AMENDMENT NO._____ Calendar No._____

Purpose: In the nature of a substitute.

IN THE SENATE OF THE UNITED STATES—115th Cong., 2d Sess.

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.

Referred to the Committee on _____ and ordered to be printed

Ordered to lie on the table and to be printed

AMENDMENT IN THE NATURE OF A SUBSTITUTE intended to be proposed by Mr. THUNE (for himself and Mr. NELSON)

Viz:

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.—The table of contents of this Act is as follows:

SEC. 2. DEFINITIONS.

In this Act:

(1) ADVISORY COMMITTEE.—The term "Advisory Committee" means the National Quantum Initiative Advisory Committee established under section 104(a).

(2) APPROPRIATE COMMITTEES OF CONGRESS.—The term "appropriate committees of Congress" means—

(A) the Committee on Commerce, Science, and Transportation of the Senate;

(B) the Committee on Energy and Natural Resources of the Senate; and

(C) the Committee on Science, Space, and Technology of the House of Representatives.

(3) COORDINATION OFFICE.—The term "Coordination Office" means the National Quantum Coordination Office established under section 102(a).

(4) INSTITUTION OF HIGHER EDUCATION.—The term "institution 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)).

(5) PROGRAM.—The term "Program" means the National Quantum Initiative Program implemented under section 101(a).

(6) QUANTUM INFORMATION SCIENCE.—The term "quantum information science" means the use of the laws of quantum physics for the storage, transmission, manipulation, computing, or measurement of information.

(7) 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 purpose of this Act is 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—

(A) to expand the number of researchers, educators, and students with training in quantum information science and technology to develop a workforce pipeline;

(B) to promote the development and inclusion of multidisciplinary curriculum and research opportunities for quantum information science at the undergraduate, graduate, and postdoctoral level;

(C) to address basic research knowledge gaps, including computational research gaps;

(D) to promote the further development of facilities and centers available for quantum information science and technology research, testing and education; and

(E) to 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;

(3) maximizing the effectiveness of the Federal Government's quantum information science and technology research , development, and demonstration programs;

(4) promoting collaboration among the Federal Government, Federal laboratories, industry, and universities; and

(5) promoting the development of international standards for quantum information science and technology security—

(A) to facilitate technology innovation and private sector commercialization; and

(B) to meet economic and national security goals.

TITLE I—NATIONAL QUANTUM INITIATIVE

SEC. 101. NATIONAL QUANTUM INITIATIVE PROGRAM.

(a) IN GENERAL.—The President shall implement a National Quantum Initiative Program.

(b) REQUIREMENTS.—In carrying out the Program, the President, acting through Federal agencies, councils, working groups, subcommittees, and the Coordination Office, as the President considers appropriate, shall—

(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 under paragraph (1);

(3) invest in activities to develop a quantum information science and technology workforce pipeline;

(4) provide for interagency planning and coordination of Federal quantum information science and technology research, development, demonstration, standards engagement, and other activities under the Program;

(5) partner with industry and universities to leverage knowledge and resources; and

(6) leverage existing Federal investments efficiently to advance Program goals and priorities established under paragraph (1).

SEC. 102. NATIONAL QUANTUM COORDINATION OFFICE.

(a) ESTABLISHMENT.—

(1) IN GENERAL.—The President shall establish a National Quantum Coordination Office.

(2) ADMINISTRATION.—The Coordination Office shall have—

(A) 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

(B) staff comprised of employees detailed from the Federal departments and agencies described in section 103(b).

(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 by encouraging and supporting joint agency solicitation and selection of applications for funding of activities under the Program;

(3) serve as the point of contact on Federal civilian quantum information science and technology activities for Federal departments and agencies, industry, universities professional societies, State governments, and such other persons as the Coordination Office considers appropriate to exchange technical and programmatic information;

(4) ensure coordination among the collaborative ventures or consortia established under section 201(a), 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 the 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 industry, including startup companies; and

(7) promote access, through appropriate Federal Government agencies, and an open and competitive merit-reviewed process, to existing quantum computing and communication systems developed by industry, universities, 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 Federal departments and agencies

described in section 103(b), 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, the Subcommittee on Quantum Information Science.

(b) MEMBERSHIP.—The Subcommittee shall include a representative of—

(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) such other Federal department or agency as the President considers appropriate.

(c) CHAIRPERSONS.—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, information sharing about international standards development and use, 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;

(4) assess the status, development, and diversity of the United States quantum information science workforce;

(5) assess the global outlook for quantum information science research and development efforts;

(6) evaluate opportunities for international cooperation with strategic allies on research and development in quantum information science and technology; and

(7) propose a coordinated interagency budget for the Program to the Office of Management and Budget to ensure the maintenance of a balanced

quantum information science research portfolio and an appropriate level of research effort.

(e) STRATEGIC PLANS.—In order to guide the activities of the Program and meet the goals, priorities, and anticipated outcomes of the Federal departments and agencies described in subsection (b), the Subcommittee shall—

(1) not later than 1 year after the date of enactment of this Act, develop a 5-year strategic plan;

(2) not later than 6 years after the date of enactment of this Act, develop a subsequent 5-year strategic plan; and

(3) periodically update each plan, as necessary.

(f) SUBMITTAL TO CONGRESS.—The chairpersons of the Subcommittee shall submit to the President, the Advisory Committee, and the appropriate committees of Congress each strategic plan developed under subsection (e) and any updates thereto.

(g) ANNUAL PROGRAM BUDGET REPORT.—

(1) IN GENERAL.—Each year, concurrent with the annual budget request submitted by the President to Congress under section 1105 of title 31, United States Code, the chairpersons of the Subcommittee shall submit to the appropriate committees of Congress and such other committees of Con-

gress as the chairpersons deem appropriate a report on the budget for the Program.

(2) CONTENTS.—Each report submitted under paragraph (1) shall include the following:

(A) The budget of the Program for the current fiscal year, for each Federal department and agency described in subsection (b).

(B) The budget proposed for the Program for the next fiscal year, for each Federal department and agency described in subsection (b).

(C) An analysis of the progress made toward achieving the goals and priorities established under subsection (d)(2).

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 shall consist of members, appointed by the President, who are representative of industry, universities, and Federal laboratories and are qualified to provide advice and information on quantum information science and technology research, development, demonstrations, standards, edu-

cation, technology transfer, commercial application, or national security and economic concerns.

(c) MEMBERSHIP CONSIDERATION.—In selecting the members of the 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 universities), the defense community, and other appropriate organizations.

(d) DUTIES.—

(1) IN GENERAL.—The Advisory Committee shall advise the President and the Subcommittee and make recommendations for the President to consider when reviewing and revising the Program.

(2) INDEPENDENT ASSESSMENTS.—The Advisory Committee shall conduct periodic, independent assessments of—

(A) any trends or developments in quantum information science and technology;

(B) the progress made in implementing the Program;

(C) the management, coordination, implementation, and activities of the Program;

(D) whether the Program activities and the goals and priorities established under sec-

tion 103(d)(2) are helping to maintain United States leadership in quantum information science and technology;

(E) whether a need exists to revise the Program;

(F) whether opportunities exist for international cooperation with strategic allies on research and development in, and the development of open standards for, quantum information science and technology; and

(G) whether national security, societal, economic, legal, and workforce concerns are adequately addressed by the Program.

(e) REPORTS.—Not later than 180 days after the date of enactment of this Act, and at least biennially thereafter, the Advisory Committee shall submit to the President, the appropriate committees of Congress, and such other committees of Congress as the Advisory Committee deems appropriate a report on the findings of the independent assessment under subsection (d), including any recommendations for improvements to the Program.

(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) FACA 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 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 CONSORTIUM.

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

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

(2) shall use the existing programs of the National Institute of Standards and Technology, in collaboration with other Federal departments and agencies, as appropriate, to train scientists in quantum information science and technology to increase participation in the quantum fields;

(3) shall establish or expand collaborative ventures or consortia with other public or private sector entities, including industry, universities, and Federal

laboratories for the purpose of advancing the field of quantum information science and engineering; and

(4) may 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 National Institute of Standards and Technology and on such terms as the Director considers appropriate, in furtherance of the purposes of this Act.

(b) QUANTUM CONSORTIUM.—

(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 consortium of stakeholders to identify 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.

(2) GOALS.—The goals of the consortium shall be—

(A) to assess the current research on the needs identified in paragraph (1);

(B) to identify any gaps in the research necessary to meet the needs identified in paragraph (1); and

(C) to provide recommendations on how the National Institute of Standards and Technology and the Program can address the gaps in the necessary research identified in subparagraph (B).

(3) 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 submit to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Science, Space, and Technology of the House of Representatives a report summarizing the findings of the consortium.

(c) FUNDING.—The Director of the National Institute of Standards and Technology shall allocate up to $80,000,000 to carry out the activities under this section for each of fiscal years 2019 through 2023, subject to the availability of appropriations. Amounts made available to carry out this section shall be derived from amounts appropriated or otherwise made available to the National Institute of Standards and Technology.

TITLE III—NATIONAL SCIENCE FOUNDATION QUANTUM ACTIVITIES

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, including the competitive award of grants to institutions of higher education or eligible nonprofit organizations (or consortia thereof).

(b) PROGRAM COMPONENTS.—

(1) IN GENERAL.—In carrying out the program under subsection (a), the Director of the National Science Foundation shall carry out activities that—

(A) support basic interdisciplinary quantum information science and engineering research; and

(B) support human resources development in all aspects of quantum information science and engineering.

(2) REQUIREMENTS.—The activities described in paragraph (1) shall include—

(A) using the existing programs of the National Science Foundation, in collaboration with

other Federal departments and agencies, as appropriate—

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

(ii) to 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, 1885b);

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

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

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

(E) engaging with other Federal departments and agencies, research communities, and

potential users of information produced under this section.

(c) 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.

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

(a) IN GENERAL.—The Director of the National Science Foundation, in consultation with other Federal departments and agencies, as appropriate, shall award grants to institutions of higher education or eligible nonprofit organizations (or consortia thereof) to establish at least 2, but not more than 5, Multidisciplinary Centers for Quantum Research and Education (referred to in this section as "Centers").

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

(c) PURPOSE.—The purpose of the Centers shall be to conduct basic research and education activities in sup-

port of the goals and priorities established under section 103(d)(2), including by—

(1) continuing to advance quantum information science and engineering;

(2) supporting curriculum and workforce development in quantum information science and engineering; and

(3) fostering innovation by bringing industry perspectives to quantum research and workforce development, including by leveraging industry knowledge and resources.

(d) REQUIREMENTS.—

(1) IN GENERAL.—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 of the National Science Foundation at such time, in such manner, and containing such information as the Director may require.

(2) APPLICATIONS.—Each application under paragraph (1) shall include a description of—

(A) how the Center will work with other research institutions and industry partners to leverage expertise in quantum science, edu-

cation 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 funding under this section.

(e) SELECTION AND DURATION.—

(1) IN GENERAL.—Each Center established under this section is authorized to carry out activities for a period of 5 years.

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

(3) TERMINATION.—Consistent with the authorities of the National Science Foundation, the Di-

rector of the National Science Foundation may terminate an underperforming Center for cause during the performance period.

(f) FUNDING.—The Director of the National Science Foundation shall allocate up to $10,000,000 for each Center established under this section for each of fiscal years 2019 through 2023, subject to the availability of appropriations. Amounts made available to carry out this section shall be derived from amounts appropriated or otherwise made available to the National Science Foundation.

TITLE IV—DEPARTMENT OF ENERGY QUANTUM ACTIVITIES

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 under subsection (a), the Secretary of Energy 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) provide research experiences and training for additional undergraduate and graduate students in quantum information science, including in the fields of—

(A) quantum information theory;

(B) quantum physics;

(C) quantum computational science;

(D) applied mathematics and algorithm development;

(E) quantum networking;

(F) quantum sensing and detection; and

(G) materials science and engineering;

(4) coordinate research efforts funded through existing programs across the Department of Energy, including—

(A) the Nanoscale Science Research Centers;

(B) the Energy Frontier Research Centers;

(C) the Energy Innovation Hubs;

(D) the National Laboratories;

(E) the Advanced Research Projects Agency; and

(F) the National Quantum Information Science Research Centers; and

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

SEC. 402. NATIONAL QUANTUM INFORMATION SCIENCE RESEARCH CENTERS.

(a) ESTABLISHMENT.—

(1) IN GENERAL.—The Secretary of Energy, acting through the Director of the Office of Science (referred to in this section as the "Director"), shall ensure that the Office of Science carries out a program, in consultation with other Federal departments and agencies, as appropriate, to establish and operate at least 2, but not more than 5, National Quantum Information Science Research Centers (referred to in this section as "Centers") to conduct basic research to accelerate scientific breakthroughs in quantum information science and technology and to support research conducted under section 401.

(2) REQUIREMENTS.—

(A) COMPETITIVE, MERIT-REVIEWED PROCESS.—The Centers shall be established through a competitive, merit-reviewed process.

(B) APPLICATIONS.—An eligible applicant under this subsection shall submit to the Director an application at such time, in such man-

ner, and containing such information as the Director determines to be appropriate.

(C) ELIGIBLE APPLICANTS.—The Director shall consider applications from National Laboratories, institutions of higher education, research centers, multi-institutional collaborations, and any other entity that the Secretary of Energy determines to be appropriate.

(b) COLLABORATIONS.—A collaboration that receives an award under this section 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 of Energy shall ensure the coordination, and avoid unnecessary duplication, of the activities of each Center with the activities of—

(1) other research entities of the Department of Energy, including—

(A) the Nanoscale Science Research Centers;

(B) the Energy Frontier Research Centers;

(C) the Energy Innovation Hubs; and

(D) the National Laboratories;

(2) institutions of higher education; and

(3) industry.

(e) DURATION.—

(1) IN GENERAL.—Each Center established under this section is authorized to carry out activities for a period of 5 years.

(2) REAPPLICATION.—An awardee may reapply for additional, subsequent periods of 5 years. The Director shall approve or disapprove of each reapplication on a competitive, merit-reviewed basis.

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

(f) FUNDING.—The Secretary of Energy shall allocate up to $25,000,000 for each Center established under this section for each of fiscal years 2019 through 2023, subject to the availability of appropriations. Amounts made available to carry out this section shall be derived

from amounts appropriated or otherwise made available to the Department of Energy.