of information that is encoded in sub-atomic particle systems that can only be understood and controlled by the laws of quantum physics—is one of the most promising and exciting fields of science today. QIS involves a multitude of science and engineering disciplines, with potential applications in cybersecurity, medicine, communications, financial services and transportation.

The Committee is concerned that as other nations around the world are rapidly advancing quantum programs, the United States faces the threat of falling behind. China and the European Union are investing billions of dollars in new research facilities and equipment for quantum computing. China, in particular, has stated publicly its national goal of surpassing the U.S. during the next decade.

The Committee believes that now is the time to compose a national quantum strategy and preserve America’s dominance in the scientific world. The Committee believes that the United States must leverage the expertise and resources of U.S. industry, academia and government to move QIS to the next level of research and development. The Committee believes that the United States has an opportunity to be a world leader in quantum computing, quantum sensing, and quantum communications.

National Institute of Standards and Technology

The Committee recognizes the National Institute of Standards and Technology’s leadership role in the field of quantum information science and technology. The Committee acknowledges NIST’s current intramural and extramural research efforts that are critical to driving advancements in the field of quantum in order to maintain the Nation’s preeminence in the field.

The Committee recommends \$80,000,000 each fiscal year, for 5 years, to support NIST’s QIS activities. The Committee believes that this additional investment of \$50,000,000 a year over the current level of NIST support for QIS research will help accelerate the scientific advancements necessary to maintain United States leadership in QIS. The Committee encourages NIST to utilize such

models as public-private partnerships and industry and academic consortia to use its unique capabilities to accelerate quantum measurement science, standards development, basic research and workforce development.

National Science Foundation

The Committee recognizes that the National Science Foundation's (NSF) scientific leadership and decades of sustained support for basic research in physics, quantum mechanics, mathematics, computer science, engineering and other core fields has enabled the advances in QIS that are occurring and possible today. The Committee believes that NSF's support for innovative academic research collaborations with industry, private foundations, other agencies, as well as international collaborations, gives NSF an important leadership role in accelerating QIS research and workforce development as part of the National Quantum Initiative.

The Committee recommends \$50,000,000 each fiscal year, for five years, to establish up to five NSF Multidisciplinary Centers for Research and Education. The Committee believes that this should supplement important core research NSF is already supporting in QIS research and education activities. The Committee has not recommended an overall allocation for QIS research for NSF. The Committee believes that NSF supports many multidisciplinary research projects that contribute to the knowledge of QIS and an overall recommended level could be unintentionally limiting to NSF and its research over the next five years.

Department of Energy

The Committee recognizes DOE's capabilities, research infrastructure, and expertise in materials science, physics, applied mathematics, and computer science provide a foundation for significant advances in QIS research and technological development. In particular, the DOE National Laboratories, which operate world-class, open-access user facilities around the country, provide access to the supercomputers, x-ray light sources, photon sources, and neutron sources that are necessary to conduct ground-breaking quantum research. The Committee supports DOE's current efforts to increase investment in QIS across the Office of Science, including for proposed programs in Biological and Environmental Research, High Energy Physics, Nuclear Physics, Basic Energy Sciences, and Advanced Scientific Computing Research (ASCR), as requested in the President's fiscal year 2019 Budget.

The Committee also recommends the establishment of up to five National Quantum Information Science Research Centers, which will support the DOE Office of Science's basic research mission by convening talented groups of researchers in order to conduct basic research and accelerate scientific breakthroughs in quantum information science and technology. The Committee recommends \$125,000,000 each fiscal year, for five years, to establish and operate these centers. The Committee encourages DOE to consider a cross-cutting research approach to ensure coordination of QIS research across the Office of Science and effective engagement with the research community and industry.

The Committee acknowledges the contributions of the following reports: the Basic Energy Sciences Advisory Committee (BESAC)

“Grand Challenges” report; the BESAC “From Quanta to the Continuum: Opportunities for Mesoscale Science” report; and the 2015 publication of the Office of Science Quantum Computing Working Group titled, “ASCR Report on Quantum Computing for Science.”

Quantum computing resources

The Committee believes that federal research agencies, through their quantum research programs and the new NSF and DOE Centers, should utilize existing or new prototype quantum computers and communications systems for federally funded research. The Committee believes that the most transformative QIS technology will likely be the quantum computer, with its ability to solve certain problems that can never be approached with conventional devices.

SECTION-BY-SECTION

TITLE I—NATIONAL QUANTUM INITIATIVE

Sec. 1. Short title; Table of contents

This section establishes the short title for the bill as the “National Quantum Initiative Act.”

Sec. 2. Definitions

This section defines the terms “Advisory Committee,” “Coordination Office,” “institutions of higher education,” “Program,” “quantum information science,” and “Subcommittee.”

Sec. 3. Purposes

This section outlines the purposes of the Act in promoting U.S. leadership in quantum information science and technology by supporting research and development, as well as improving interagency planning and coordination within Federal programs, promoting collaboration among government, Federal laboratories, industry, and universities, as well as promoting the development of standards for quantum information science and technology security.

Sec. 101. National Quantum Initiative Program

This section directs the President to implement a 10-year National Quantum Initiative Program. The Program will establish goals, priorities, and metrics for quantum science and technology in the U.S., invest in Federal quantum research and development, develop a quantum workforce pipeline, provide for interagency coordination of Federal quantum information science, research, and development, as well as partner with industry and academia to leverage knowledge and resources.

Sec. 102. National Quantum Coordination Office

This section establishes a National Quantum Coordination Office within the White House Office of Science and Technology Policy. The Office will provide technical and administrative support to the Subcommittee and the Advisory Committee, oversee interagency coordination, serve as the point of contact on Federal civilian quantum information science and technology activities, including public

outreach and dissemination of findings and recommendations, promote access to and early application of technologies, innovations, and expertise derived from quantum activities, and promote access to existing quantum computing and communications systems for research. This section also directs funding for the Coordination Office come from funds made available by the participating agencies of the Subcommittee, as recommended by the Director of the Office of Science and Technology Policy.

Sec. 103. Subcommittee on Quantum Information Science

This section directs the President to establish a Subcommittee on Quantum Information Science of the National Science and Technology Council. The Subcommittee shall include OSTP, NIST, NSF, DOE, the National Aeronautics and Space Administration, the Department of Defense, the Office of the Director of National Intelligence, the Office of Management and Budget, and any other federal agencies designated by the President. The Subcommittee will be co-chaired by the NIST Director, NSF Director, and the DOE Secretary. The Subcommittee will coordinate QIS among the Federal agencies, establish the Program's goals and priorities, recommend Federal infrastructure needs, and evaluate opportunities for international cooperation on quantum research. This section directs the Subcommittee to develop a five-year strategic plan, and another five-year strategic plan, six years after enactment. This section requires the Subcommittee Chairs to submit reports to the President, the Advisory Committee, and Congress.

Sec. 104. National Quantum Initiative Advisory Committee

This section directs the President to establish a National Quantum Initiative Advisory Committee comprised of members from industry, academia, and Federal laboratories. Specific qualifications and criteria for membership consideration are also outlined in this section. The Advisory Committee will advise the President and the Subcommittee and make recommendations that shall be considered in reviewing and revising the Program, including independent assessments outlined in this section. A report is due to the President within one year of enactment, and subsequently once every two years, on the assessments required, as well as any recommendations to improve the Program.

Sec. 105. Sunset

This section terminates authority to carry out the National Quantum Initiative Program, the National Quantum Coordination Office, the National Quantum NSTC Subcommittee, and the National Quantum Initiative Advisory Committee 11 years after enactment. The President can extend the activities of these programs if they are necessary to meet national economic and security needs.

TITLE II—NATIONAL INSTITUTE OF STANDARDS AND
TECHNOLOGY QUANTUM ACTIVITIES

Sec. 201. National Institute of Standards and Technology Activities and Quantum Workshop

This section directs NIST to continue to support quantum information science and technology research and development of meas-

urement and standards infrastructure necessary to advance deployment of commercial quantum applications, establishes or expands collaborations with public or private sector entities, and grants authority to enter into contracts or other transactions for quantum research and development. This section also requires NIST to convene a workshop of stakeholders within one year of enactment to discuss the future measurement, standards, cybersecurity, and other needs for supporting the development of the quantum information science and technology industry in the United States. A report is also required within two years of enactment on the findings of the workshop. This section authorizes \$400,000,000 to carry out the section over five years, which shall include \$80,000,000 for each fiscal year 2019 through 2023.

TITLE III—NATIONAL SCIENCE FOUNDATION AND MULTIDISCIPLINARY CENTERS FOR QUANTUM RESEARCH AND EDUCATION

Sec. 301. Quantum information science research and education program

This section directs the NSF Director to carry out a basic research and education program on quantum information science and engineering. It directs the NSF Director to continue to support interdisciplinary QIS research and human resource development, use existing programs at NSF to improve the teaching and learning of QIS, increase participation of underrepresented individuals in the quantum fields, formulate NSF's goals for quantum research, coordinate research efforts across the Foundation, and engage with other Federal agencies.

Sec. 302. Multidisciplinary Centers for Quantum Research and Education

This section directs the NSF Director to award grants to eligible entities to establish up to five Multidisciplinary Centers for Quantum Research and Education. The purpose of the Centers is to conduct basic research and education activities in support of the Program. The section specifies requirements for Center applications. Centers are authorized for five years and can reapply for five additional years on a competitive, merit-based process. This section authorizes \$250,000,000 to support the Centers, which shall include \$50,000,000 for each fiscal years 2019 through 2023. This section also authorizes the NSF Director to establish a traineeship program for U.S. citizen graduate students at U.S. institutions of higher education in QIS.

TITLE IV—DEPARTMENT OF ENERGY RESEARCH AND NATIONAL QUANTUM INFORMATION SCIENCE RESEARCH CENTERS

Sec. 401. Quantum information science research program

This section directs the Secretary of Energy to carry out a basic research program on quantum information science. This program will formulate scientific goals for QIS basic research in the U.S., utilize the collective knowledge from existing quantum research,

coordinate research efforts across the DOE Office of Science, and engage users of the quantum information produced.

Sec. 402. National Quantum Information Science Research Centers

This section directs the DOE Office of Science to establish and operate up to five National Quantum Information Science Research Centers to conduct basic research to accelerate scientific breakthroughs in quantum information science and technology. This section also outlines criteria for establishment, collaborations, and other requirements. The Centers are directed to carry out activities for a period of five years. This section authorizes appropriations of \$625,000,000 over five years for the Office of Science to carry out this section, which shall include \$125,000,000 for each fiscal years 2019 through 2023.

Sec. 403. Spending limitation

No additional funds are authorized to be appropriated to carry out this Act and its amendments, and shall be carried out using amounts otherwise available for such purpose.

EXPLANATION OF AMENDMENTS

An amendment offered by Representative Randy Hultgren was adopted by the Committee. The amendment adds to the Coordination Office responsibility for promoting access to existing quantum systems for research.

COMMITTEE CONSIDERATION

On June 27, 2018, the Committee met in open session and ordered reported favorably the bill, H.R. 6227, as amended, by voice vote, a quorum being present.

APPLICATION OF LAW TO THE LEGISLATIVE BRANCH

Section 102(b)(3) of Public Law 104–1 requires a description of the application of this bill to the legislative branch where the bill relates to the terms and conditions of employment or access to public services and accommodations. This bill provides for a coordinated Federal program to accelerate quantum research and development for the economic and national security of the United States. As such this bill does not relate to employment or access to public services and accommodations.

Legislative branch employees and their families, to the extent that they are otherwise eligible for the benefits provided by this legislation, have equal access to its benefits.

STATEMENT OF OVERSIGHT FINDINGS AND RECOMMENDATIONS OF
THE COMMITTEE

In compliance with clause 3(c)(1) of rule XIII and clause (2)(b)(1) of rule X of the rules of the House of Representatives, the Committee's oversight findings and recommendations are reflected in the descriptive portions of this report.

STATEMENT OF GENERAL PERFORMANCE GOALS AND OBJECTIVES

H.R. 6227, the National Quantum Initiative Act, will accelerate quantum research and development for the United States' economic and national security.

DUPLICATION OF FEDERAL PROGRAMS

No provision of H.R. 6227 establishes or reauthorizes a program of the Federal Government known to be duplicative of another Federal program, a program that was included in any report from the Government Accountability Office to Congress pursuant to section 21 of Public Law 111-139, or a program related to a program identified in the most recent Catalog of Federal Domestic Assistance.

DISCLOSURE OF DIRECTED RULE MAKINGS

The Committee estimates that enacting H.R. 6227 does not direct the completion of any specific rule makings within the meaning of 5 U.S.C. 551.

FEDERAL ADVISORY COMMITTEE ACT

The Committee finds that the legislation does not establish or authorize the establishment of an advisory committee within the definition of 5 U.S.C. App., Section 5(b).

UNFUNDED MANDATE STATEMENT

Section 423 of the Congressional Budget and Impoundment Control Act (as amended by Section 101(a)(2) of the Unfunded Mandate Reform Act, P.L. 104-4) requires a statement as to whether the provisions of the reported include unfunded mandates. In compliance with this requirement the Committee has received a letter from the Congressional Budget Office included herein.

EARMARK IDENTIFICATION

H.R. 6227 does not include any congressional earmarks, limited tax benefits, or limited tariff benefits as defined in clause 9 of rule XXI.

COMMITTEE ESTIMATE

Clause 3(d)(2) of rule XIII of the Rules of the House of Representatives requires an estimate and a comparison by the Committee of the costs that would be incurred in carrying out H.R. 6227. However, clause 3(d)(3)(B) of that rule provides that this requirement does not apply when the Committee has included in its report a timely submitted cost estimate of the bill prepared by the Director of the Congressional Budget Office under section 402 of the Congressional Budget Act.

BUDGET AUTHORITY AND CONGRESSIONAL BUDGET OFFICE COST ESTIMATE

With respect to the requirements of clause 3(c)(2) of rule XIII of the Rules of the House of Representatives and section 308(a) of the Congressional Budget Act of 1974 and with respect to requirements of clause (3)(c)(3) of rule XIII of the Rules of the House of Rep-

representatives and section 402 of the Congressional Budget Act of 1974, the Committee has received the following cost estimate for H.R. 6227 from the Director of Congressional Budget Office:

U.S. CONGRESS,
CONGRESSIONAL BUDGET OFFICE,
Washington, DC, July 20, 2018.

Hon. LAMAR SMITH,
*Chairman, Committee on Science, Space, and Technology,
House of Representatives, Washington, DC.*

DEAR MR. CHAIRMAN: The Congressional Budget Office has prepared the enclosed cost estimate for H.R. 6227, the National Quantum Initiative Act.

If you wish further details on this estimate, we will be pleased to provide them. The CBO staff contact is Janani Shankaran.

Sincerely,

MARK P. HADLEY
(For Keith Hall, Director).

Enclosure.

H.R. 6227—National Quantum Initiative Act

Summary: H.R. 6227 would establish an office and a program to advance research in quantum information science and technology applications. The bill would authorize the appropriations for the Department of Energy (DOE), the National Institute of Standards and Technology (NIST), and the National Science Foundation (NSF) to carry out related activities. CBO estimates that implementing H.R. 6227 would cost \$1.1 billion over the 2019–2023 period, assuming appropriation of the authorized and necessary amounts.

Enacting the bill would not affect direct spending or revenues; therefore, pay-as-you-go procedures do not apply.

CBO estimates that enacting H.R. 6227 would not increase net direct spending or on-budget deficits in any of the four consecutive 10-year periods beginning in 2029.

H.R. 6227 contains no intergovernmental or private-sector mandates as defined in the Unfunded Mandates Reform Act (UMRA).

Estimated cost to the Federal Government: The estimated budgetary effect of H.R. 6227 is shown in the following table. The costs of the legislation fall within budget functions 250 (science, space, and technology) and 370 (commerce and housing credit).

	By fiscal year, in millions of dollars—						
	2018	2019	2020	2021	2022	2023	2019–2023
INCREASES IN SPENDING SUBJECT TO APPROPRIATION							
Department of Energy:							
Authorization Level	0	125	125	125	125	125	625
Estimated Outlays	0	69	106	125	125	125	550
National Institute of Standards and Technology:							
Authorization Level	0	80	80	80	80	80	400
Estimated Outlays	0	62	78	80	80	80	380
National Science Foundation:							
Authorization Level	0	50	50	50	50	50	250
Estimated Outlays	0	6	24	37	44	49	160
National Quantum Coordination Office:							
Estimated Authorization Level	0	1	1	1	1	1	5

	By fiscal year, in millions of dollars—						
	2018	2019	2020	2021	2022	2023	2019–2023
Estimated Outlays	0	1	1	1	1	1	5
Total:							
Estimated Authorization Level	0	256	256	256	256	256	1,280
Estimated Outlays	0	138	209	243	250	255	1,095

Basis of estimate: For this estimate, CBO assumes the legislation will be enacted near the end of 2018. Section 403 of the bill states that no additional funds are authorized to be appropriated by H.R. 6227. In CBO's view, however, the bill effectively authorizes the appropriation of specified amounts by directing agencies to fund certain activities.

H.R. 6227 effectively would authorize appropriations totaling \$1.3 billion over the 2019–2023 period for the following agencies:

- \$125 million annually for DOE to carry out basic research and establish and operate quantum information science research centers;
- \$80 million annually for NIST to expand quantum research and advance commercial development of quantum applications; and
- \$50 million annually for the NSF to carry out a quantum research and education program and to award grants to non-profit organizations and institutions of higher education.

According to a Congressional Research Service report, in recent years the federal government has spent between \$200 million and \$250 million annually on quantum information science research and development.¹ DOE, NIST, and NSF received appropriations in 2018 for such activities. Under current law, no specific sums are authorized to be appropriated to those agencies for those purposes.

H.R. 6227 also would direct the President to establish a national quantum coordination office to manage interagency activities and conduct public outreach. Under the bill, the office would be staffed by employees detailed from federal agencies such as DOE, NIST, the NSF, the Department of Defense, the Office of Management and Budget, and the National Aeronautics and Space Administration. Based on programs of similar size and scope, CBO estimates that the office would require five full-time employees annually at a cost of about \$150,000 each. The bill also would establish an advisory committee of representatives from industry, academic institutions, and federal laboratories, whose travel expenses could be reimbursed. CBO estimates that such expenses would be insignificant in any year. In total, CBO estimates that implementing the bill's staffing provisions would cost \$1 million annually.

Based on historical spending patterns for similar activities, and assuming appropriation of the authorized and necessary amounts, CBO estimates that enacting H.R. 6227 would cost \$1.1 billion over the 2019–2023 period.

Pay-As-You-Go considerations: None.

Increase in long-term direct spending and deficits: CBO estimates that enacting H.R. 6227 would not increase net direct spend-

¹Congressional Research Service, *Federal Quantum Information Science: An Overview* (July 2, 2018).

ing or on-budget deficits in any of the four consecutive 10-year periods beginning in 2029.

Mandates: H.R. 6227 contains no intergovernmental or private-sector mandates as defined in UMRA.

Estimate prepared by: Federal Costs: Janani Shankaran (Department of Energy and National Science Foundation), Stephen Rabent (National Institute of Standards and Technology); Mandates: Jon Sperl.

Estimate reviewed by: Kim P. Cawley, Chief, Natural and Physical Resources Cost Estimates Unit; H. Samuel Papenfuss, Deputy Assistant Director for Budget Analysis.

