KEEPING AMERICA FIRST: FEDERAL INVESTMENTS IN RESEARCH, SCIENCE, AND TECHNOLOGY AT NSF, NIST, OSTP, AND INTERAGENCY STEM PROGRAMS

HEARING

BEFORE THE

SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

ONE HUNDRED THIRTEENTH CONGRESS

FIRST SESSION

NOVEMBER 13, 2013

Serial No. 113–53

Printed for the use of the Committee on Science, Space, and Technology

Available via the World Wide Web: http://science.house.gov

U.S. GOVERNMENT PRINTING OFFICE

86–891PDF WASHINGTON : 2013

For sale by the Superintendent of Documents, U.S. Government Printing Office
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CONTENTS

November 13, 2013

KEEPING AMERICA FIRST: FEDERAL INVESTMENTS IN RESEARCH, SCIENCE, AND TECHNOLOGY AT NSF, NIST, OSTP, AND INTERAGENCY STEM PROGRAMS

WEDNESDAY, NOVEMBER 13, 2013

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Subcommittee met, pursuant to call, at 10:03 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Larry Bucshon [Chairman of the Subcommittee] presiding.

LAMAR S. SMITH, Texas
CHAIRMAN

EDDIE BERNICE JOHNSON, Texas
RANKING MEMBER

Congress of the United States
House of Representatives
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Subcommittee on Research and Technology

Keeping America FIRST: Federal Investments in Research, Science, and Technology at NSF, NIST, OSTP and Interagency STEM Programs

Wednesday, November 13, 2013
10:00 a.m. to 12:00 p.m.
2318 Rayburn House Office Building

Witnesses

Dr. Richard Buckius, Vice President for Research, Purdue University

Dr. Daniel Sarewitz, Co-Director, Consortium for Science, Policy & Outcomes, Professor of Science and Society, Arizona State University

Dr. Timothy Killeen, President, The Research Foundation for SUNY, Vice Chancellor for Research, SUNY System Administration

Mr. James Brown, Executive Director, STEM Education Coalition

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY

HEARING CHARTER

Keeping America FIRST: Federal Investments in Research, Science, and Technology at NSF, NIST, OSTP and interagency STEM Programs

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Purpose

On November 13th, the Research and Technology Subcommittee will hold a hearing to examine the fundamental science and research activities at the National Science Foundation (NSF), National Institutes for Standards and Technology (NIST), and the Office of Science and Technology Policy (OSTP). The coordination of Science, Technology, Engineering and Mathematics (STEM) education programs across several federal agencies will also be examined during this hearing. Witnesses have been asked to testify on their perspectives about a discussion draft of legislation entitled the Frontiers in Innovative Research, Science, and Technology (or FIRST) Act (see attached Discussion Draft).

Witnesses

Dr. Richard Buckius, Vice President for Research, Purdue University

Dr. Daniel Sarewitz, Co-Director, Consortium for Science, Policy & Outcomes, Professor of Science and Society, Arizona State University

Dr. Timothy Killeen, President, The Research Foundation for SUNY, Vice Chancellor for Research, SUNY System Administration

Mr. James Brown, Executive Director, STEM Education Coalition

Overview

National Science Foundation (NSF)

The NSF is the primary source of federal funding for non-medical basic research. The NSF is the major source of federal funding for many fields of scientific endeavor. Through more than 11,700 competitive awards per year, NSF supports an average of 326,000 scientists, engineers, educators and students at universities, laboratories and field sites all over the U.S. and

throughout the world. These grants fund specific research proposals that have been judged the most promising by a merit-review system.

NSF's research and education activities can be divided into 6 major funding areas:

Research and Related Activities (RRA) comprises the majority of the Foundation's activities and budget by funding research in biological sciences, computer science, engineering, geosciences, mathematics, physical sciences, and the social sciences. Additional research activities include funding of international and integrative activities, and the U.S. Artic Research Commission. Research awards are awarded from a competitive, merit-review process.

Education and Human Resources (EHR) supports the preparation of a diverse, globally competent STEM workforce and a STEM-literate citizenry through investment in research and development on STEM education and learning.

Major Research Equipment and Facilities Construction (MREFC) is responsible for funding the construction of large research facilities, ranging from ground-based telescopes to research ships. Funding for the design, operation and management of these major user facilities is included in the RRA budget.

Agency Operations and Award Management (AOAM) funds all internal operations of NSF.

National Science Board (NSB) is responsible for establishing policies for NSF and for providing national science policy advice to the President and Congress.

Office of the Inspector General (OIG) conducts and supervises audits and investigations of NSF programs, evaluates allegations of research misconduct, and issues reports to the NSB, Foundation, and Congress regarding problems, corrective actions, and progress towards improving the management and conduct of NSF programs.

Federal STEM Education Programs and Activities

The Administration's FY14 budget request, released in April 2013, included a proposal to reorganize STEM education programs across the federal government. The proposal would decrease the number of federal STEM programs from 236 to 110, with 126 programs either eliminated or consolidated into existing programs and grow the number of agencies with federal STEM programs from 13 to 14, to include the Smithsonian Institution. The proposal identified the U.S. Department of Education as the lead for K-12 instruction and the National Science Foundation (NSF) as the lead on undergraduate and graduate STEM education. The Smithsonian Institution would lead the Administration's work on informal education activities, activities that take place outside the classroom. The Committee held a hearing in June 2013 to review the Administration's proposal.[1]

[1] http://science.house.gov/hearing/full-committee-hearing-stem-education-administration%E2%80%99s-proposed-re-organization

The 2010 COMPETES Act (P.L. 111-358) included a number of requirements for the review and coordination of federal STEM programs. The Act required the National Science and Technology Council, an interagency group led by the White House Office of Science and Technology Policy, to form a Committee on STEM (CoSTEM) to develop and implement a 5-year strategic plan. CoSTEM released an inventory of federal STEM programs in December 2011 and the final Strategic Plan was released in May 2013, over a month after the reorganization was proposed.

Prior to completing the Strategic Plan, CoSTEM released a progress report in February 2012. In the progress report CoSTEM found among the hundreds of federally-funded STEM activities identified in the report that none had the same objectives, target audiences, products, or STEM fields of focus. The report acknowledged that "this conclusion should not be interpreted to mean there are no opportunities for improving the alignment, deployment, and efficiency of federal STEM education investments."[2]

Office of Science and Technology Policy (OSTP)

The National Science and Technology Policy, Organization, and Priorities Act of 1976 authorized the establishment of the Office Science and Technology Policy (OSTP) to specifically advise the President on science and technology policy issues. OSTP also leads interagency efforts to development and implement science and technology budgets and to coordinate science education efforts.

The mission of OSTP has several aspects: "first, to provide the President and his senior staff with accurate, relevant, and timely scientific and technical advice on all matters of consequence; second, to ensure that the policies of the Executive Branch are informed by sound science; and third, to ensure that the scientific and technical work of the Executive Branch is properly coordinated so as to provide the greatest benefit to society."[3]

National Institute of Standards and Technology (NIST)

NIST is a non-regulatory agency within the Department of Commerce. Originally founded in 1901 as the National Bureau of Standards, NIST's mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life. By working closely alongside industry, NIST has become recognized as a provider of high-quality information utilized by the private sector.

NIST operates two main research laboratories in Gaithersburg, Maryland, and Boulder, Colorado, as well as radio stations in Hawaii and Colorado. NIST also maintains partnerships with the Hollings Marine Labs in Charleston, South Carolina, the Joint Institute for Laboratory Astrophysics (JILA) with the University of Colorado in Boulder, as well as the Center for

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[2] *Coordinating Federal Science, Technology, Engineering, and Mathematics (STEM) Education Investments: Progress Report.* Committee on STEM Education, National Science and Technology Council, p. 10. http://www.whitehouse.gov/sites/default/files/microsites/ostp/nstc_federal_stem_education_coordination_report.pdf

[3] http://www.whitehouse.gov/administration/eop/ostp/about

Advanced Research in Biotechnology (CARB) and the Joint Quantum Institute with the University of Maryland.

NIST employs approximately 3,000 scientists, engineers, technicians, support, and administrative personnel. NIST hosts an additional 2,700 associates and facility users from academia, industry, and other government agencies each year. NIST also partners with 1,300 manufacturing specialists and staff at about 400 Manufacturing Extension Partnership (MEP) service locations around the country.[4]

NIST has three main budget accounts:

Scientific and Technical Research and Services (STRS)

STRS includes NIST's Core Laboratory research programs. STRS initiatives also include advanced manufacturing, cybersecurity research and standards and education, developing measurement tools and standards for cyber physical systems, advancing broadband communications, and disaster resilience.

Construction of Research Facilities (CRF)

CRF supports construction of new facilities and maintenance and repair of existing NIST buildings.

Industrial Technology Services (ITS)

In addition to the NIST laboratories, NIST manages several extramural programs supporting industry. ITS includes the Manufacturing Extension Partnership (MEP) program. The MEP program is a public/private partnership run by Centers in all 50 states and Puerto Rico that provides technical assistance for small- and medium-sized manufacturers to modernize their operations and adapt to foreign competition. MEP Centers are supported by equal contributions from federal funds, state funds, and industry client fees.

NIST currently operates six laboratory units which conduct research and development for measurement science, standards, and technology: the Material Measurement Laboratory (MML); the Physical Measurement Laboratory (PLM); the Engineering Laboratory (EL); the Information Technology Laboratory (ITL); the Center for Nanoscale Science and Technology (CNST); and the Center for Neutron Research (NCNR).

Technology Transfer

In fiscal year 2012, the Federal Government funded more than $131 billion in research and development (R&D) activities. Colleges and universities conduct the majority of basic research in the United States, and cumulatively receive more than half of their total research funding from federal agencies. Because of the large amounts expended by the Federal Government on basic research by universities, research institutes, and national laboratories,

[4] http://www.nist.gov/public_affairs/general_information.cfm (Updated April 11, 2013).

efforts to improve the transfer of federally-funded research are of interest to both the Federal Government and stakeholders across the nation.

Recently, there has been bipartisan support to establish a grant program within Federal Agencies that currently participate in the Small Business Technology Transfer program to support innovative approaches to technology transfer at institutions of higher education, nonprofit research institutions, and Federal laboratories[5]. The purpose of this program is to accelerate the commercialization of federally funded research and technology by small business concerns, including new businesses.

Networking Information Technology Research and Development (NITRD)

Originally authorized in the High-Performance Computing Act of 1991 (P.L. 102-194), the NITRD program is the main R&D investment portfolio of 15 federal participating agencies in networking, computing, software, cyber security and related information technologies. The program totals over $3.7 billion in FY2013 (with the National Science Foundation being the principal contributor). Other federal agencies participate in program activities beyond the 15 member agencies. The NITRD program supports a number of research areas, including big data, cyber physical systems, cyber security and information assurance, health technology, high performance computing and large scale networking.

The NITRD Subcommittee of the National Science and Technology Council (NSTC) is the working body for interagency planning and coordination and includes representatives from each of the participating NITRD agencies as well as the Office of Management and Budget (OMB). The National Coordination Office (NCO) provides staff support for the NITRD Subcommittee and the program's advisory committee and serves as the public interface for the program.

[5] http://science.house.gov/hearing/subcommittee-research-and-technology-improving-technology-transfer-universities-research

Chairman BUCSHON. The Subcommittee on Research and Technology will come to order.

Good morning, everyone. Welcome to today's hearing titled "Keeping America First: Federal Investments in Research, Science and Technology at NSF, NIST, OSTP and Interagency STEM Programs." In front of you are packets containing the written testimony, biographies, and Truth in Testimony disclosures for today's witnesses. I will now recognize myself for five minutes for an opening statement.

I am pleased to call to order this morning's hearing to examine the fundamental science and research activities at NSF, the National Institutes for Standards and Technology, known as NIST, and the Office of Science and Technology Policy, OSTP. We have circulated a discussion draft, and I want to emphasize, it is a discussion draft, of legislation that would reauthorize basic science research and education programs at NSF, NIST and OSTP, and strengthen coordination of science, technology, engineering and mathematics—STEM—education programs across the Federal Government.

I am pleased the majority and minority staff had an opportunity to review the discussion draft carefully and identify areas of agreement. We have asked NSF, NIST and OSTP as well as other stakeholders in the university and business communities for their comments about the discussion draft. We look forward to a thoughtful and productive dialogue.

Scientific research is essential fuel for America's engine of innovation. Research-driven innovation is critical for American businesses to remain competitive and world-class in a global marketplace. Additionally, educating our children in the STEM fields is crucial to their futures and to the future of our Nation.

NSF spends nearly $7 billion of taxpayers' money every year. Congress has a responsibility to work with leaders at the NSF and the National Science Board to ensure that these taxpayer dollars focus on high-priority research.

The FIRST Act discussion draft affirms our commitment to high-integrity science and transparency of research results. The proposed legislation improves transparency of taxpayer-funded research by making more information available to the public about awarded grants and how they promote the national interest. Furthermore, it is consistent with steps the NSF is already considering to improve accountability, which have been approved by the National Science Board.

As it relates to STEM education, if leading the world in the high-tech sector and achieving the innovations of tomorrow are an imperative goal of the United States, American students and America's education system must excel in the STEM fields.

Unfortunately, America lags behind many other nations when it comes to STEM education. American students rank 23rd in science and 31st in math. We must improve these numbers substantially if we expect to remain a world leader. We must engage our Nation's youth to study science and engineering so they will want to pursue these careers. Private and nonprofit stakeholders are also working to engage students in STEM subjects. Understanding and leveraging these resources is an important aspect of strengthening

Federal support for STEM education. The FIRST Act discussion draft improves coordination for Federal STEM programs and recognizes the importance of industry investment in outcome-oriented STEM education efforts.

Another key part of this discussion draft is the "Technology and Research Accelerating National Security and Future Economic Resiliency Act"—I did get that out—or TRANSFER Act, of which I am a cosponsor, and which has been endorsed by a long list of business and nonprofit organizations. The research and development conducted at our nation's universities, research institutes and national laboratories have served as the basis for many technology breakthroughs that have driven American innovation and our economic growth. In order to bolster American economic competitiveness, the TRANSFER Act will improve technology transfer and accelerate commercialization of federally funded research and development at our Nation's research universities and laboratories, in part, by encouraging stronger R&D partnerships among universities, national laboratories and businesses.

Basic research funded through our Nation's science agencies has provided the basis for many of the technology breakthroughs that have kept America and our universities at the scientific forefront. They have also helped create new industries, innovations and jobs that have boosted our economy and strengthened our economic competitiveness.

As our country continues to face a fiscal crisis, part of our challenge is how to achieve the most benefit from our limited resources both now and in the years ahead. We recognize that returns on these long-term investments, including expanding STEM education, may take many years to be realized fully.

As we all anxiously await the results of the work done by our colleagues who are taking part in the budget conference negotiations, we also recognize that in a time of tight budgets in Washington, it is even more important to preserve as much stability in Federal funding as possible.

I want to reiterate what we are reviewing is a discussion draft, not final legislation, and on both sides of the aisle, the staff and the Members are working together to come up with a final piece of legislation that will benefit our country.

I look forward to hearing from our distinguished witnesses and having a productive discussion.

[The prepared statement of Mr. Bucshon follows:]

PREPARED STATEMENT OF SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
CHAIRMAN LARRY BUCSHON

I am pleased to call to order this morning's hearing to examine the fundamental science and research activities at the National Science Foundation, known as the NSF, National Institutes for Standards and Technology, known as NIST, and the Office of Science and Technology Policy, OSTP.

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Private and nonprofit stakeholders are also working to engage students in STEM subjects. Understanding and leveraging those resources is an important aspect of strengthening federal support for STEM education. The FIRST Act discussion draft improves coordination for federal STEM programs and recognizes the importance of industry investment in outcome-oriented STEM education efforts.

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They have also helped create new industries, innovations, and jobs that have boosted our economy and strengthened our economic competitiveness.

As our country continues to face a fiscal crisis, part of our challenge is how to achieve the most benefit from our limited resources—both now and in the years ahead.

We recognize that returns on these long-term investments, including expanding STEM education, may take many years to be realized fully.

Also, as we all anxiously await the results of the work done by our colleagues who are taking part in the budget conference negotiations, we also recognize that in a time of tight budgets in Washington, it's even more important to preserve as much stability in federal funding as possible.

I want to reiterate what we are reviewing is a discussion draft, not final legislation. I look forward to hearing from out distinguished witnesses and having a productive discussion.

Chairman BUCSHON. At this point I now recognize the Ranking Member, the gentleman from Illinois, Mr. Lipinski, for an opening statement.

Mr. LIPINSKI. Thank you, Chairman Bucshon, for holding today's hearing on the discussion draft of the FIRST Act, and I want to welcome our witnesses here today.

We have all seen the headlines about how our competitors are pouring resources into research and development. They may not be

ahead of us now in total investment, but China and others are already far outpacing us in R&D growth. As we all know, these are long-term investments, and failing to adequately invest now will catch up with us when we see slower job growth from less innovation.

In my district last week, Argonne National Lab announced that due to sequestration and future budget uncertainty, they would be forced to let go 120 of their staff. Although Argonne is funded primarily by the Department of Energy rather than NSF or NIST, this serves as a reminder of what will happen if we continue to let science funding stagnate across the Federal Government. If this trend continues, the long term effects on our scientific competitiveness will be catastrophic. Agencies and universities won't be able to plan, some of the best and brightest will give up and leave their labs, and the younger generation will see what their mentors are up against and decide against a career as a researcher altogether. A witness before this Committee recently said that if he were a young scientist in a foreign country he doesn't think he would decide to come to America to study and stay to do research, as he had done early in his career, and this is something that we have to be concerned about.

I understand very well that America faces a serious debt threat and that we need to make some tough decisions, but almost all of these are well outside the purview of this Committee or the scope of today's hearing. The Chairman's intent is to hold off on including authorization levels until we have a budget deal. I hope that we can use the time before the budget deadline to more fully discuss some of the policy proposals contained in the draft, and I also hope this does not mean that we intend to let budget negotiators dictate to this committee what the appropriate levels of funding are for Federal science agencies. We are an authorizing committee, and as an authorizing committee, I always hate to see the appropriators be able to call all the shots, and I think it is important for us here to have a discussion on authorization levels that reflect a smart and balanced approach to making sure we remain strong and competitive in science, technology and innovation. I look forward to working with the Chairman and all of my colleagues to do that.

Before we hear from the witnesses, let me just comment on a few of the priorities I have for this legislation. First, manufacturing plays a significant role in our economic and national security. We must reinvigorate and expand America's manufacturing base, and we cannot do that with the technologies and processes of yesterday. The small and medium-sized industries that comprise a significant portion of our manufacturing capacity don't have the resources or capacity to invest in the most far-reaching R&D with potential application to the manufacturing technologies and processes of the future. NIST and NSF play a critical role in funding such research, and we should take the opportunity of moving legislation to reinforce and expand our efforts to revitalize American manufacturing.

Next, NSF is responsible for supporting research across all scientific disciplines, from the physical and life sciences, to engineering, to the social, economic and behavioral sciences. I know that some of my colleagues question the value of research in the social and behavioral sciences, but there is ample evidence that this re-

search is just as important as any NSF conducts, and the budget for the entire social, behavioral, and economic science directorate amounts to just over three percent of all of NSF's budget. Social and behavioral sciences have played a critical role in strengthening our response to disasters, improving public health, strengthening our legal system, and optimizing the use of Federal resources. I believe any reauthorization of NSF should provide sustainable funding to all scientific disciplines and not impose any unique restrictions or conditions on any specific type of research.

I would also like to see inclusion of language to formally establish NSF's I–Corps program. Results from the first couple of years of this program support my belief that I–Corps will yield exponential benefits, helping turn NSF's research investments into new companies and jobs across the country. In fact, it is important that we work together across the Federal research portfolio to lower the barriers for the commercialization of federally funded research. Supporting the creation of public-private partnerships, reducing the risk for capital investment, and eliminating obstacles to technology transfer will help us get a larger return on our investment in science not only in economic terms, but in benefits for all Americans.

I am going to close with just a couple of thoughts about the draft bill. I have concerns with language in the bill that would make changes to the way that NSF conducts merit review of research proposals. While some of my colleagues may believe that these provisions merely increase accountability and transparency in the use of Federal resources, which certainly we all agree we want to do, I fear that the criteria used in the bill are vague and the process is unnecessarily burdensome. At best, this language may add a good deal of uncertainty as to how research grants would be awarded; at worst I fear it could fundamentally alter how merit review is done at an agency that is viewed as a gold standard by the rest of the world. As I said, I am certainly not opposed to increasing accountability and transparency, and I welcome rigorous oversight of NSF programs, and we have an obligation to do that, but I believe we need to think through these concerns and possible solutions more carefully, and I hope we will have the opportunity to do so not just today, but in additional hearings on this bill. I think we are going to have some questions on that for the witnesses. I look forward to hearing from them on this and other issues. I want to thank the Chairman, and I yield back the balance of my time.

[The prepared statement of Mr. Lipinski follows:]

PREPARED STATEMENT OF SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
RANKING MINORITY MEMBER DANIEL LIPINSKI

Thank you, Chairman Bucshon for holding today's hearing on the discussion draft of the FIRST Act, and welcome to our witnesses.

We have all seen the headlines about how our competitors are pouring resources into R&D. They may not be ahead of us now in total investment, but China and others are already far outpacing us in R&D growth. As we all know, these are long-term investments, and failing to adequately invest now will catch up with us when we see slower job growth.

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Next, NSF is responsible for supporting research across all scientific disciplines, from the physical and life sciences, to engineering, to the social, economic, and behavioral sciences. I know that some of my colleagues question the value of research in the social and behavioral sciences, but there is ample evidence that this research is just as important as any NSF conducts, and the budget for the entire social, behavioral, and economic science directorate amounts to just over three percent of all of NSF's budget. Social and behavioral sciences have played a critical role in strengthening our response to disasters, improving public health, strengthening our legal system, and optimizing the use of federal resources. I believe any reauthorization of NSF should provide sustainable funding to all scientific disciplines and not impose any unique restrictions or conditions on any specific type of research.

I would also like to see inclusion of language to formally establish NSF's I-Corps program. Results from the first couple of years of this program support my belief that I-Corps will yield exponential benefits, helping turn NSF's research investments into new companies and jobs across the country. In fact, it is important that we work together across the federal research portfolio to lower the barriers for the commercialization of federally funded research. Supporting the creation of public-private partnerships, reducing the risk for capital investment, and eliminating obstacles to technology transfer will help us get a larger return on our investment in science not only in economic terms, but for the benefit of all Americans.

I will close with just a couple of thoughts about the draft bill under consideration today. I have concerns with language in the bill that would make changes to the way that NSF conducts merit review of research proposals. While some of my colleagues may believe that these provisions merely increase accountability and transparency in the use of federal resources, I fear that the criteria used in the bill are vague and that the process is unnecessarily burdensome. At best this language may add a good deal of uncertainty as to how research grants would be awarded, at worst I fear it could fundamentally alter how merit review is done at an agency that is viewed as a gold standard by the rest of the world. I am not opposed to increasing accountability and transparency. I welcome rigorous oversight of NSF programs. But I believe we need to think through these concerns and possible solutions more carefully and I hope we will have the opportunity to do so not just today, but in additional hearings on this bill.

Thank you, Mr. Chairman and with that I yield back the balance of my time.

Chairman BUCSHON. Thank you.

At this time I am going to recognize the Ranking Member of the full Committee, Ms. Johnson, for her statement.

Ms. JOHNSON. Thank you very much, Mr. Chairman, and let me say thank you to our witnesses for being here this morning.

The Science Committee, perhaps more than any other committee, is where we lay the groundwork for long-term economic growth and prosperity. It is here where we make the decision to continue or to cede the U.S. leadership in science and technology. It is here where we make the decision to plant the seeds for the fruits of U.S. science to grow into new companies and jobs, improved health, strengthened national security, and improved quality of life for all Americans.

The 2005 Rising Above the Gathering Storm report was a call to action that brought us all together in this common cause, Democrat and Republican, Congress and the Administration. In 2007, Congress enacted the *America COMPETES Act* with an overwhelmingly bipartisan majority. That bill set three of our agencies, NSF, NIST and DOE's Office of Science, on a doubling path and it created the very successful ARPA–E. Unfortunately, as we all know, the vision of COMPETES was not fully realized. Across-the-board cuts magnified by all of the budget uncertainty over the last few years are causing deep and in some cases irreparable harm to our leadership in S&T.

Last week, Republican Senator Lamar Alexander, one of the champions of the original COMPETES Act, testified before his colleagues during a hearing on reauthorization of the Competes Act. He said there are plenty of things that we do that are less important than this, if we want to keep a high standard of living. Senator Alexander went on to urge his colleagues to authorize what our goals should be. I can't agree more.

This is not the time to be timid. This is the time to send a clear message to the appropriators of our priorities as authorizers.

While all of the feuding about the budget goes on around us, the Science Committee is one place where we should be able to agree more than we disagree. We did so successfully for many years, even during divided government, and it is my hope that we can do so again. I have been troubled by occasions over the past year where that spirit of bipartisanship has broken down, and where science has at times seemed to be under siege. We need to get back to the approach to legislating that has served this Committee well for many years, and certainly the 21 years that I have been on it.

Unfortunately, the draft legislation before us today leaves me puzzled. For one thing, it appears to cede our responsibility as authorizers to the appropriations committee by leaving out the funding levels that we think are necessary to carry out the provisions of the bill. Perhaps more concerning are the policy directions in this bill. There are some provisions on which we can agree. However, it troubles me that this draft seems to be dominated in both tone and volume by everything that some of my colleagues believe that NSF and scientists are doing wrong, and contains very little in the way of a vision for the future. I am also confused why the draft strikes two sections of existing law establishing broadening participation as an important part of NSF's mission when the changing demographics of this country should make efforts to

broaden participation in STEM. That is really a no-brainer. I worry that this discussion draft reflects a lack of imagination that will not help this Nation meet the competitive challenge we face.

A few weeks ago I circulated a comprehensive COMPETES reauthorization draft bill that I hope captures the COMPETES principles laid out earlier this year by the scientific community. I am in the process of gathering feedback and more ideas from stakeholders and Democratic Members, and I welcome the witnesses' thoughts on my discussion draft. As we move forward, I would be very happy to work with the Chairman and with all of my colleagues on both sides of the aisle as I have always done to craft a bipartisan bill that truly sets a vision for continued U.S. leadership in science and technology.

Thank you again, Mr. Chairman, and thanks to all the witnesses for being here. I yield back.

[The prepared statement of Ms. Johnson follows:]

PREPARED STATEMENT OF FULL COMMITTEE RANKING MEMBER EDDIE BERNICE JOHNSON

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The Science Committee, perhaps more than any other Committee, is where we lay the groundwork for long-term economic growth and prosperity. It is here where we make the decision to continue, or to cede U.S. leadership in science and technology. It is here where we make the decision to plant the seeds for the fruits of U.S. science to grow into new companies and jobs, improved health, strengthened national security, and improved quality of life for all Americans.

The 2005 Rising Above the Gathering Storm report was a call to action that brought us all together in this common cause, Democrat and Republican, Congress and the Administration. In 2007 Congress enacted the America Competes Act with an overwhelmingly bipartisan majority. That bill set three of our agencies, NSF, NIST, and DOE's Office of Science, on a doubling path and it created the very successful ARPA-E. Unfortunately, as we all know, the vision of Competes was not fully realized. Across the board cuts magnified by all of the budget uncertainty over the last few years are causing deep and in some cases irreparable harm to our leadership in S&T.

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While all of the feuding about the budget goes on around us, the Science Committee is one place where we should be able to agree more than we disagree. We did so successfully for many years, even during divided government, and it is my hope that we can do so again. I have been troubled by occasions over the past year where that spirit of bipartisanship has broken down, and where science has at times seemed to be under siege. We need to get back to the approach to legislating that has served this Committee well for many years.

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draft reflects a lack of imagination that will not help this nation meet the competitive challenge we face.

A few weeks ago I circulated a comprehensive Competes Reauthorization draft bill that I hope captures the Competes principles laid out earlier this year by the scientific community. I am in the process of gathering feedback and more ideas from stakeholders and Democratic Members and I welcome the witnesses' thoughts on my discussion draft. As we move forward, I would be very happy to work with the Chairman and with all of my colleagues on both sides of the aisle to craft a bipartisan bill that truly sets a vision for continued U.S. leadership in science and technology.

Thank you again to the witnesses for being here this morning and I look forward to your testimony.

Chairman BUCSHON. Thank you, Ms. Johnson, and thank you for your comments, and I will remind everyone again, it is a discussion draft, and obviously we want to work with everyone on amendments and changes that will make it a true bipartisan approach.

If there are Members who wish to submit additional opening statements, your statements will be added to the record at this point.

At this time I am going to introduce our witnesses.

Our first witness today is Professor Richard Buckius of Purdue University. Dr. Buckius is currently the Vice President for Research and Professor of Mechanical Engineering. Previously, he was a faculty member at the University of Illinois at Urbana-Champaign, my alma mater, and Dr. Buckius also served as the National Science Foundation's Assistant Director for Engineering. Dr. Buckius received his bachelor's and master's degrees and Ph.D. in mechanical engineering at the University of California at Berkeley.

Our second witness is Professor Daniel Sarewitz of Arizona State University. He currently is a Professor of Science and Society, and the Co-Director and Co-Founder of the Consortium for Science, Policy and Outcomes at Arizona State University. Dr. Sarewitz is the editor of the magazine Issues in Science and Technology, and is also a regular columnist for the journal Nature. He received his Ph.D. in geological sciences from Cornell.

Our third witness is Professor Tim Killeen. In June 2012, Dr. Killeen was appointed President of the Research Foundation for the state of New York, and State University of New York Vice Chancellor for Research. Dr. Killeen previously served as the National Science Foundation's Assistant Director for Geosciences. He also served as the Director of the National Center for Atmospheric Research. Dr. Killeen completed his undergraduate and graduate education at the University College-London, earning his Ph.D. in atomic and molecular physics.

And our final witness today is Mr. James Brown. Mr. Brown is the Executive Director of the STEM Education Coalition, an alliance of more than 500 businesses, professional and education organizations that works to raise awareness about the critical role of STEM education. Prior to joining the coalition, he was Assistant Director for Advocacy at the American Chemical Society. Mr. Brown received his B.S. from the University of New Mexico and an M.S. from Penn State, both in nuclear engineering. He also holds an MBA from George Washington University.

I would like to thank all of our witnesses for being here this morning, and as our witnesses should know, spoken testimony is

limited to five minutes, after which the Members of the Committee will have five minutes each to ask questions.

I now recognize Dr. Buckius for five minutes to present his testimony. Thank you.

TESTIMONY OF DR. RICHARD BUCKIUS, VICE PRESIDENT FOR RESEARCH, PURDUE UNIVERSITY

Dr. BUCKIUS. Thank you, Chairman Bucshon, Ranking Member Lipinski and the honorable Members of the Committee. I am here to discuss the discussion draft of FIRST. Thank you for the introduction. You saved me some time. I don't have to go through my background.

I just want to add, though, that I was 30 years at UIUC, Illinois, and served as a Department Head, and Associate Vice Chancellor for Research. During that time, I was fortunate enough to serve at NSF in almost all the capacities. I was a Division Program Director initially, then later came back and served as a Division Director, and then as the AD, the Assistant Director for Engineering. Now at Purdue, we overlook almost all of the research activities that go on at Purdue University.

Two comments that might be important. The service that I provided to NSF was granted on an Intergovernmental Personnel Act leave from Illinois, which is the subject of some of the discussion in this particular discussion draft, and at NSF, in engineering, engineering at NSF oversees the SBIR/STTR program, and so that might be important.

I would really only want to share a few comments, and then I am looking forward to questions. First thing was regarding fiscal reality and basic research. As noted in the original Act in 1950, fundamental basic research continues to provide tremendous impact, and we need to make sure that that occurs in the future. Some outcomes of basic research can be anticipated, some might be obvious to others, yet many of the discoveries and innovations are entirely unexpected. NSF takes a very long view for supporting efforts that expand knowledge, enhance understanding and provide an engine for new technologies. As important, Federal research supports and enables the education and training of the next generation of innovators.

It is clear that we are in a period of great financial stress in many areas of the Federal Government, and it is stressing all of us in our homes around the Nation. The projections of the national future debt paint a picture of an extremely heavy burden on future generations. With this Act, the opportunity exists to meet a great challenge that can both fund future discoveries and innovations and prepare our young people to participate in the innovation future. Placing discretionary research spending in opposition to mandatory spending could jeopardize the future discoveries that will yield tomorrow's innovations. It could also jeopardize the undiscovered talent in our youth who will make those future research generations. It is my hope that we can finance future innovative research and thereby cultivating this future generation of innovators together with balancing and handling our looming fiscal debt.

On the STEM priority, Purdue strongly urges Congress to provide a reliable, sustained funding for STEM research and education

in the context of a responsible budget. We applaud the current draft's language to consider the coordination in Federal STEM funding yet ensuring each agency's approach. A coordinated multidisciplinary approach is that which is taken at Purdue. We believe in our STEM students, and all of our students need a broad-based education to make a difference in the world. A diverse, interdisciplinary approach can only work if we remove barriers. We don't duplicate activities but rather collaborate across disciplines to enhance the total impact. This is very similar to the current approach in this country as well as NSF in support of STEM research and education.

And finally, comments on transparency and impact. We fully support the open public access for results of federally funded research. It is central to the mission of higher education. For decades, Purdue together with others in higher education community have promoted open access. The publication delay of open public access is a key point, and various sound arguments have been provided, yet I think it is important to proceed with the implementation of this as soon as possible and with a shorter publication delay time. We applaud the open access directive and are eager to see it succeed.

Finally, comments on NSF, and you have heard this from our Chair and Ranking Chair. The National Science Foundation relies on thousands of experts every day in their expert fields to provide knowledgeable evaluations of the proposals. Reviewers deliver these detailed evaluations confidentially and without compensation. This is a valuable service to the Nation, and it needs to be preserved. Consistent with the wording in Section 104 of this discussion draft related to the awarding of the proposals, an affirmation of award quality by the Foundation in general should be possible with a slight increase in administrative load. Yet the prior publication of awards and associated information will severely compromise the process and add tremendous burden, administrative burden, to the process.

In summary, I would like you to consider the intellectual discovery debt incurred by foregoing investments in basic research together with the looming financial debt. Hopefully we can enable a coordinated and distributed approach currently proposed for STEM education research, and finally, ensure open public access to federally funded research findings while protecting the confidential merit review process.

Thank you very much for letting me provide you some insight, and for your leadership on this Act.

[The prepared statement of Dr. Buckius follows:]

Richard Buckius
REMARKS BEFORE THE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY OF THE U.S. HOUSE OF REPRESENTATIVES
13 November 2013

Thank you, Chairman Bucshon, Ranking Member Lipinski, and the honorable members of this subcommittee, for this opportunity to discuss the proposed legislation provisionally referred to as "Frontiers in Innovative Research, Science, and Technology Act."

I am Richard Buckius, Vice President for Research and Professor of Mechanical Engineering at Purdue University. I have been involved in various aspects of fundamental scientific research for my entire career. It is a privilege for me to share with the committee some of the "lessons learned" along the way, and I look forward to answering your questions. After receiving my PhD from the University of California, Berkeley, I took a position at the University of Illinois at Urbana-Champaign (UIUC). My 30-plus year tenure at UIUC provided me with many opportunities to advance, naturally beginning as an Assistant Professor then moving to serve as Department Head of Mechanical and Industrial Engineering, and then as Associate Vice Chancellor for Research. During those years, with time on an Intergovernmental Personal Act (IPA) leave granted from UIUC, the National Science Foundation offered me several occasions to serve the Nation's research enterprise. First, in 1988, I served as the Program Director for the Thermal Systems and Engineering Program. Later, in 2004, after returning to UIUC for several years, the National Science Foundation offered me the chance to serve as Division Director for Chemical and Transport Systems, and, between 2006 and 2008, I served as assistant director of the NSF Directorate of Engineering.

In 2008, I joined Purdue University as the Vice President for Research and as a Professor in Mechanical Engineering. Purdue is a public land grant university educating over 75,000 undergraduate and graduate students each year throughout the state. Faculty conduct $240 million in federally funded research projects annually, which is a significant contribution to the University's overall research portfolio totaling more than $640 million annually in sponsored program research expenditures. The Office of the Vice President for Research assists faculty and staff in their research efforts, and leads the University's research administration and oversight efforts. We also assist faculty with research development, such as proposal preparation, identifying funding opportunities, and building private sector partnerships.

Richard Buckius
REMARKS BEFORE THE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY OF THE U.S. HOUSE OF REPRESENTATIVES
13 November 2013

Fiscal Reality and Basic Research

As a representative of a public research institution, we join with our colleagues at many institutions of higher learning to appeal to the Congress to help close the Nation's innovation deficit and promote economic growth for the sake of future generations. Economists estimate that technological innovation, much of which is a result of federally-funded scientific research, has been responsible for more than 50 percent of the US economic growth in recent decades. Federal research also allows us to educate and train the next generation of innovators.

It is clear that we are in a period of great financial stress in many areas of the federal budget, and this stress is felt in our states, and within people's homes. The projections of the Nation's future debt paint a picture of an extremely heavy burden on future generations. With this proposed Act, the opportunity exists to meet a great challenge that can both fund future discoveries and innovations and prepare our young people to participate in the innovation future. I suggest that it would be most effective to promote both the well-being of our Nation's human resources along with our ability to compete in a global environment of innovation. Placing discretionary research spending in opposition to mandatory spending could jeopardize future discoveries that yield tomorrow's innovations, and undiscovered talent in our youth today who will make those future research discoveries. With the financial debt and limited resources, it is our hope that financing future innovative research, science, and technology and the need to cultivate future generations to pursue STEM fields, are carefully considered together with the looming fiscal debt.

Science often advances by enhancing previous findings and is the foundation for applied research. In many ways, transformative discoveries cannot happen without building off of those previous outcomes. NSF takes the long view by supporting efforts that expand knowledge and enhance understanding, which in turn provides the engine for new technologies.

As important, federal research enables the education and training of the next generation of innovators.

Richard Buckius
REMARKS BEFORE THE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY OF THE U.S. HOUSE OF REPRESENTATIVES
13 November 2013

STEM Priority, an example of diverse, interdisciplinary research

Purdue University strongly urges Congress to provide reliable, sustained funding for STEM research and education in the context of a responsible budget. We applaud the discussion draft's language to consider coordination of federal STEM funding, yet ensuring the agency's dependent approach.

Purdue is among the institutions graduating the most engineers in the nation. In our effort to address the Nation's competitive need for graduates with STEM degrees, Purdue is in the process of increasing the College of Engineering faculty by 30 percent in the next 5 years. Purdue has also committed to grow the Department of Computer Science by 25 percent, and to transform our College of Technology with a more experiential and project-based curriculum. At the same time, Purdue recognizes the central role the liberal arts play in building a well-rounded curriculum at an institution as strong as Purdue in science, technology, engineering, and math.

Purdue has earned the reputation as a national and global leader in discovery and innovation with preeminent scholars in science, engineering, agriculture, business, technology, as well as in the health and human sciences, education, humanities, social sciences, pharmacy, veterinary medicine, and the arts. We believe our STEM students and all students need a broad-based education to make a difference in the world. Purdue's Discovery Park, our interdisciplinary hub, assists in promoting disciplinary strengths and coordinating interdisciplinary activities. The diverse, interdisciplinary approach can only work without barriers. We don't duplicate efforts, but rather collaborate across disciplines to enhance the total impact. This is very similar to the current federal agency and NSF approach. Enhancements to breaking down "silos" between research areas are encouraged and welcomed.

Transparency and Impact

We fully support the public access to the results of federally-funded research which is central to the mission of higher education. For nearly a decade, Purdue University, together with others in the higher education community, have promoted open access policies for federally- and state-funded research output to better manage the intellectual assets of higher education in support of teaching and learning (see Purdue e-Pubs for articles http://docs.lib.purdue.edu/ and Purdue University Research Repository (PURR) for data sets https://purr.purdue.edu/). The publication delay time for public access is a key

point and various sound arguments have been provided, yet it is important to proceed with the implementation and a shorter delay. We applaud the open public access directive and are eager to see it succeed.

As appropriate and depending upon the research, moving discoveries from the bench to the marketplace is a high priority. At Purdue, 47 Purdue University faculty, students, and staff made discoveries that were patented last year. The Purdue Research Foundation reported 356 invention disclosures, 446 patent applications worldwide, 95 patents issued worldwide, and the creation of five startups from Purdue-licensed technologies. In the most recent four-year period, Intellectual Property disclosures at the University have increased by 21.4 percent, and patent filings have increased 14.6 percent compared to the previous four-year period. This year, at the urging of many of Purdue's own engineering and science faculty, the University made changes to its Intellectual Property practices to streamline the process of moving inventions and innovations from the lab to the market.

The National Science Foundation relies on thousands of experts from every field to provide knowledgeable evaluations on proposals. Reviewers deliver this detailed level of evaluation confidentially and without compensation. This is a valuable service provided to the Nation and it needs to be preserved. Consistent with the wording in section 104 (b) (i.e., affirmation that the award is in the national interest, worthy of Federal funding, and achieves one or more of the stated goals – increased economic competiveness, advances the health and welfare of the American public, develops a STEM workforce and increased public scientific literacy , increases academic/industry partnerships, promotes the progress of US science, and supports national defense), an affirmation by the foundation should be possible with a slight increase in administrative load. Yet the prior publication of awards and associated information will severely compromise the process and add tremendous administrative burden.

In closing, I wish to express my sincerest thanks to the Committee for the opportunity to participate today and for your leadership, commitment, and partnership on this important topic of maintaining American innovation and competitiveness through fundamental/basic scientific research.

Richard O. Buckius
Vice President for Research
Professor of Mechanical Engineering
Purdue University

Dr. Buckius joined Purdue University on September 16, 2008, as Vice President for Research and Professor of Mechanical Engineering. Previously, he was a faculty member at the University of Illinois at Urbana-Champaign. He was Head of the Department of Mechanical and Industrial Engineering at Illinois (1998-2005). In addition, he served as Associate Head (1985-87), the Richard W. Kritzer Professor (1992-97), and the Associate Vice Chancellor for Research (1988-91) at Illinois.

Dr. Buckius served as the National Science Foundation's (NSF) Assistant Director for Engineering (2006-08), Acting Assistant Director for Engineering (2005-06), Director for the Engineering Directorate's Division of Chemical and Transport Systems (2004-05), and Program Director of the Thermal Systems and Engineering Program (1987-88).

Buckius is author/co-author of over 100 publications, books and invited talks and articles. He co-authored a textbook titled Fundamentals of Engineering Thermodynamics (Mc-Graw-Hill). Published in English, Spanish and international versions (1987), and the expanded second edition versions followed in 1992. He is a member of the editorial boards of Nanoscale and Microscale Thermophysical Engineering, Heat Transfer Research, and Heat Transfer-Asian Research. He was Associate Technical Editor for the Journal of Heat Transfer (1992-98).

A Fellow of American Society of Mechanical Engineers (ASME), Buckius has served as the Technical Group Leader of Basic Engineering; he previously served as Vice President (2004-05) and was a member of the Basic Engineering Technical Operating Board (1999-2001). For the Division of Heat Transfer, he was on the Executive Committee (1988-96) and served as Chair (1995-96); and was a member of the Energy Systems Committee (1982-2000).

Among his honors include ASME's Richards Memorial Award (2007), ASME's Potter Gold Medal (2006), ASEE's Ralph Coats Roe Award (2003), Western Electric Fund Award (1981) and Dow Outstanding Young Faculty award from the Illinois-Indiana Section (1978); and numerous UIUC teaching awards, ranging from the Stanley H. Pierce Faculty Award from the College of Engineering (1979) and Campus Award for Excellence in Undergraduate Teaching (1980) to six Alumni Teaching awards, the most recent from the department of mechanical and industrial engineering in 2000.

Buckius received his bachelor's and master's degrees and his PhD in mechanical engineering at the University of California, Berkeley, in 1972, 1973 and 1975, respectively.

Chairman BUCSHON. Thank you, Dr. Buckius, for that testimony.

I now recognize Dr. Sarewitz for five minutes to present his testimony.

TESTIMONY OF DANIEL SAREWITZ DR. DANIEL SAREWITZ, CO-DIRECTOR, CONSORTIUM FOR SCIENCE, POLICY & OUTCOMES, PROFESSOR OF SCIENCE AND SOCIETY, ARIZONA STATE UNIVERSITY

Dr. SAREWITZ. Thank you, Mr. Chairman, Members of the Committee.

I want to begin by bringing to your attention the cover story of the October 19th issue of The Economist, which was titled "How Science Goes Wrong." The article investigates the question, can the scientific community by itself assure the quality of its research results, and we have all been taught to believe that it can through peer review, the scientific method and a culture of skeptical inquiry, and of course, these accountability mechanisms are crucial to the integrity and value of science, but the article—as the article details, they are not always enough. So The Economist provides a timely reminder of one reason why today's hearing is important and appropriate, and I will limit my comments right now to the issues raised in Title I of the discussion draft of the FIRST Act, which represents a positive step in considering how do we improve the performance of the publicly funded science enterprise, and I am pleased to be testifying as a part of this effort.

It is apparent that we all agree that NSF is a remarkably effective Federal agency, institutionally quite innovative and with a complex, increasingly complex and important mission. In this context, Title I makes clear the Committee's desire to ensure that NSF is accountable for spending research dollars effectively, that research results are valid and that alternative research funding models are explored. These goals are laudable, yet as detailed in the discussion draft, are somewhat scattershot. The draft could benefit from a more strategic focus and greater clarity about how and where to intervene to incentivize better performance. For example, talking also about Section 104 that Dr. Buckius mentioned, I would say that it doesn't seem like it would create the new level of accountability at NSF that the Committee seeks. I don't see this interfering with peer review as articulated but the list of eight criteria that would be used to determine if a grant is worthy of support seems so general that it could actually act against the Committee's aims by adding a meaningless rubber stamp to the grant approval process.

The key strategic goal here has to be to maintain and improve the integrity, capacity and productivity of NSF despite the fact that Federal support for science is not likely to increase significantly over the next several years or more and despite the fact that competition for limited resources is likely to grow ever more fierce.

The Committee could work with NSF and other R&D funders to explore a range of approaches to improving accountability, public value and sustainability of the enterprise. Let me mention just five possibilities that I think are not typically considered.

NSF could ensure that peer review panels give full consideration as required in NSF's proposal guidelines to both of NSF's review

criteria, intellectual merit and broader impacts. This approach to accountability recognizes that excellence arises both from the quality of the science and its potential to contribute to larger programmatic goals, and I say this fully aware of the question of patience and unpredictability that Dr. Buckius mentioned. In this regard, NSF would need to expand its definition of peer expertise to allow for competent assessment of broader impact.

NSF could implement a process to identify and reduce hype in proposals. The super-competitive environment for getting Federal grants encourages hyping the potential for projects to yield results that are important, groundbreaking, transformational and so on. Hype serves to inflate expectations about what a project might accomplish and may contribute to bias as well by committing researchers to look for positive results even when the evidence is weak or absent as detailed again in this Economist article that I mentioned. Hype assessment should be done by evaluating the plausibility of specific claims and promises of scientific advance and broader impacts that are made in proposals, and overhyped research could be denied funding.

NSF could competitively fund red team projects aimed at replicating research results from high-priority or high-profile lines of research. NSF could similarly fund groups that would assess the scientific robustness of computer models used in a variety of fields with potential application for policymaking. NSF could give preference to researchers whose previous work has been replicated by independent research groups, to researchers whose academic units assess quality rather than quantity of research as the main criteria for tenure promotion, and to researchers who demonstrate that their projects have been developed collaboratively with potential knowledge users or that results from previous projects have been taken up by organizations outside of the academic setting.

NSF could broaden the range of its programs to require partnerships between universities and industrial firms, nonprofit organizations, museums, state and local governments and so on as they do in a number of programs. The goal of such partnerships would be in part cost sharing but equally important would be creating meaningful linkages between knowledge creation and knowledge use.

While these suggestions are made tentatively, I want to emphasize that cumulatively, a portfolio of appropriate policies strategically conceived, carefully tested, and implemented with adequate staffing might have the effect of helping to catalyze a shift in the incentive structure and culture of university science in ways that could better allow the Federal Government to ensure sustainable, long-term support and improved accountability and value for our public investment.

The discussion draft of the FIRST Act in today's hearing offers valuable opportunity for consideration of such options. I am pleased to discuss these ideas and other points raised in my written testimony, and thank you for your time and attention.

[The prepared statement of Dr. Sarewitz follows:]

Accountability and Public Value in Publicly Funded Science

Testimony before the U.S. House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Research and Technology
November 13, 2013

Hearing on: Keeping America FIRST: Federal Investments in Research, Science, and Technology at NSF, NIST, OSTP and Interagency STEM Programs

Daniel Sarewitz
Co-Director, Consortium for Science, Policy, and Outcomes
Professor of Science and Society, Arizona State University

Mr. Chairman, Members of the Committee, thank you for inviting me to testify today. My name is Daniel Sarewitz, and I am co-founder and co-director of the Consortium for Science, Policy and Outcomes at Arizona State University, as well as Professor of Science and Society at ASU. My formal academic training is in geosciences, but for almost 25 years I have worked in science and technology policy, first as a AAAS Congressional Science Fellow and then a staffer on this Committee, working for Chairman George E. Brown, Jr., and more recently as an academic, for the past nine years at ASU. I'm always very pleased to return to the place that launched me on a new and incredibly interesting and exciting career and intellectual journey, and honored that you have asked for my input to the Committee's deliberations on how the Nation can make the best possible investments in science and technology.

In the context of this hearing I also want to make clear that I have been extraordinarily privileged during my career in having received generous research funding from the National Science Foundation, mostly from the Directorate for Social, Behavioral, and Economic Sciences, but as well from the Geosciences and Engineering directorates. I have also served as a peer reviewer of many NSF proposals, and as a review panel member for a number of NSF programs. So my perspective reflects not only my research on science policy, but also my direct involvement in many aspects of the enterprise, from the Hill to the university.

Introduction: A Problem Long in the Making

The cover story of the October 19th issue of *The Economist* is entitled "How Science Goes Wrong." The article takes the lid off a problem that has been simmering for decades. The basic question is whether the scientific community itself can assure the quality of the research results that it produces. We have all been taught to believe that accountability in science is indeed an internal matter—that peer review, competition, the scientific method, an insistence that results be reproducible and replicable, and an overall culture of skeptical inquiry and devotion to objectivity was all that was necessary to ensure that the products of science were of the highest quality, greatest reliability, and most value to society. Moreover, those who insist that accountability in science is automatically delivered through the culture and practice of science

itself have also commonly asserted that efforts by outsiders, however well-meaning, to improve accountability will actually make things worse by substituting the politics of the outside world for the self-correcting essence of the scientific world.

The Economist article provides a valuable summary of troubling evidence, across many fields of research, that the internal mechanisms of scientific accountability are insufficient and are to some extent failing. Such evidence includes failed efforts to reproduce the results of research published in high-prestige, peer-reviewed journals; increasing rates of retraction of published results; major areas of research that yield little of public value but continue to attract significant public resources; and even what amount to experiments that show that the peer review process is unable to distinguish scientifically valid papers from those that are worthless. While much of this is familiar to those of us who work in the field of science policy, the fact that it made the cover of *The Economist*, a pragmatic, centrist international magazine that is strongly supportive of robust national investments in research and development, makes clear that the issue can no longer be dodged.

Two observations about this problem need to be emphasized from the outset. The first is that scientific misconduct—that is, the intentional manipulation or fabrication of scientific results—is not the major cause of the problems of scientific accountability and reliability covered in *The Economist* article. To a much greater extent the problem seems to be traceable to numerous sources of systemic positive bias (that is, bias toward results that confirm the ideas being researched) in the research system, a problem I'll come back to. The second observation is that the solution to the reliability problem cannot lie wholly with the science enterprise itself. *The Economist* article, and leaders in the scientific community, have appropriately emphasized the need for improved training in statistics and experimental design, better mechanisms of peer review, changes in publication policies that allow an increased focus on negative findings, and so on, in order to address systemic problems of reliability, reproducibility, and positive bias in science. But the underlying causes of the problem lie with the institutions and cultures of science, and thus will not likely be solved without incentives for change that come from outside of the science enterprise itself.

Let me emphasize the there is nothing new about this general problem, and about this tension between external and internal accountability. Like any community, the scientific enterprise would like to be left alone to govern its own affairs. Over the past five decades or so, issues relating to scientific accountability have emerged around such questions as: informed consent of human research subjects; patenting and technology transfer; ethical treatment of primate research subjects; research on alternative and complementary medicine; the use of stem cells in research; the gender composition of clinical trials; the risks of emerging technologies; and the broader social impacts of basic science. In these cases and more, pressure from outside the scientific community for new mechanisms of accountability have been resisted by that community on the basis of its claim that political interference would only weaken science. But in each case the tension and the resulting negotiations have led to changes that have managed to protect the prerogatives of science while also helping to meet science's obligations to a democratic society.

It is, therefore, not only appropriate but necessary to explore ways to improve scientific accountability to society through improved governance of the science enterprise. In this light, I want to compliment the Members of the Committee for beginning to confront the difficult problem of improving accountability in publicly funded science through the provisions in Title 1 of the discussion draft of the Frontiers in Innovation, Research, Science, and Technology (FIRST) Act of 2013.

With this brief, context-setting introduction, let me respond to the questions that the Committee has asked me to address.

Question 1. What are your concerns regarding the existing grant approval process within the National Science Foundation? How does this proposed bill address policy concerns regarding the accountability of the research grant process at the NSF?

NSF takes seriously its responsibility to subject its proposals to a rigorous peer review process and to select projects for funding based on merit as judged by expert peers. The process can likely be improved, in some ways that I'll suggest, but at the same, peer review is not the only, and is likely not the most effective, intervention point for improving the accountability of publicly funded science to the public, or for improving the potential value of NSF-funded research to society.

Most of us hold in our head an idealized view of science that corresponds to something like Albert Einstein figuring out the relationships between time and space while sitting at his desk in the Swiss patent office. There's the scientist, there's nature, and nothing in between but the scientist's brain and the methods of scientific inquiry. But most science isn't like that at all. Most scientists are like soldiers, laboring in the trenches as part of a much larger effort to accomplish a much bigger goal. Most individual projects can do no more than take another step or two towards understanding some larger problem, train a few more young scientists, demonstrate, usually not for the first time, the utility of some particular tool or method, and so on. Science is largely an incremental business, and major advances rarely come from any one particular project. Nor is any single project ever likely to make a discernible impact on societal outcomes. We want our scientists, and our soldiers, to act with integrity, to do their job well, and help advance our nation's interests as a cumulative consequence of their work. But whether scientists are working on the right projects, in the institutional settings that are most likely to lead to new knowledge that will become valuable for society, is much more a function of the character of those institutional settings than of things that any individual scientist is likely to achieve or able to control.

Title 1, Sec. 104: The grant approval process at NSF mostly reflects judgments that are made by peer reviewers. This is the soldier's point of view, not the field commander's. My point here is a bit complex, but in brief the value of the peer review process for society is only as good as the priorities and institutions within which it is working. I am very sympathetic with the Committee's effort to encourage a greater degree of accountability at NSF for ensuring that NSF

uses public moneys for science that is of good quality, and for the public good. I also think that Title 1, Section 104, on "Greater Accountability in Federal Funding For Research," is clear in its intent to allow the peer review process to do its work, while adding another level accountability over peer review, which in principle is totally appropriate.

But I have concerns that the provisions of Title 1, Section 104, won't appreciably advance the goals that the Committee seeks. For one thing, as I've suggested, the individual project is probably not the most effective point to intervene in the grant system if accountability for broadly advancing science and the national interest is the goal. For another, the list of eight criteria that would be used to determine if a particular grant is worthy of federal support is both very general and broadly inclusive. It's hard to imagine that any competently conceived and written proposal that made it through peer review couldn't also pass that second gauntlet unscathed. My guess is that the scientific community might therefore be concerned that decisions made at this next level would likely be subject to a political filter, rather than a scientific one. I would raise a different concern: I think, as written, this provision could actually act against the Committee's aims by adding a meaningless level of rubber stamping to the grant approval process.

Yet I do think there are questions that could be asked at the project level that would help NSF and Congress achieve their mutual and hopefully commensurate goals of improved accountability. Let me suggest two.

First, a post-review accountability process could ensure that peer review panels have given "full consideration," as required in NSF's proposal guidelines, to both of NSF's review criteria: "intellectual merit" and "broader impacts." This level of accountability recognizes that the advance of basic science and the pursuit of particular desired impacts are often strongly interrelated. For example, a grant proposal in sustainable chemistry might promise that a new class of chemicals being researched would be valuable to industry because it would allow firms to reduce their exposure to expensive regulation and litigation through a cleaner production process. But if the researchers proposing this work do not have strong connections to companies that might eventually benefit from such advances, then it would be difficult for them to ascertain if their research actually would be useful for industry, and implausible that they would be able to identify effective lines of technology transfer.

Second, a post-review accountability process could focus on identifying and reducing hype in the proposal process. The super-competitive environment for getting federal grants strongly incentivizes hyping the potential for any proposed project to yield results that are important, ground-breaking, "transformational," and so on. Hype is encouraged by universities looking to promote the research accomplishments of their faculty, but also by the promises of NSF and, it must be acknowledged, by the expectations of Congress. Hype is invited in research proposals both in claims of scientific importance, and in claims about "broader impacts" of a project to achieve social goals beyond its intrinsic scientific merit. Hype not only serves to inflate expectations about what a project might accomplish, but it also likely contributes to the bias problem discussed in the *Economist* article, by incentivizing researchers to look for positive

results even when the evidence for them is weak or even absent. So another function that a post-review accountability process could serve is to identify over-hyped proposals. This should be done rigorously, by analyzing the specific claims and promises of intellectual merit and broader impacts that are made in the proposal, and assessing their plausibility on the basis of a broader understanding of the state of the field being researched, as well as the technical and institutional capabilities available to the grant applicant.

Post-peer-review accountability could therefore focus on assuring that grants give full consideration to both NSF review criteria, and that they are not over-hyped. Implementing such a process would likely improve the peer review process itself in three ways. First, it would encourage applicants and reviewers alike to take seriously the "broader impacts" criterion and its integral relation to the "intellectual merit" criterion. Second, it would encourage peer reviewers and review panels to be skeptical about hype, and incentivize grant applicants to be more realistic in explaining the value of their work. But most importantly, it would require NSF to embrace an expanded definition of the types of expertise that needed to be involved in peer review processes, and a better balance among various types of expertise involved in the review process. For example, to continue with the hypothetical case of sustainable chemicals research, reviewers with expertise in the relevant industrial processes, in the regulatory regime, in the business models of the affected sector of industry, and in university-industry collaborations might all be directly relevant to assessing the merits of the proposed research—in addition to the academic experts in the specific field of chemistry that would constitute the standard peer review group. Such an extended peer review community could be a valuable source of enhanced accountability.

Question 2. What approaches or strategies might NSF pursue, during these tight fiscal times, to prioritize research which supports innovation and competitiveness?

Let's begin by establishing something upon which I think we can all agree: The National Science Foundation is a remarkably effective federal agency that has not only done an excellent job, overall, in carrying out its mission over the decades since its creation in 1950, but has taken on an increasingly complex set of activities in support of that mission, and in doing so has often been admirably innovative and open in seeking to meet the evolving science needs of a changing nation and world. In this context, a major problem in terms of improving NSF's focus on innovation and competitiveness is the complexity of the agency's mission. The goals of advancing knowledge and the science base, supporting graduate education and training through research practice, providing research infrastructure, supporting STEM education and public understanding of science, and advancing basic knowledge to support particular outcomes such as competitiveness, are in many ways distinct, and in some ways contradictory. This may lead to confusion, the biggest source of which is the widely held but false belief that "basic" science must be divorced from any consideration of application.

An important 1994 article by the economists Nathan Rosenberg and Richard Nelson documents that the vital contribution of American universities to industrial advance since the second half of the nineteenth century has been through the creation of basic scientific knowledge relevant

to industrial needs. As the authors are careful to note: "A widely accepted definition of basic research has come to focus on the absence of a concern with practical applications rather than the search for a fundamental understanding of natural phenomena. This is unfortunate, indeed bizarre." [1]The authors go on to explain, "It is a gross misconception to think that if research is 'basic' this means the work is not motivated by or funded because of its promise to deal with a class of practical problems."[2]

A good illustration of this important distinction is the discovery, in 1948, of the transistor effect, which helped to launch the information and communications revolution that has created the world that we live in today. It is well known that this phenomenon was first identified, through research that was undeniably basic, at ATT's famous Bell Laboratories. As a research institution, Bell Labs was consciously designed to mix "scientific curiosity, technological utility, and corporate goals" in advancing innovation for telecommunications. Yet at the same time as the Bell group was making their famous discovery, another group of academic physicists, at Purdue University, was working on a similar problem of semiconductivity. Historians of technology have speculated that, had the Purdue group "been looking for a solid-state amplifier, instead of exploring general physical phenomena, [they] would have invented the transistor."[3]

Now I want to clearly explain that I am not suggesting that NSF should be supporting scientists who are directly in the business of developing industrial products. But keep in mind that the work done at Bell Labs, and the work done at Purdue, were both "basic science," it's just that at Bell there was an awareness of the larger context in which the new knowledge might be valuable, and direct linkages to other parts of the innovation process that could make use of that new knowledge. This awareness of contexts, and these linkages to the world beyond the laboratory walls, are attributes that can and sometimes do exist at universities. Not only that, it was only *after* the discovery of the transistor effect that the basic science field of semiconductor physics really blossomed at major research universities—precisely because the potential value of transistors for innovation required rapid advances in basic knowledge—a point that illustrates how basic academic science itself can benefit from links to the industrial context.

The larger point here is that if the committee is interested in improving NSF's capacity to contribute to innovation and competitiveness through advances in basic science, one way to do this is to focus on creating mechanisms that enhance communication and exchange between academic researchers and those involved in actual innovation processes. This will often mean collaboration with industrial firms, but also with state and local governments and non-profit

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[1] Rosenberg, N, and Nelson, R., 1994, American universities and technical advance in industry, *Research Policy* 23, p. 332.

[2] Ibid, p. 340.

[3] Misa, Thomas J., 1985, Military Needs, Commercial Realities, and the Development of the Transistor, 1948-1958, in: M.R. Smith, ed. *Military Enterprise and Technological Change: Perspectives on the American Experience* (Cambridge, MA: MIT Press), p. 257.

organizations that need new scientific and technological capabilities to solve problems. Indeed, NSF has, through its Engineering Research Centers, Materials Research Science and Engineering Centers, and Nanoscale Science and Engineering Centers, sought to do that in selected domains. Arguments that such interactions will inevitably limit the imagination of scientists, and thus limit as well the potential contributions of science to industrial advance, are groundless. The goal is not to shackle academic science to an industrial agenda, but to accelerate the learning that can take place between researchers at universities and in industry. As the case of transistors shows, such collaboration can in fact lead to the explosion of new fields of academic basic research.

Thus, if the Committee wishes to encourage NSF to more effectively support innovation and competitiveness in specific, and the linking of basic science to societal advance more generally, it should focus on encouraging communication, interchange, and understanding among university scientists and the potential users of new fundamental knowledge in industry and other sectors. Again, turning to Rosenberg and Nelson, if university scientists are to conduct basic research that has strong potential to contribute to innovation, there "must be close communication and interaction between those who do research, and those who are responsible for product and process design and development . . . "[4] These links cannot be achieved by advisory committees or tech transfer offices or annual meetings, but require meaningful and ongoing interactions via shared positions, personnel exchanges, jointly supported students, joint project review teams, and so on.

This approach raises interesting opportunities for the Committee and NSF to rethink the problem of accountability. Because the effective linking of fundamental scientific advance to innovation and competitiveness requires a focus on appropriate institutional arrangements, accountability cannot be assessed merely in conventional terms of "scientific excellence." Rather, it must be sought in the quality and persistence of relationships between academic scientists and their collaborators beyond the university walls. This means assessing projects and programs not merely in terms of promised "intellectual merit" and "broader impacts" but also through evidence of linkages to and engagement with firms and other organizations and sectors that are prospective users of the science being done. I want to emphasize that such linkages also provide a direct and important check on research quality, because firms and other knowledge-using organizations will not only demand, but may be in a position to test, the reliability and relevance of the scientific knowledge that they are getting from academic collaborators. Indeed, some of the most powerful recent evidence of systemic unreliability in biomedical research has come from biotechnology firms that have been unable to replicate the results of academic research projects.

For this Committee there is a question of appropriate expectations here as well. The impacts of fundamental scientific advance on innovation and competitiveness are typically gradual and not highly predictable. Hinging research accountability on promises to achieve economic results would therefore be a mistake, and can mostly be recognized as hype. But hinging

[4] Rosenberg and Nelson, Op. cit. p. 346.

accountability on the demonstrated ability of projects and programs to forge persistent and meaningful linkages between NSF-funded researchers and collaborators in industry and other sectors would be an entirely appropriate lens for assessing the capacity of NSF's basic academic research activities to support innovation and competitiveness.

Question 3. Why is it important that the United States address predictable, sustainable future science funding?

Warnings about unsustainable expansion of the post-World War II American science enterprise date back to the early 1960s. In this light it is, or at least should be, uncontroversial to note that the academic scientific community has been utterly unable to control its own growth, and thus its demand for public funding, despite a widespread awareness that continued expansion of the science enterprise must eventually outstrip the capacity of the federal government to sustain that growth.

The causes of this expansion are well documented.[5] In part they are simply a function of population dynamics: professors in our research universities train new Ph.D. scientists at a much faster rate than the academic research enterprise can absorb them or than the research funding system can support them, and have been doing so for the past fifty years. At the same time, more and more universities have come to recognize that fielding prestigious scientific research programs across multiple fields is part of the formula for success for the modern university. It is basically impossible for a university to attract good students or good faculty, or to do well in the national rankings, or even, to an extent, to get big alumni gifts, without a robust scientific research capacity.

Voices in the scientific community have of course periodically proclaimed that a funding crisis was occurring or was about to occur, and that the prospects of the nation were thus in jeopardy and could only be addressed through additional federal spending on science. Meanwhile, federal support for research has grown robustly in real terms (for example, from FY 1976 – FY 2013 total federal spending for research, defense and non-defense, rose from $25.8 billion to $63.3 billion in constant 2013 dollars[6]). Nonetheless it was never plausible that budgetary growth would keep up with demand for funding, given, as just one example, that the number of science and engineering Ph.D.'s produced annually has risen from about 5600 per year in the late 1950s to about 27,000 per year today.[7] This tension between has come to a head in the current funding climate.

I should emphasize at this point that the problem here is not that science has not been given adequate priority across the portfolio of national needs. Federal R&D funding as a proportion of the total non-defense discretionary budget has stood at a remarkably stable 10% or so for more

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[5] For an excellent recent discussion of the problem and some possible solutions, see Howard, D. and F. Laird, 2013, The New Normal in Funding University Science, *Issues in Science and Technology*, (Fall), pp. 71-76.

[6] http://www.aaas.org/spp/rd/guihist.shtml

[7] http://www.nsf.gov/statistics/nsf06319/

than forty years.[8] In other words, through good times or bad, the government has seen fit to devote approximately 10% of its discretionary resources to science. Whether this is the right number, or should be more, or less, is not objectively answerable, but the stability of the number over time does demonstrate a remarkably consistent level of commitment.

That being said, as the demand for resources has continued to outstrip growth in the amount of federal funding, competition has become increasingly fierce for federal research dollars. I suspect you are familiar with these sorts of numbers, but for example success rates for proposals to NSF and NIH have declined from around 30% on average in the 1990s to 20% or less today[9]—this at the same time that universities increasingly pin their own reputations on their ability to mount top-flight science programs across diverse disciplines. At the same time, promotion, tenure, and professional stature, not to mention the resources necessary to pursue one's scientific interests, depend on getting federal grants, and NSF plays a particularly important role here as the one agency that funds basic academic science across almost all fields of endeavor. Professional advance also depends on publishing results, preferably in high-prestige journals, preferably demonstrating important discoveries that can set one apart from one's peers and give one a competitive edge in the pursuit of still more research funds. And so on.

A key point documented in the *Economist* article, one that seems broadly accepted by the scientific community as a whole, is that the hyper-competitive nature of the academic research enterprise puts a premium on a particular kind of success in one's research: the success of making new discoveries, of new findings that attract the attention and envy of one's peers, that make it into university press releases, and onto the pages of the best journals. The system, that is, has become pervasively biased toward the achievement of positive results from research—even as the problems that science is dealing with become more complex, interdisciplinary, and difficult. The peer review system has limited capacity to police and control this bias: peer reviewers are every bit as busy as the scientists they are reviewing; peers may well have bought into exactly the same assumptions and biases that influence the research to begin with; and besides a reviewer can't wade in and reproduce everything that's reported in a paper, or address all of the interdisciplinary issues raised in a manuscript authored by a team of scientists, as so many today are. They can look for errors, for implausible assumptions or conclusions, inappropriate methods and so forth, but in the end their ability to vouch for the validity of an asserted scientific finding is limited.

Title 1, Sec. 110, 112, 113, 114, 116: The Committee's desire to ensure that research dollars are well-spent, that research results are not misrepresented, that large facilities are openly re-competed, that peer review is not biased toward more senior researchers, and that "alternative research funding models" are explored, is laudable, yet somewhat scattershot. A key strategic goal here must be to maintain the capacity, productivity, and integrity of the research system despite the fact that federal support for science is not likely to increase significantly over the

[8] http://www.aaas.org/spp/rd/Hist/BudgetDISC.jpg

[9] Howard and Laird, op. cit.

next several years—and despite the fact that, over the longer term, no plausible amount of funding growth can slake the ever-increasing appetite for money of the academic research system as it is currently organized. And let me re-emphasize the links here between expectations and integrity. To the extent to which academic scientists are judged by how much federal money they can bring in through research grants, the resulting hypercompetitive environment in turn feeds the systemic bias toward positive findings, as investigators, peer reviewers, program managers, university administrators, and policy makers alike harbor the expectation that every project must be somehow leading directly to an important new discovery that can advance science and solve social problems.

Although incentives that help steer universities and the science community toward more realistic expectations and more sustainable behavior must come mostly from the universities themselves, the NSF, and other federal R&D funders, can contribute to the creation of a more sustainable science enterprise, and this Committee can provide guidance to help them do so. What sorts of "alternative funding models" and other policies might contribute to a longer term establishment of a more sustainable science enterprise? The Committee could explore a range of approaches. Here are some possibilities:

1. Universities often try to "poach" highly productive faculty from other universities, especially those who bring with them big federal grants. This competition helps to drive up the salaries and resource demands of "star" researchers in ways that make the system increasingly costly and unsustainable. NSF could provide a disincentive to this practice by prohibiting the transfer of grants from one institution to another.

2. NSF could provide preference in funding competitions to (a) researchers whose previous work has been replicated by independent research groups; (b) researchers whose academic units assess quality of publications, rather than quantity, as a criteria for promotion and tenure; (c) researchers who can demonstrate that their research has been positively influenced by engagement with knowledge users outside of the university setting, or that results from previous projects have been applied to real-world problem solving; and so on.

3. NSF could broaden the range of academic research projects that require partnerships between universities and other entities, including firms, non-profit organizations, philanthropic foundations, museums, state and local governments, and so on. The goal of such partnerships would in part be cost-sharing, but equally important would be creating the linkages between knowledge creation and knowledge use that can increase the social value of scientific research.

4. NSF could fund "science shops" that support university faculty working directly with local and regional governments or organizations to address problems with scientific and technical underpinnings. Such programs would be relatively inexpensive ways to encourage academic scientists to engage with their local communities, and could also be a powerful laboratory for orienting science students towards career paths aimed at solving real-world problems.

5. NSF could competitively fund "red team" projects aimed at replicating (or falsifying) research results from high-priority or high-profile lines of research; they could similarly fund "sensitivity auditing" groups that would assess the scientific robustness of computer models used in a variety of fields with potential application to policy making.

6. In support of these, or any like-minded, efforts to improve the accountability of the science enterprise and the public value of the nation's investment in science, this Committee could play a direct positive role by working with NSF to ensure that the agency has sufficient and appropriate staffing capabilities to carry out the sorts of programmatic innovations that will be necessary. In the absence of an adequate administrative capability at NSF, the default will be to revert to the standard, entrenched programmatic practices that have attracted the Committee's attention to the need for action in the first place.

While these suggestions are made tentatively, I want to emphasize that cumulatively, a portfolio of such policies, strategically conceived and carefully implemented, might have the effect of helping to catalyze a shift in the incentive structure and culture of university science in ways that could better allow the federal government to ensure sustainable, long-term support, and improved public value for our public investment in scientific research.

As I've tried to emphasize in my testimony today, there are many interrelated issues at play here: the science community's expectation that resources must always expand to keep up with demand; the fierce, often counter-productive competition resulting from such an expectation; the incentives and reward structure of the research enterprise; the links between considerations of scientific excellence and broader impact; and ultimately and most importantly, the need for improved ways to assure accountability for the delivery of research results that are scientifically reliable and societally useful. There will be no single policy intervention that can productively address all of these issues together, yet it is important to recognize that neither can they be considered or addressed separately. What I've tried to suggest is that there are many possible intervention points where relatively modest changes in policy or priorities might move things in the direction of stronger accountability and greater public value. Today's hearing offers a valuable opportunity for consideration of such options.

Daniel Sarewitz is Professor of Science and Society, and co-director and co-founder of the Consortium for Science, Policy, and Outcomes (CSPO), at Arizona State University (www.cspo.org). His work focuses on revealing and improving the connections between science policy decisions, scientific research and social outcomes. His most recent book is *The Techno-Human Condition* (co-authored with Braden Allenby; MIT Press, 2011). He is editor of the magazine *Issues in Science and Technology* (www.issues.org) and is also a regular columnist for the journal *Nature*. From 1989-1993 he worked on R&D policy issues for the U.S. House of Representatives Committee on Science, Space, and Technology. He received a Ph.D. in Geological Sciences from Cornell University in 1986. He directs the Washington, DC, office of CSPO, and focuses his efforts on a range of activities to increase CSPO's contribution to federal science and technology policy processes, and to improve public debate about scientific and technological issues.

Chairman BUCSHON. Thank you, Dr. Sarewitz.
I recognize Dr. Killeen for five minutes for his testimony.

TESTIMONY OF DR. TIMOTHY KILLEEN, PRESIDENT, THE RESEARCH FOUNDATION FOR SUNY, VICE CHANCELLOR FOR RESEARCH, SUNY SYSTEM ADMINISTRATION

Dr. KILLEEN. Chairman Bucshon, Ranking Member Lipinski and Members of the Subcommittee, thank you for inviting me to testify today on this important draft legislation and for your important work, critically important work.

My name is Tim Killeen. I am President of the Research Foundation for the State University of New York and Vice Chancellor for the 64-campus system. I would like to thank the Committee for releasing two different legislative proposals that focus on innovation through scientific research and development as keys to improving our economic competitiveness. I believe that this legislation should send an unmistakable message to our international competitors that we will take the actions and make the investments necessary that will keep the United States at the cutting edge of the 21st century's global knowledge economy.

Just over one year ago, Superstorm Sandy slammed into our coast. As recovery efforts still continue, we should ask what would be the impact if the storm had hit 50 years earlier without the subsequent research and development over those decades. Frankly, it could have killed thousands of people living in the storm's path. Hurricane advisories back then existed only two days into the future. Computer models and weather satellites were in their infancy, and forecasters would probably not have predicted Sandy's right hook into the Jersey Shore. While not perfect, the modern forecasts save lives and property.

So how did we acquire that ability to offset those costs and make such a forecast? The Nation did make continuous investments over decades in its research and education enterprise. Key to this work was basic research in mathematics, computer science, the development of satellites and instrument packages that make the vital observations. It included interdisciplinary environmental research as well as research into the social and behavioral sciences to examine how people use storm-related information to respond to warnings. And through commitments to STEM education, we had the talented human capital to put these tools into use that enable local officials to prepare citizens in ways that save many lives.

Sandy is just one example that demonstrates the linkage of research and education to the economy. My longer list would include Internet, lifesaving vaccines, medical devices such as the heart, lung and MRI technologies developed initially at SUNY, the laser, GPS, touch screens, and the ability to access natural gas from shale deposits.

So the Nation owes a debt of gratitude to Congress and this Committee for its steadfast support for excellence in research and education that has led us to our position as first in the world. The new legislation offers a chance to build on and strengthen that enterprise. If done well, the return on future investment will be incalculable, just as it has been in the past.

As we meet today, however, it must also be said that our Nation's role as the world's innovation leader is imperiled. The combination of eroding buying power here and the enormous resources that other Nations are pouring into these areas is creating a new kind of deficit for the United States, one that has been called an innovation deficit. It is troubling, for example, as the Chair has pointed out, that we have fallen to 12th among developed countries in the proportion of young adults who hold college degrees and our lead in patent applications is eroding. So ensuring the health and vitality of the research enterprise therefore is and should be a national imperative. If we fail to act boldly and in a determined and united fashion of the past, we could face a less prepared, less highly skilled U.S. workforce, fewer U.S.-based game-changing breakthroughs, fewer patents, startups, products and jobs. These impacts may not be immediately obvious but the consequences are inevitable if we do not respond.

In my written testimony, I tried to list a set of principles that I believe should be considered for the legislation. First, even with the major budget challenges we face, the bill should make clear the priority that scientific and engineering research has as a top national priority and provide support for responsible and sustainable growth and across all scientific and engineering disciplines.

Second, the bill should provide robust support for STEM education tools, to enhance public scientific literacy, and to prepare our young people for the jobs of tomorrow while continuing to work to open doors for underrepresented groups. Third, we must insist upon both public accountability and vibrancy in our research enterprise. Both are needed to retain support of the taxpaying public. Our research system has been successful because it has relied on highly competitive merit review processes to make decisions about funding. This gold standard of peer review cannot be allowed to degrade because of complacency, lax oversight or overly onerous new bureaucratic burdens.

This international competition we face is real, and we simply cannot coast and stay first. We also need to tune up, indeed, I would say turbo charge, the innovation ecosystem, accelerating the purposeful commercialization of federally funded research and technologies. In New York, for example, led by Governor Cuomo, we are working on a full innovation agenda tied to research and education and leveraging higher education and industry and businesses as never before.

Throughout our history, this Nation has kept the promise of a better tomorrow for each new generation. This has been possible because our economic prosperity has relied on our role as the global innovation leader, so the message should be sent: the United States will remain at the absolute cutting edge of the 21st century global knowledge economy.

Thank you so much for inviting me. I will be glad to answer any questions.

[The prepared statement of Dr. Killeen follows:]

Written Testimony of
Dr. Timothy L. Killeen
President, The Research Foundation for The State University of New York and
Vice Chancellor for Research, The State University of New York

Submitted to the
Subcommittee on Research and Technology
Committee on Science, Space, and Technology
for the hearing
Keeping America FIRST: Federal Investments in Research, Science, and Technology at NSF, NIST, OSTP and Interagency STEM Programs.

House of Representatives
Washington, D.C.

November 13, 2013

I thank Chairman Bucshon, Ranking Member Lipinski, and honorable Members of the Subcommittee for the privilege of testifying at today's hearing, on a vitally important subject: that of securing the future of this Nation's research enterprise. My name is Timothy Killeen and I am the President of the Research Foundation for the State University of New York (SUNY) and the Vice Chancellor for Research for the 64-campus SUNY system.

I would like to begin by thanking the Committee members for the long-standing and steadfast support and stewardship of the Nation's research enterprise. I also thank you for releasing two different discussion drafts of reauthorization legislation, the primary purpose of which will be to provide adequate, sustained national investment in innovation through scientific research and development. In my opinion, this critically important legislation is needed to foster the economic security and the national security of the United States. These discussion drafts will stimulate a serious conversation in the Administration, the Congress, and in the scientific and engineering research and education community about the future health and well-being of the citizens of the United States as the 21st Century's knowledge economy unfolds.

At the outset, I would like to respectfully suggest that whatever legislative product this Committee ultimately produces should send a clear and unmistakable message to our international competitors that this Nation is committed to making the investments necessary to keep us at the cutting edge of the global knowledge economy. We compete to be first!

The State University of New York (SUNY) is the Nation's largest comprehensive public university system. SUNY consists of 64 geographically dispersed campuses that bring educational opportunity within commuting distance of virtually all New Yorkers. SUNY has a total enrollment of over 450,000 students attending our research universities and medical schools, our comprehensive colleges, our technology colleges, and our community colleges. The SUNY Research Foundation is working to capitalize on the scope, scale, and diversity of SUNY as an engine for our state's innovation economy. The Research Foundation works with academic and business leaders to support research and discovery at SUNY through administration of sponsored projects and the transfer and sharing of intellectual property for public benefit and economic growth.

I want to take the Subcommittee back to just about one year ago when Hurricane Sandy slammed into the eastern seaboard. Now that the storm has come and gone – and we continue our efforts to recover from its impact – we might stop and ask what would have been the impact of Sandy on the mid-Atlantic region of this country if the storm had hit in October 1963 – 50 years earlier.

It might have played havoc with the New York Giants-Dallas Cowboys football game at Yankee Stadium (which, incidentally, the New York Giants won).

On the other hand – it just might have killed large numbers of people living on the eastern seaboard.

Fifty years ago, hurricane advisories extended only two days into the future, computer models and weather satellites were in their infancy, and forecasters might not have expected Sandy's late westward curve into New Jersey. We did not have the sophisticated weather information system that made it possible for the Nation's weather enterprise to make the call on Sandy as early and as accurately as was achieved, so that residents and businesses had sufficient warning to prepare and take shelter. While still not perfect, these modern forecasts undoubtedly made a profound difference for many, many people.

How did we acquire such a sophisticated and important weather forecast system?

The short answer is that we – society – continuously invested over decades in science, technology, engineering, mathematics, and education. These investments supported everything from basic research in mathematics and computer science to the development of satellites and parachute-borne instrument packages that could make the key observations. They enabled us to develop and run forecast models on advanced computing systems so that the large amounts of data could be turned into "actionable intelligence".

But it was not just the investment in the physical and mathematical sciences or satellite technology that delivered this life-saving information. It was also our investment in interdisciplinary environmental sciences – including weather, climate, ocean and coastal research – as well as the social, behavioral and economic sciences that examine how people use storm-related information and respond to warnings. Together, this knowledge enabled state and local emergency managers and first responders to prepare and inform citizens in ways that saved lives and property. And it was a host of innovative technologies that allowed all of this information to be presented in a manner that most people—with or without smart phones—could understand. Finally, it was through investments in education that we had the talented human capital needed to put all this together and make it work.

The need for such multifaceted and creative research and education continues and we should not become complacent and feel that we have all the answers. We are, in some ways, even more vulnerable to severe storms today than we were in 1963. We now have many more people living in coastal areas. We are highly dependent on communication systems that can be disrupted by powerful storms. And we are more reliant on the power grid for everything from transportation to commerce and sophisticated medical care.

The Sandy example is just one of many such stories that speak directly to how specific investments in basic and applied research and education have supported the economic and national security of the United States and its citizens. The NSF Organic Act of 1950 is well worth re-reading in this context, calling for the NSF "to promote the progress of science, to advance the national health, prosperity and welfare, [and] to secure the national defense". The Nation thus owes a debt of gratitude to this Subcommittee and the Congress for authorizing the resources over time that have led us to this point. The legislation the Subcommittee is now developing offers us the opportunity to continue this incredible – and, to our competitors, *enviable* - story of success, and to shape an even more vibrant, accountable, and transparent research and education enterprise for the future.

Unfortunately, however, it must be said that our Nation's role as the world's innovation leader is imperiled today. The combination of eroding federal buying power in research and education and the enormous resources other nations are pouring into these areas is creating a new kind of deficit for the United States: one that has been called an *innovation deficit*. It is troubling, for example, that we have fallen to 12th among developed countries in the proportion of young adults who hold college degrees. Closing the widening gap between needed and actual investments, while ensuring the health and vitality of the research enterprise, must be a national imperative.

If we fail to act boldly – and in the determined and united fashion of the past – we could face a less prepared, less highly skilled U.S. workforce, fewer U.S.-based scientific and technological breakthroughs, and fewer patents, startups, products, and jobs. These impacts may not be immediately obvious because the education and research that lead to advances do not happen overnight. But the consequences are inevitable if we do not respond to the innovation deficit.

The path forward for resolving the budget challenges facing the Nation is undeniably complicated and I fully appreciate that these challenges must be met resolutely and with realism. A strategic component of whatever answer we reach, however, should be sustained true growth of the federal investment in basic and applied research, and in education and student financial aid – a budgetary resolve that will bolster our Nation's economic and national security for decades to come. Such growth will allow for fundamental new knowledge to be discovered at a pace consistent with the growing needs – here, by us, in the United States. It will allow for brilliant young scientists and engineers to contribute and innovate, and will, as in the past, enable economically significant, but often unanticipated, advances to occur to drive our economy forward. Such a budgetary component should be seen as an *investment* with returns of almost incalculable value in terms of economic prosperity, quality education, national security, and international standing and competitiveness.

The justification for this view is rooted in past success. More than half of the national economic growth since World War II has been a consequence of scientific and technological innovation, overwhelmingly stemming from federally funded research. Such groundbreaking research has led to life-saving vaccines and medical devices, lasers, MRI diagnostic devices, touchscreens, GPS, the Internet, and, yes, accurate life-saving predictions of severe storms. We are certainly proud of the track record of SUNY researchers in many of these areas. These and other advances have improved lives and generated entirely new sectors of our economy. And it must be stressed that many of the researchers making these discoveries and translating them into positive societal

outcomes would simply not have succeeded without the generous sustained federal support for research and education.

The onrushing international competition is real and we cannot coast and stay "first". Having witnessed this Nation's success at turning investments in research and higher education into innovation and economic growth, countries such as China, Singapore, India, and South Korea have dramatically increased their own investments in these areas. Over the past decade these other national investments have climbed at two to four times the rate of growth in our own research and development expenditures.

Part of any response to the innovation deficit should be to "turbo-charge" merit-based grant opportunities for proof-of-concept research and other innovative technology transfer activities at universities, research institutes and Federal laboratories, serving to accelerate the commercialization of federally-funded research outcomes and technologies. The TRANSFER Act that is under discussion represents a major step forward in this regard.

In New York, led by Governor Cuomo, we are leveraging our world-class SUNY system and other institutions of higher education in the state to partner with industry and new businesses as never before, providing them with direct access to advanced research capabilities, development resources, expertise in nanotechnology, biomedical, information technology and other fields, as well as to relevant human capital and expertise. And this new compact between the knowledge creation (research and education) and the job creation (private sector) communities will also directly enrich the educational experiences and job prospects of our students in a win-win partnership. I applaud the emphasis in both discussion drafts on enhancing technology transfer and commercialization through a major retooling and "tuning-up" of what is often called the *innovation ecosystem.*

I reiterate my belief that the legislation this Subcommittee is developing should send a very strong message to our international competitors that this Nation is committed to doing what is necessary to keep us at the cutting edge in today's global knowledge economy. Both discussion drafts have important elements for this overall message. To further that end, I would like to suggest that the Subcommittee consider the following set of draft principles for its work towards the further development of the bill. These principles have been adapted from a set developed recently by a distinguished group of industry and academic leaders.

1. Principles for the Funding of Science and Engineering

The National Academies' report, *Rising Above the Gathering Storm*, and both the America COMPETES Acts of 2007 and 2010, set goals and established funding targets aimed at doubling funding for key federal research agencies within seven years. I fully recognize the difficulty of achieving the doubling goal in the current fiscal environment, but I believe that the reauthorization bill should:

- Make a strong statement that the United States sees robust funding across all disciplines of basic scientific and engineering research as a top national priority;

- Set targets that provide for steady and sustained real growth in funding for all of the major federal research agencies. The bill should specifically set such targets for the NSF, the Department of Energy (DOE) Office of Science and the National Institutes of Standards and Technology (NIST);

- Support funding pathways for competitive programs and core research that avoid detrimental tradeoffs between fields of science and engineering and that are based on utilization of well-managed peer review mechanisms designed to assess merit and avoid real and perceived conflicts of interest;

- Maintain a strong foundation of basic research across all scientific disciplines, from the physical, mathematical, environmental and life sciences, to engineering, to education research and the social, economic and behavioral sciences;

- Ensure that federal scientific agencies, guided by national needs and their scientific advisory committees and boards, continue to set and articulate clear priorities for funding within and among the full range of scientific disciplines – priorities that serve the advancement of scientific knowledge and are clearly in the national interest; and

- Commit to public accountability, transparency, and excellence in all aspects of the national research and education enterprise.

2. Principles for the Funding of Education Research and Workforce Development

Maintaining and promoting scientific literacy for all to prepare our young people for 21st century jobs and citizenship, and strengthening the pipeline of scientists and engineers who will propel science and innovation forward, were essential goals of *Rising Above the Gathering Storm* and of previous America COMPETES Acts. Maintaining and enhancing our science technology, engineering and mathematics (STEM) literacy and talent base is essential to continuing U.S. scientific, technological and economic global leadership. To this end, I believe that the reauthorization bill should:

- Support innovative and effective education programs to promote the broad-based scientific literacy necessary to equip all citizens with the scientific and technical knowledge required to meet future national and global challenges, as well as to train future generations of U.S. scientists and engineers;

- Support the NSF's mission of improving STEM education at all levels – and at a true national scale - by sustaining research critical to our understanding of how students learn STEM, how best to teach students in STEM fields, and how to increase participation of women and underrepresented minorities in STEM;

- Support proven STEM education programs at other federal research agencies aimed at ensuring an adequate STEM workforce in direct support of the fulfillment of their respective agency missions; and

- Support immigration reform for high-skilled workers and other policies to ensure that the United States has access to, and is fully able to take advantage of, the best and brightest talent in STEM fields from around the world.

3. Principles for Maintaining Research Excellence and Opportunity

The U.S. system of scientific research has been tremendously successful because it has remained broadly based and insulated from political pressures. The key evolving scientific focus areas have been determined by federal agencies, guided by the scientific community through a strong system of merit review and advisory committees; and research results have been widely distributed and made accessible. I suggest that the reauthorization bill take steps to:

- Support the "gold standard" system for research funding based upon competitive scientific merit, and broader impact, as evaluated through rigorous peer review. Peer review has been a critical factor in the success of America's research system through its use of panels of scientific experts to evaluate the quality of proposals. In this competitive process, proposals compete for resources based on their scientific merit and potential for broader impacts. Peer review helps ensure that federal agencies support the best, cutting edge research, provides a self-correcting mechanism that works to help improve the quality of future research proposals, and provides public accountability by assuring that tax dollars are spent in the most effective manner;

- Preserve and support programs that seek to stimulate competitive research capabilities and opportunities in particular states and regions and for those institutions and populations currently under-represented in science and engineering;

- Reduce or eliminate unnecessary or duplicative federal regulations and reporting requirements that increase research costs, impede research productivity, and needlessly divert researchers' time from directly conducting scientific research and mentoring students; and

- Ensure that any new programs, reporting requirements and/or other mandates that may be contained in the bill are provided with the funding necessary to carry them out and that they are accompanied by an analysis that details the cost of the new requirements.

Concluding Thoughts

We are all aware of the serious budgetary challenges the Congress must confront and I recognize that such challenges will clearly impact this legislation. However, as you grapple with these difficult issues, it is important to keep our Nation on an innovation path that makes it possible for our economy to grow and our citizens to prosper. Public trust in the conduct of our scientific and educational research efforts must be gained – and retained - through appropriate accountability and transparency provisions, and - just as importantly - through a national commitment to vibrancy and excellence in the pursuit of new knowledge and in the development of human capital.

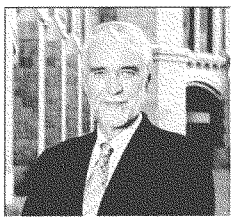
Throughout our history, this Nation has kept the promise of a better tomorrow for each new generation. This has been possible because of our economic prosperity is based in large part on America's role as global innovation leader. Failing to respond to today's challenges with sustained strategic investments in our research and education enterprise will pass to future generations the burdens of lost leadership in innovation, possible economic decline, and significantly more limited job opportunities for our youth. It is that important.

As the Congress moves to develop the Keeping America FIRST legislation that builds on efforts made via prior America COMPETES Acts, I hope the Subcommittee will find the principles I cited here helpful to gauge and assess specific ideas and elements for the legislation.

Thank you for the opportunity to present these views. I would be happy to answer any questions the Subcommittee and the Members may wish to raise.

SUNY The State University of New York

SUNY RF The Research Foundation for The State University of New York



Dr. Timothy Killeen, President, The Research Foundation for The State University of New York & SUNY Vice Chancellor for Research

In June 2012, Dr. Killeen was appointed president of the RF and SUNY vice chancellor for research. As RF president, Dr. Killeen is the chief executive officer responsible for the supervision and operation of the largest comprehensive university-connected research foundation in the country. As SUNY vice chancellor for research, he is at the center of SUNY's strategy for the growth of basic, translational, and clinical research. Dr. Killeen leads the SUNY Research Council, an advisory body to the SUNY board of trustees, RF board of directors, SUNY provost, and campus presidents, and chairs SUNY's Patent and Inventions Policy Board. Prior to joining the SUNY community, Dr. Killeen served as the National Science Foundation's (NSF) assistant director for geosciences from 2008-2012. From 2000-2008, he was the director of the National Center for Atmospheric Research (NCAR). During that time, he was a Lyall Research Professor at the University of Colorado and, in 2007, was elected to the National Academy of Engineering. He spent more than 20 years on the faculty and in the administration of the University of Michigan, Ann Arbor, including a term as associate vice president for research. He has been the principal investigator on numerous theoretical and experimental investigations relating to atmospheric and space science, computing and information technology, and educational innovation. Dr. Killeen has served on various White House Office of Science and Technology Policy committees and task forces, testified to Congress and the executive branch, and from 2010-2012 was chair of IGFA, the 25 member International Group of Funding Agencies for global change research. Dr. Killeen, a US citizen, grew up in Wales and completed his undergraduate and graduate education at University College London, earning his Ph.D. in atomic and molecular physics.

Chairman BUCSHON. Thank you, Dr. Killeen.

I now recognize Mr. Brown for five minutes for his testimony.

TESTIMONY OF MR. JAMES BROWN,
EXECUTIVE DIRECTOR,
STEM EDUCATION COALITION

Mr. BROWN. Well, first, thank you to the Committee for the opportunity to be here today and offer our coalition's views on the draft legislation that is before us and on issues related to Federal STEM education policies.

As you mentioned in your introduction, we are a very broad coalition but what unites us is the belief that we need to elevate STEM education as a national priority. At the end of our testimony, our written testimony, there is a list of the 35 members of our coalition's leadership council which inform our policy positions and which guide our activities.

I am fond of mentioning a couple of statistics whenever I talk about this topic that I think really clearly illustrate the challenge that we have both for our coalition and for the country. A 2011 poll showed that 93 percent of parents think that STEM education should be a top priority for the United States. The poll also showed that little less than half believe it is actually a priority for the United States, and something I think is at least a little bit related, and that is, another poll I saw showed that 68 percent of parents think their kids are in the top third of their class, which I think those are at least ironically linked, right?

So suffice it to say, one of the things this Committee has done over the years is with a long line of witnesses established the connections between STEM education and the STEM workforce and the future of the country. They are inextricably linked. They underpin our capacity for innovation and our American leadership. I also think the parents are on to something else, and that is that they get a very clear sense that STEM education, the STEM fields are where the best jobs of the future are going to be, and if you look at the statistics as an aggregate, the STEM fields have higher salaries, lower unemployment, and I think just parents get that sense from looking at the world around them, that is where the future is going. But it is one of the easiest things in the world to talk in broad terms about the importance of STEM education. It is much harder—the Committee has a much harder job in formulating policies that are practical, that are real to deal with these challenges, and in that spirit, we tried to answer your questions in as much detail as we possibly can in our written testimony, and we have also attached a letter to that testimony that in a five-page letter that addresses our views on the Administration's most recent budget proposal which was signed by more than 50 leading national organizations. So we hope that is helpful to you.

I wanted to touch on three topics that I thought were the most important points of our message to you, and that is—the first is on the subject of fiscal sustainability. The other witnesses have acknowledged this, and I think it is absolutely clear when you look at the budget environment of today and you look at the challenges that we face, that the Federal portfolio of more than 200 different STEM education programs across multiple agencies is in need of a

very serious overhaul, but that overhaul, if we are to do the service that our kids and our future innovators deserve, has to be based on evidence and it has to be based on stakeholder input and it has to be capable. We have to make decisions as a country that will scale up the programs that we think work and that will improve or will eliminate the programs that are not working over time, and you emphasized this in your opening statement: this has to be a long-term process.

The other thing I would just say is, we also have to recognize that every Federal education program can be improved and that if we are going to use taxpayer dollars to support them, we need to have constructive oversight mechanisms. That is simply a fact of life.

Another point to make is that we have offered some views in our testimony around what we think the properties of a good coordination and management mechanism would look like, and some of those relate to the fact that it has to have a good conduit for stakeholder input, there has to be a mechanism for that input informing policy decisions, the coordinating mechanism has to have a voice in budget deliberations at the various high—very highest levels of government, and we have to do what we can to expand the evidence base around what is working, and that is a very complicated problem. It is not simple.

And finally, why does stakeholder input matter? At the end of the day, the challenges we face in this space are so complicated that no one entity in government, no one person, no one education group is going to be able offer a master plan that will solve these challenges. It is simply not going to happen. So we have to work together across party lines, across disciplinary lines, and across the boundaries of Federal agencies to make it happen, and we have to do it over time.

And the last thing I would just echo, and it is something you mentioned in your opening statement, Mr. Chairman, and that is, we have to be persistent. This is a long-term challenge, and I hope what we can do with this draft legislation is set in place a process that will get at this challenge over time. Thank you.

[The prepared statement of Mr. Brown follows:]

Testimony
Committee on Science, Space, and Technology
Hearing on "*Keeping America FIRST: Federal Investments in Research, Science, and Technology at NSF, NIST, OSTP, and Interagency STEM Programs*"
November 13, 2013

James Brown
Executive Director
STEM Education Coalition

Introduction

Thank you for the opportunity to testify before the Committee and to offer our views on the discussion draft of the FIRST Act and issues related to federal STEM education programs and policies.

The STEM Education Coalition is an alliance of more than 500 education, business, and professional organizations from across the country that are united in the goal of promoting policies to improve science, technology, engineering, and mathematics (STEM) education at every level. Our Coalition closely follows the development and evolution of policies across the federal government that seek to address the challenges our nation faces in educating the future STEM workforce. A listing of the members of the Coalition's Leadership Council, which develops and guides our public policy agenda is included as Appendix A to this testimony.

STEM education is closely linked with our nation's economic prosperity in the modern global economy and strong STEM skills are a central element of a well-rounded education. Why?

Here are a few reasons:

- According to the Council on Foreign Relations, 60 percent of U.S. employers are having difficulties finding qualified workers to fill vacancies at their companies.[1]
- While the U.S. economy grapples with economic recovery, job postings in in the STEM occupations outnumber unemployed workers by nearly two to one.[2]
- At all levels of educational attainment, STEM job holders earn 11 percent higher wages compared with their same-degree counterparts in other jobs.[3]
- 47 percent of Bachelor's degrees in STEM occupations earn more than PhDs in non-STEM occupations.[4]

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[1] http://www.cfr.org/united-states/us-education-reform-national-security/p27618
[2] http://changetheequation.org/stemdemand
[3] http://www.nga.org/cms/home/nga-center-for-best-practices/center-publications/page-edu-publications/col2-content/main-content-list/building-a-science-technology-en-1.html
[4] http://www9.georgetown.edu/grad/gppi/hpi/cew/pdfs/STEMWEBINAR.pdf

Accordingly, STEM education must be elevated as a national policy priority as reflected through education reforms, policies to drive innovation, and budgetary priorities. More precisely, the Coalition feels strongly that action on STEM education policy should match the rhetoric on its importance.

While the collected fields that make up "STEM" are clearly connected with future economic growth and the job market for people with these skills is relatively strong, it's also important to point out that the STEM fields are not a monolith – policies to strengthen the U.S. STEM education pipeline must be flexible and adaptive to a rapidly changing educational and workforce landscape.

U.S. Competitiveness, STEM Education, and the Importance of the America COMPETES Act

We are very pleased that this Committee is again considering federal STEM education policies and the reauthorization of major portions of the America COMPETES Act.

The passage of the original America COMPETES Act in 2007 and its subsequent reauthorization in 2010 demonstrated to the entire world that U.S. leaders can work together effectively to strengthen the foundations of American innovation. That original and overwhelmingly bipartisan bill laid out a very bold vision for expanding federal investments in basic scientific research and bolstering the U.S. STEM education pipeline. That vision was a direct response to widespread concerns that U.S. leadership in science and technology was slipping.

Six years later, with our nation slowly emerging from worst economic downturn since the Great Depression, and with fiscal budget pressures at unprecedented levels, those same concerns have only multiplied.

A 2011 Harris poll funded by one of our member organizations found that, although most parents of K–12 students (93 percent) believe that STEM education should be a priority in the U.S., only half (49 percent) agreed that it actually is a top priority for this country. Further, this study found that only one in five U.S. STEM college students felt that their K–12 education prepared them extremely well for their college courses in STEM.[5]

Compounding this struggle to improve education outcomes is the reality that the federal STEM education portfolio is in need of a serious overhaul. There are currently more than 200 STEM education programs scattered across 13 different agencies, a huge portion of which fall under the jurisdiction of the Committee. A large fraction of these programs are quite small in scope. On the other end of the spectrum, the Department of Education's Math and Science Partnership program – the largest federal program that is focused solely on STEM outcomes – has not been reauthorized in more than a decade. Many federal programs have limited data on outcomes and effectiveness and all of the programs in the current federal portfolio would benefit from greater cross-agency coordination and a better system of evaluation.

[5] http://www.microsoft.com/presspass/press/2011/sep11/09-07MSSTEMSurveyPR.mspx

Our government needs a comprehensive and strategic effort to review all federal STEM programs on a regular basis to ensure that effective programs are scaled up and that underperforming programs are improved or eliminated over time. Further, effective policies to manage the federal STEM education portfolio should be bipartisan and evidence-based and must be informed by a strong and supportive community of stakeholders in the business, professional, research, and education communities. Scaling up what we know works is the only way we will ever improve real learning opportunities for the millions of students who must succeed in STEM fields in the future.

As the global economic landscape continues to expand and evolve, a succession of Continuing Resolutions, coupled with the persistent Sequester, have put federal agencies like the National Science Foundation (NSF) in the extremely difficult position of needing to do more with less in order just to keep up with other countries.

While it is relatively easy to talk about the broad challenges we face around U.S. competitiveness and STEM education, it is much harder to construct reasonable policy solutions. Our Coalition certainly appreciates this challenge and shares responsibility with you and others to develop and support policies that will give the country the vibrant and diverse STEM workforce it needs. We are pleased to have the opportunity to offer our views on several important education policy issues addressed in the FIRST Act discussion draft.

Specific Feedback on the FIRST Act Discussion Draft

In preparing our Coalition's testimony, we are responding to several direct questions posed by the Committee and we also offer additional observations and recommendations.

Question: Why is stakeholder input important for the federal support of STEM education programs and activities? How will the proposed legislation encourage greater input and engagement from STEM education related stakeholder communities?

Because improving U.S. STEM education is a long-term undertaking, our nation desperately needs a thorough and ongoing public debate on the best overall strategy. No one within our government or the education community is going to be able to develop or implement any kind of "master plan" on their own. We are going to have to work together across party lines, across disciplinary lines, and across federal agency boundaries and the different branches of government.

The Administration put forward a budget proposal for Fiscal Year 2014 that was the most ambitious and sweeping effort to reorganize federal programs related to STEM education since the Sputnik era. This budget proposal would have consolidated or restructured more than 100 existing programs. However, the Administration's plan lacked crucial details and was produced with minimal critical input from STEM stakeholders. As an example, a major flaw in this plan was the lack of detail about how – or if – the missions of consolidated or eliminated programs would be incorporated into new initiatives proposed at other agencies. Included as Appendix B to our testimony is a copy of a detailed letter to the House and Senate Appropriations

Committees with our Coalition's more detailed assessment of the Administration's budget proposal. Many of our members and allied organizations have offered similar sets of recommendations on strategies related to federal STEM programs. [6] [7] [8]

Education has become a data-driven endeavor and education policy decisions need a firm basis in evidence, the effectiveness of which must be informed by educational stakeholders. We also need to remove political considerations as much as possible from this process.

The discussion draft would ~~create~~ a STEM Education Advisory Panel, established under the President's Council of Advisors on Science and Technology (PCAST) that would be appointed by the President and populated by knowledgeable individuals from across the stakeholder spectrum. The explicit purpose of this panel would be to provide a range of external input to federal decision makers on STEM-related policy questions from current trends, to non-profit and business community contributions, to management and evaluation of federal programs.

When we talk about STEM stakeholders it is important to be specific. In order for any feedback process to be truly effective, it needs to be based in large degree on the "ground truth" inputs of educational practicioners – the teachers, school leaders and administrators that run public schools and universities, as well as their partners in the out-of-school world that includes discliplinary societies, employers, museums, community centers and the like. Too often these "on the ground" voices are lost in conversations of national education policy. These stakedholders are also essential in determining the questions about what "effective" really means when evalutating federal programs. Securing the buy-in of these groups is critical to the long-term success of the education reforms that will be the object of changes in the federal STEM portfolio.

The Advisory Panel could be also improved by providing more specificity and transparency on the types of inputs and critical issue areas where the expertise of panel would be sought. For example, this group could be charged explicitly with developing specific recommendations on the criteria for evaluating the effectiveness of federal STEM programs and the proper "mix" of programs across agencies.

Another important area of focus is around the intergration of in-school and out-of-school STEM content and programming, where an increasing body of research shows that effective out-of-school-time programs can help young people appreciate the value of STEM fields and provide them with hands-on "real" experiences. This is a particular challenge that involves coordination and management of programs across multiple agencies.

Also notably absent from the mission of the Advisory Panel is a specific charge to address diversity, inclusion, and equity issues. One of the central goals of our Coalition has been to support innovative initiatives to encourage more of our best students, especially those from underrepresented or disadvantaged groupspopulations, to study in STEM fields – an important goal of any federal STEM strategy. A large number of our Coalition members and others across the science and technology community operate successful programs focused on addressing

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[6] https://www.aau.edu/registration/public/Guiding_Principles_for_Community_Support_of_America_COMPETES_Reauthorization_as_of_4-18-13.pdf

[7] http://www.stemedcoalition.org/wp-content/uploads/2010/05/SupportAfterschoolSTEM_letter_with_sigs.pdf

[8] http://www.acs.org/content/dam/acsorg/policy/publicpolicies/enable/innovation/acs-letter-to-house-s-t-committee-competes-bill.pdf

inequalities in education and the workforce and there are many valuable lessons learned that can inform federal efforts with similar goals.

Finally, our Coalition has also long-supported an inclusive definition and use of the term "STEM education" by federal and state programs that is not limited to only math and science, but also embraces engineering and technology, and broadly encompasses STEM fields and their unique needs in formal and informal settings. A broader, more flexible and more diverse federal definition of STEM education would afford states and localities the ability to invest in subjects outside of traditional math and science. For example, those concerned about the teaching and learning of computer science are particularly concerned about the narrowness of definitions of STEM education and other provisions in federal laws that have contributed to the marginalization of computer science education. This Advisory Panel should represent all these fields and dimensions in order to provide comprehensive insights on STEM education programs.

Question: Understanding the current fiscal realities, how will the discussion draft of the FIRST Act help maintain and spur additional innovation and competitiveness in the United States? Why is it important that the United States address the issue of a sustainable path towards future scientific and STEM education funding?

While the discussion draft deals with a broad range of science and technology policies – many of which are beyond the scope of our Coalition's mission – the fiscal realities we face today as a collective community are starkly clear. Until the U.S. government gets its fiscal house in order, we will continue to endanger our nation's ability to make sustained investments in the foundations of our prosperity.

We must also do everything we can to ensure that federal resources are being put to the best possible use. Limited budgets mean that we must prioritize federal investments in science and technology, innovation, and education. Every program involving public money must have constructive oversight – and any management system can be improved.

As we see it, one of the most critical public policy challenges is to tackle the knot of issues inherent in a federal portfolio of more than 200 distinct STEM education programs. Numerous studies by the General Accountability Office, several congressional committees, and other outside groups have repeatedly pointed out concerns about duplication, overlap, and effectiveness within some of these programs. At the same time, we could easily point to positive outcomes associated with each of these initiatives.

The challenge for our government is to establish a much more effective, evidence-based process for sorting through the vast landscape of federal STEM programs to leverage limited investments for maximum student learning. It is only through such a process that we will ensure that effective programs are scaled up and that underperforming programs are improved or eliminated.

The discussion draft addresses this critical challenge by bolstering the oversight, input, and evaluation mechanisms that will fuel future budget decisions for STEM programs. In our view, the best possible outcome of these proposals would be to establish a mechanism that, over time, helps build our knowledge base about what truly "effective" means for each element of the federal portfolio. In an environment of constrained budgets, this is the best possible move toward making each federal dollar spent to improve STEM education more effective – and to justify a sustainable expansion of such investments in the future.

Question: The discussion draft proposes a new advisory panel, led by outside stakeholders, changes to CoSTEM and establishes a STEM education coordinating office. How will these changes affect the STEM education community and the way STEM education programs and activities are managed through the federal government?

Over the last several years, our Coalition has been involved in a variety of policy conversations around the issue of how best to deal with the challenges surrounding the management and strategic direction of the federal STEM portfolio. Numerous bills have sought to create or bolster this function in some way and the 2010 America COMPETES Act reauthorization bill set forth a concerted process to do so, through its creation of the interagency Committee on STEM Education under the National Science and Technology Council.

As the federal STEM portfolio strategy issue has evolved and our understanding of the intergovernmental, bureaucratic, and budgetary challenges has improved, a few key factors that can help such an effort succeed have emerged:

- Our ability to evaluate the effectiveness of many of the individual programs that make up the diverse federal STEM portfolio is quite limited. For the largest programs, student achievement impacts and other traditional educational measures serve as excellent indicators. However, for the vast array of smaller programs[9], many of which are targeted at very specific objectives or constituencies, the question of evaluation is much more complex and difficult. It is also a common overgeneralization to view small educational programs as inherently ineffective. Therefore, a key aspect of the federal management strategy is building up our capacity to critically and properly evaluate these programs. There is no single performance measure – such as impacts on test scores – that will work for every program.
- Access to a large pool of staff expertise on STEM education-related teaching, learning, and programmatic matters is essential to the success of any coordination process.
- The coordination and management effort needs to be able to solicit and receive regular input from outside stakeholders within the STEM community.
- It is ~~highly~~ desirable to locate the bulk of ~~the~~ coordination effort in an area of government that is insulated as much a possible from perceived political influence.

[9] Of the 247 STEM programs identified by CoSTEM: 67 are less than $1 million, 149 are less than $5 million, and only 5 are greater than $100 million annually.

- This activity should not be overly focused on eliminating duplication and overlap amongst federal programs and also be empowered to identify and address emerging issues, such as the need to balance and integrate afterschool and in-school STEM learning or to build pathways for getting interesting content produced by federal scientists into the hands of the right educators.
- The coordination effort should have a clear pathway for informing and influencing budget decisions.

While there is no single body in government that satisfies all of these conditions, the STEM Education Coordination Office that the discussion draft would create at the NSF would address nearly all of these criteria.

The NSF already has a large pool of the requisite expertise, is widely recognized for its peer-review process and its work in educational research and program evaluation, and it's professional staff are widely respected for their independence and extensive network of relationships within the community.

The major challenges posed by locating the Coordination Office at NSF will be in ensuring that it has an adequate staff and secures the "buy-in" of other science and education agencies in its work and that its recommendations have "teeth" within the Administration's budget development and interagency management process.

One way to address the staffing challenge might be to develop this new office under the model used by several other interagency coordinating bodies to require agencies that fall under the coordination of the new office to detail one or more staffers to work in it, creating both buy-in and capacity at the same time.

From our perspective, the most significant single impact of the policies proposed by the discussion draft will be to put in place a permanent, evidence-driven mechanism to coordinate, evaluate, and manage the more than $3 billion in annual federal investments dedicated to improving STEM education.

Conclusion

Simply put, if we are to keep up with our global competitors, we had better step up our commitment to improving STEM education and increasing opportunities to access innovative STEM education programs both in and out-of-school.. While the rhetoric around the issue is loud, and the community has powerful supporters, associated changes in policies and public investments have been disappointing. We hope that changes to the programs that govern investments in our future STEM workforce and the research that is so important to innovation more closely match the calls for more and better STEM education in the future. We appreciate the opportunity to share our views with you and look forward to working with you as the Committee further considers this legislation.

Appendix A: Members of the STEM Education Coalition Leadership Council and Affiliates

Chair: National Science Teachers Association

Co-Chairs

- American Chemical Society
- ASME
- Education Development Center, Inc.
- Hands-On Science Partnership
- Microsoft Corporation
- National Council of Teachers of Mathematics

Council Members

- Afterschool Alliance
- American Association of Colleges for Teacher Education
- American Farm Bureau Foundation for Agriculture
- American Society for Biochemistry and Molecular Biology
- American Society for Engineering Education
- American Society of Civil Engineers
- American Statistical Association
- ASHRAE
- Association for Computing Machinery
- Association of Public and Land-grant Universities, APLU
- Battelle
- Business-Higher Education Forum
- Cable in the Classroom
- Campaign for Environmental Literacy
- Education Testing Service, ETS
- Entertainment Industries Council
- ExxonMobil
- IEEE-USA
- Illinois Math and Science Academy/Committee for the Advancement of STEM Speciality Schools
- John Wiley & Sons, Inc.
- National Association of Manufacturers
- Project Lead the Way
- Texas Instruments
- The Alliance for Science and Technology Research in America
- Time Warner Cable
- Universal Technical Institute

Link to: Affiliate Members of the STEM Education Coalition

Appendix B: STEM Education Coalition Letter in Response to the Budget Proposal

STEM
EDUCATION
COALITION

May 22, 2013

The Honorable Barbara A. Mikulski
Chair, Committee on Appropriations
United States Senate

The Honorable Harold Rogers
Chair, Committee on Appropriations
U.S. House of Representatives

The Honorable Richard C. Shelby
Ranking Member, Committee on Appropriations
United States Senate

The Honorable Nita M. Lowey
Ranking Member, Committee on Appropriations
U.S. House of Representatives

CC: Members of the House and Senate Appropriations Committees

Dear Appropriations Committee Leaders:

As the House and Senate Committees on Appropriations proceed with setting federal spending priorities for Fiscal Year (FY) 2014, the STEM Education Coalition would like to offer views on the Administration's recently released budget proposals related to science, technology, engineering, and mathematics (STEM) education programs.

The Administration's FY2014 budget proposal is the most ambitious and sweeping effort to reorganize federal programs related to STEM education since the Sputnik era and we greatly appreciate the clear commitment of the Administration to continue to support STEM education as a national priority. The budget proposes $3.1 billion to support federal STEM education programs, a 6.7 percent increase over FY2012/13 levels. The budget proposes 13 new initiatives, most of which would require separate Congressional authorization, and also seeks to consolidate or restructure 114 of the 226 currently existing federal programs, 78 of which would be terminated with funds totaling $176 million being directed to other agencies.

However, the broad scope of these proposed changes raises a number of serious policy questions about the relative and proper roles of federal agencies in supporting STEM education efforts within K-12, undergraduate, graduate, informal, and workforce settings that deserve careful and complete consideration by Congress in partnership with the STEM education community.

Appendix B: STEM Education Coalition Letter in Response to the Budget Proposal

Consolidation and Realignment of Federal STEM Programs

Our Coalition has a long history of support for comprehensive and strategic efforts to coordinate, evaluate, and review all federal STEM programs on a regular basis to ensure that effective programs are scaled up and that underperforming programs are improved or eliminated. Over that past three years, we have encouraged and participated in the efforts of the Federal Coordination in STEM Education Task Force and the Committee on STEM Education of the National Science and Technology Council which were established by the America COMPETES Act in 2009 to accomplish this function across federal agencies.

The Administration's budget proposal would consolidate or restructure more than half of the more than 200 existing federal STEM education programs. The Administration has also signaled that it intends to release a "Strategic Plan for STEM Education" in the next several weeks which we hope will share more details on how the proposed consolidations would align to overall national goals for improving STEM education. Many of the programs proposed for consolidation or elimination are at mission agencies that have longstanding expertise in specialized STEM fields or address specific workforce needs and many others have focused on informal STEM education activities. These areas make important contributions to improving U.S. STEM education. We eagerly look forward to reviewing the Administration's forthcoming Strategic Plan, especially with regard to how the missions of programs proposed for consolidation would be integrated into newly proposed initiatives.

While our Coalition does not take a position on each individual program that would be affected, we encourage the Appropriations Committees to look at each of the specific STEM education programs on an individual basis and to listen carefully to the organizations and constituencies – especially the students and educators – who would be impacted by the proposed consolidations.

Views on Specific Administration Proposals

We greatly appreciate the Administration's continued commitment to support STEM education as a budgetary priority – especially in an environment of constrained resources – as demonstrated by the overall proposed spending level of $3.1 billion for STEM programs, a 6.7% increase. As discussed previously, we strongly urge the Appropriations Committee to look closely at each of the Administration's proposed changes to specific programs on an individualized basis and not simply eliminate each program proposed for termination while also not funding any of the newly proposed STEM initiatives intended to replace them.

Our nation desperately needs a thorough public debate on the best overall strategy for improving U.S. STEM education and the remainder of this letter will detail our views on a wide range of the Administration's proposals.

Appendix B: STEM Education Coalition Letter in Response to the Budget Proposal

Department of Education (DoEd)

Math and Science Partnerships (MSP)- The DoEd's own most recent evaluation of this program has shown that it is effective at improving student success and teacher content knowledge in STEM subjects and we strongly support continued funding of the MSP program at at least the current level of $150 million. Similar to prior years, the Administration has proposed a new Effective Teacher and Learning: STEM initiative to replace the MSP program and we appreciate the Administration's updated budget justification language acknowledging that the current program will continue intact until this new initiative is authorized by Congress.

STEM Master Teacher Corps- We support the Administration's proposal for a pilot-scale STEM Master Teacher Corps program. This appropriately-sized effort would allow the DoEd to develop a better understanding of how to identify, recognize, and reward the most accomplished STEM educators by increasing their compensation, providing them with leadership opportunities, and helping to create a national community of outstanding STEM educators.

STEM Innovation Networks: We commend the Administration's focus on expanding efforts to support innovation in K-12 STEM education and look forward to working with the Administration to secure Congressional authorization for this proposal. We have long supported a balanced approach to STEM education at DoEd that combines both large-scale formula-based efforts with more targeted and flexible competitive programs. We also strongly urge that this new initiative support strong partnerships that incorporate informal and hands-on STEM learning with classroom-based approaches.

National Science Foundation (NSF)

Education and Human Resources (EHR) Directorate: We support full funding of the National Science Foundation's Education and Human Resources Directorate at the proposed level of $880 million. Robust and sustained investments in STEM-related educational research and innovation programs are an essential element of improving U.S. STEM education. We believe very strongly that education is a core mission of the NSF, equal in importance to its other missions in research and public awareness. NSF must maintain an appropriate long-term balance between serving needs in K-12, undergraduate, graduate, and informal education settings. While we appreciate the NSF's emphasis on new undergraduate and graduate educational initiatives, we also want to ensure that this new focus does not lessen NSF's focus or enthusiasm to advance long-standing K-12 and informal education goals.

Catalyzing Advances in Undergraduate STEM Education (CAUSE): We support the $123 million proposal to establish this new agency-wide program to maximize the impact of NSF's ongoing efforts to support undergraduate STEM education. We also support this program's focus on broadening participation in STEM, increasing institutional capacity, and alignment with workforce needs.

Appendix B: STEM Education Coalition Letter in Response to the Budget Proposal

Science, Technology, Engineering, and Mathematics, Including Computing Partnerships (STEM-C Partnerships): We support NSF's proposal to integrate a focus on computing into the existing NSF MSP program in the $57 million STEM-C Partnerships initiative. We strongly support a definition of STEM subjects that would allow for the inclusion of computing and computer science and other fields relevant to workforce needs.

Noyce Teacher Scholarship Program: We support the budget request of $60 million for the Noyce program, a 10.9% increase. We strongly support efforts to recruit and retain STEM educators with strong content backgrounds, especially those that prepare new STEM graduates for teaching careers.

Advancing Informal STEM Learning (AISL): We are disappointed by the proposed reduction in FY14 for the AISL program, a $13.6M decrease (or 23%) from current funding levels. This is the only program at NSF that focuses on research and best practices to understand learning in out-of-school settings, which is an extremely important component of STEM education reform.

Graduate Fellowship Programs: We note that the budget proposal would consolidate a large number of existing graduate fellowship programs in STEM fields, both from within NSF and from other agencies, into a single large program managed by NSF. We are eager to learn more about how NSF proposes to manage this transition, especially with regard to support for graduate fellowships in STEM fields that have not traditionally been major research areas for the NSF.

Smithsonian STEM Initiative

The Administration has proposed $25 million for a new STEM education initiative at the Smithsonian. This initiative, which would be coordinated by the Center for Learning and Digital Access, proposes to create new online STEM resources for students and teachers that are aligned to the learning standards set by the states. This initiative also appears to consolidate a number of informal, afterschool, and outside-the-classroom education efforts being conducted at other science agencies. We appreciate the goal of better aligning such programs across multiple agencies and look forward to learning about how the Smithsonian would specifically support the informal science education community, integrate with ongoing mission agency efforts and areas of expertise, and work directly with educators and stakeholders in this space.

We appreciate the opportunity to share our views with you and look forward to working with you closely during the Appropriations process.

Respectfully,

Afterschool Alliance
Altshuller Institute for TRIZ Studies
American Chemical Society
American Geophysical Union
ASME Board on Education

Appendix B: STEM Education Coalition Letter in Response to the Budget Proposal

Battelle
Education Development Center
Funutation Tekademy LLC
Girls, Inc.
Hands on Science Partnership
Kemin
Lawrence Hall of Science
LearnOnLine, Inc
NARST: A Worldwide Organization for Improving Science Teaching and Learning through Research
National Council for Advanced Manufacturing
National Council of Teachers of Mathematics
National Science Education Leadership Association
National Science Teacher Association
Pathways into Science
Society of Women Engineers
SPIE, the International Society for Optics and Photonics
Technology Student Association
TODOS: Mathematics for All

(*Italics indicate members of the Coalition's Leadership Council*)

Biographical Background
James Brown
Executive Director
STEM Education Coalition
November 2013

James Brown is the Executive Director of the STEM Education Coalition, an alliance of more than 500 business, professional, and education organizations, that works to raise awareness in Congress, the Administration, and other organizations about the critical role that STEM education plays in enabling the U.S. to remain the economic and technological leader of the global marketplace of the 21st century. Prior to joining the Coalition, he was Assistant Director for Advocacy at the American Chemical Society. A nuclear engineer by training, he previously worked as a Legislative Aide for Rep. Doc Hastings of Washington, was Director of Policy and Development at the Consumer Energy Council of America, and began his career as an engineer with Newport News Shipbuilding, working on aircraft carrier construction. He received a B.S. from the University of New Mexico and an M.S. from Penn State, both in nuclear engineering. He also holds an MBA from George Washington University.

Chairman BUCSHON. Thank you very much, Mr. Brown.

I would like to thank all the witnesses for their testimony. At this point I remind Members that the Committee rules limit questioning to five minutes, and at this point the Chair will open the round of questions. I recognize myself for five minutes.

Dr. Buckius, in your opinion, yes or no, does the proposed FIRST bill have any what you would call Congressional interference in the peer review mechanism for evaluating grants at NSF?

Dr. BUCKIUS. Can I do yes and no? So the two points that I would like to make on this regard is regarding who would actually affirm the awards that go out of the Foundation. The way the language of the discussion draft says it, the Director should. I don't believe anyone is all knowing enough to be able to affirm all the 11,000-plus awards that go out of the Foundation, so that is one item I would like to change if I had my choice.

The other one is in Section C where it talks about prior announcements of awards before they are awarded. You could only imagine in some of the engineering directorates, we only fund a few out of 100, so single digits. So that means that there is going to be 90-plus folks who prior to the award can energize the system, can create what I would call chaos. So the system would become extremely bogged down. So those are the two points on the wording that I would recommend you consider.

Chairman BUCSHON. Thank you.

Dr. Sarewitz, do you have any comments on that question?

Dr. SAREWITZ. Just to reiterate what I said. It seemed to me that to a certain extent it depends on what you actually expect. As I said, it seems to me the language kind of endorses the possibility of a rubber stamp that any program manager or up through the directorship could engage in without much risk to their conscience or integrity. So it doesn't seem to me that it offers a direct threat to the integrity of the peer review process, but on the other hand, it doesn't seem to me that it offers much in the way of actual assurance.

Chairman BUCSHON. Okay. Thank you. And Dr. Sarewitz, do individual scientists behave based on incentives? I mean, how can we change the current incentive system so that we can change the culture of scientific funding? And some of you in your comments—I mean, I was a medical doctor and I did some basic science research when I was in medical school, and I think one of you commented on that the incentives can be aligned with volume of work, less focus on quality of work. I mean, how can we try to revise that culture, so to speak, so that people are rewarded for the—more along the lines of the quality of the work, and I would say the accountability is brought more forward rather than there is this pressure amongst—I mean, I understand because my professors told me, the pressure to produce work, and that seems like we could maybe—we could change the incentives around some. Is that a—can you answer that?

Dr. SAREWITZ. Let me make a couple of comments, and I think that my colleagues to my right and left would have more higher view, ability to answer this question as well. But it is certainly true that the level of time that many faculty members spend chasing after research dollars and pumping data into papers so that they

can build their publication lists makes it—often makes it difficult to actually focus with the level of depth and concentration that one would like on one's work. I think this is a common experience across academia. I think there are ways to deal with that. I think much of this has to do with the culture of academia itself, and I think many universities are experimenting with different ways to try to address it. I have suggested a few things that I thought could be done on the NSF end.

At my university, Arizona State, and I think, as I say, many universities are addressing this issue, one of the types of things we are doing is trying to organize in a more transdisciplinary way, which means around problems. That allows people from different disciplines to be attracted to research groups with a more problem-solving focus that I think kind of changes the perspective from one of just productivity and turning the crank to getting the papers done and getting the grants in to actually thinking about what is the role of one's intellectual endeavor vis-a-vis a problem that the university or the community or stakeholders have come together to identify as worth resolving. So I think there are lots of organizational things that can be done. I do think it is a problem. It can't be addressed with a simple quick fix.

Chairman BUCSHON. Thank you. I yield back now and recognize Mr. Lipinski for his line of questioning.

Mr. LIPINSKI. Thank you, Mr. Chairman.

The last NSF reauthorization I had authored, so of course, nothing is going to be nearly as good as what I authored, but I really want to focus on what are some of the things going on with NSF here, and I hope that we can make changes because we—from this draft, because we certainly have heard some issues. I just want to follow up on what the Chairman was asking with Dr. Buckius and also get Dr. Killeen to add it here if he has anything.

We were talking about—you were talking about Section 104. The new review requires the Director to make an affirmative determination that awards are in the national interest, worthy of Federal funding and meets one or more lists of potential outcomes, and Dr. Sarewitz had pointed out that—he pointed to the eight areas that had—that one of those had to be met, but this is an "and," so it has to be all three of these. One issue is what is a—what is the national interest and how do you define that. I don't know if anyone wants—that gets to be—I am not sure if that is very broad or very narrow, and that is something I think we really need to work out. But leaving that aside for the moment, Dr. Buckius had said that one person could not affirm—be able to affirm the 11,000-plus awards. Is there any way to—that such an evaluation could be carried out? Do you see this as a need for this? I mean, what—besides the fact that one person couldn't do it, the Director of the NSF doesn't have the expertise, the ability to go through 11,000-plus, is this—you know, what other comments do you have on instituting such another review?

Dr. BUCKIUS. So the current process is one where you have multiple peers assessing the merit. That goes to the program director. The program director has to then justify why the award will be made or not, and then the division director has to sign off, and so as a division director, I would read all of the evaluations of all the

awards we are going to go through and all of the ones that were on the border. It is a very detailed process already, and so I think that two-level review, I think it works really well. That is why my point is, I think the wording, as you have noted, they are all "and" but I think that those could be justified. So I really don't think that we need to make a major change. I mean, I think your point here is, you want an affirmation, and I think that is a very reasonable thing in general, but I just think putting it onto one person is the hard part.

Mr. LIPINSKI. And Dr. Killeen, do you have any thoughts on that?

Dr. KILLEEN. I have a few——

Mr. LIPINSKI. Microphone.

Dr. KILLEEN. —comments about the prior notification and also his comment about single person affirmation. The program includes all of those peer review commentary and the program director review and write-up and the division director's sign-off, and then the portfolios of grants are then further looked at by committees of visitors that come in periodically to look and see whether the balance is right. So I do worry a little bit about every proposal conforming to a specified set of criteria because we are talking about—and that is why I use the word "vibrant" in my testimony. We are talking about scientific inquiry that includes following leads that may not take you anywhere. That includes setting hypotheses. So scientific inquiry is not necessarily always reliably, predictably serving a particular element of the national interest. But I think the portfolio has to do that. The basic organic mission statement for NSF really speaks to the national interest, and all of those "and" statements are all directly relevant and are addressed often in these reviews.

There is another comment I would like to make about Section 104 in that if the Director of NSF were to affirm, then it would take that person, he or her, out of the appeal process, which is also another part of the current mechanisms that are in place. As the division director signs off on every grant, the AD looks at the balance—enough young investigators, geographic, disciplinary, collaborative. The committees of visitors come in. Then if an investigator gets declined and wants to appeal that decision, there is a very formal and rigorous process at NSF for that appeal and it goes up through two courts: the assistant director, and I managed several of those appeals during my stay, and all the way to the Director of NSF. So I think that would also be influence. There would have to be some other mechanism to ensure right of appeal for a declined proposal. So I have those comments about that Section 104.

Mr. LIPINSKI. Thank you.

Chairman BUCSHON. Mr. Collins is recognized for five minutes for your questioning.

Mr. COLLINS. Thank you, Mr. Chairman. I want to thank all the witnesses for coming today. It is an important hearing. As a mechanical engineer, I have spent my entire business career in engineering-related and science-related companies, and I think certainly we are here today with budget deficits and related debt out of control. It is important that we help Americans understand the importance of funding for the programs this hearing is referring to and the impact that funding has on future economic growth in the

United States. Basic R&D and government help in commercializing that R&D is certainly a proper and a vital role of government.

So Dr. Killeen, a fellow New Yorker, a question for you, and I will start with a point of interest. I have had a longstanding relationship with the State University of New York at Buffalo as both a mentor to the Center for Entrepreneurial Leadership and also the annual Panasci Science Competition, so I know the great work that the university does.

SUNY and the State of New York have embarked on a series of efforts designed to take advantage of the role research can and should play in the innovation and economic growth, and we often hear in Washington that the states are the laboratories or the incubators of innovative public-private partnerships, and I think it would be helpful if you described some of the efforts in New York—I know I am familiar with many of them—that are using this government funding so that we can, you know, understand the importance of it and particularly some of those which you think could have follow-up national implications, touching on the so-called innovation deficit.

Dr. KILLEEN. Thank you very much, Mr. Collins, and I noted in my testimony that research and development has accounted for roughly 40 percent of the total economic growth of the country since World War II, so we are talking about major return on these kinds of investments. In New York, as you pointed out, I think there are some very interesting experiments underway in really closing the gap between what I would call the knowledge creation and dissemination community, which is researchers and educators, and the jobs creation community, which is the private sector and commercial firms, and there is a win-win situation there with job prospects for students and so forth; so making those technologies coming to fruition from bench research funded by Federal dollars, making that transfer into commercializable products and services, what we call the innovation ecosystem, making that work really well I think is something we are really trying to focus on in New York with things like Governor Cuomo's Start Up New York program, which is turning each one of our 64 campuses into a tax-free zone for up to ten years for qualified companies to work in close combination with academic researchers to make sure that the technologies as they get developed and the new knowledge that gets created can have applicability. We also have entrepreneurs in residence so that professors and investigators who may not have any affinity or experience with writing a business plan or forming a new startup company can get help along the way.

So I would say that the innovation ecosystem is a system that is actually as weak as its weakest components, and we need to tune those components up going from the discovery-class research all the way through to full-blown commercialization and make sure that we don't lose traction along the way so that the fruition of the federal investments are seen in the economic development. I personally believe that there is much more than we can do in that, and I believe that New York is going to set the path, blaze the path to do this extremely well.

Mr. COLLINS. Well, I agree, and again, I think, you know, when we have these budget deficits and the country is saying why do you

spend money here and not here, you know, everyone has a good case to make for the money they spend but I think it is important that we connect those dots, what you are talking about, between basic research and then ultimately getting it out and creating jobs with it. It is not enough to just do the research, put it on the shelf as an academic exercise, and I have noticed in New York, at least, you know, we are emphasizing that in an important way. So I appreciate that input.

Dr. KILLEEN. If I could make a last sentence, I really applaud your work and that of Mr. Kilmer in the TRANSFER Act, because I think that really is homing in on a particular piece of the innovation ecosystem that really needs that kind of bold support. Thank you.

Mr. COLLINS. Well, that is what we refer to as the Valley of Death where the ideas come forward, just hasn't quite attracted a business partner. So currently, there just isn't that funding available, and the TRANSFER Act will allow universities to help attract a level of funding to help bridge the gap in that Valley of Death and has bipartisan support and hopefully that is something we can move forward on very quickly. Thank you all again for your time.

Chairman BUCSHON. Thank you. I now recognize Mr. Kilmer for five minutes.

Mr. KILMER. Thanks, Mr. Chairman, and thank you all for coming to address us today.

I think this is a big deal. This is part of my excitement about being on this Committee. We had a—I used to work in economic development in Tacoma, and we had a sign on the wall that said "We're competing with everyone, everywhere, every day forever," which I always found terribly intimidating. But, you know, I think, you know, if you look at the genesis of COMPETES and Rising Above the Gathering Storm, I think it is a shot across our bow in terms of what it takes to increase our global competitiveness and prepare tomorrow's workforce, and it was done initially in a bipartisan way, and I think that is the hope here as well.

Several of us on this Committee as part of the new Democratic Coalition have worked on developing a set of principles to guide the reauthorization of COMPETES legislation, and in reviewing this draft, there is some overlap including in the legislation that was just discussed about dealing with the valley of death and improving proof-of-concept ideas or seed money for projects that can lead to commercialization. At the same time, I think as drafted, this neglects some I think very core issues around the lack of funding for basic research and lack of an innovation title, and I want to ask initially at least about the lack of an innovation title. As drafted, the FIRST Act doesn't include any directed authorizations for programs such as the Regional Innovation program, the reauthorization of a program authorized in the 2010 COMPETES legislation to help spur the development of regional innovation clusters or in general any pilot that continues to examine ways to push innovation on a regional level.

I would like to address the first question to all of the witnesses. Do you feel it is important to include an innovation title in the FIRST Act, and specifically if you can speak to ideas around regional innovation clusters?

Dr. KILLEEN. I am happy to go first. I think regional innovation is very much a sweet spot. Communities have built up with past capacities, say, for example, in manufacturing that now need to reach beyond the past into the new economy, and the new economy is different from the old one. It is a knowledge economy. So I think these regional clusters where you have the combination of intellectual capacity and human capacity, students coming forward with competencies, that is why the connection to higher education is so important. You have the flow of talent, you have the intellectual setting of the—and the interdisciplinary kind of collaboration that is needed, and you put that in a regional setting where there may be specific things. So in New York, the regional economic development councils have been very successful in forging that. So I would personally strongly support an innovation title.

Dr. SAREWITZ. Let me reinforce that and add a little something to it. Dr. Killeen has mentioned a couple of times the notion of innovation ecosystem, and I think those who have been doing research on innovation systems have come increasingly to appreciate the importance of regional connections, and if you go back and look at the origins of Silicon Valley and the Route 128 corridor around Boston, what you see is the role of DOD in catalyzing all the different elements of the ecosystems so they were aggressively funding basic research at universities in the context of the defense and military mission but also in the context of trying to increase the flow of experts who they could then hire into the defense system, but they were also providing funding for startup firms, they were negotiating intellectual property agreements, helping negotiate intellectual property agreements between faculty and small startup firms, and from these—from this ecosystem approach that DOD took in the late 1940s and the early 1950s grew of course these innovation powerhouses around Boston and Palo Alto. So I think it is really important to take both a regional approach and an ecosystem approach in trying to understand how to intervene in these systems.

Dr. BUCKIUS. Well, the only thing I can really add to that is, and it goes back to the previous testimony in July on the TRANSFER Act, the recommendations that are in Section 421 here I think will have an impact. At Purdue, we have evidence that we have done very similar things with an endowment and we can show for Federal support that when you provide some proof of concept or development funding, we can show a 40 percent increase in licensing rate over a 35-year history when you invest this way. So we are very supportive of the TRANSFER Act and what it can do in general.

Mr. BROWN. I just note that our time has expired and I don't think I have anything to add. Thanks.

Mr. KILMER. Thank you, Mr. Chairman.

Chairman BUCSHON. You are welcome. I recognize Mr. Schweikert for five minutes.

Mr. SCHWEIKERT. Thank you, Mr. Chairman.

And I don't want to get too off track here, there was a couple basic questions I wanted to sort of get my head around, and Dr. Sarewitz, just as a bit of background, you have actually staffed this Committee.

Dr. SAREWITZ. The gentleman in the red vest was my esteemed boss.

Mr. SCHWEIKERT. Okay. We will talk about whether he was a good boss or a bad boss later.

Dr. SAREWITZ. He was a wonderful boss.

Mr. SCHWEIKERT. Okay. I hand you a clean slate and say we are not going to model the peer review mechanics, the way we distribute funding. The methodology we do today isn't going to be the model we built back in the 1950s but literally I am going to ask you to design a modern system based on, you know, the speed of distributed information, you know, the way the world works today. How different would it look?

Dr. SAREWITZ. Can I get back to you next year on that, Mr. Schweikert? No, it's a great question because—and I can't answer it directly but I can say that many of the issues that the Committee in the draft bill are dealing with are the legacy issues of the system that was created largely in the 1950s and that created the initial conditions that now we see in the system that we have, and I think that much of what is being discussed today is about how to move away from a really over-simple view of innovation that started with ramming some resources into the basic research end of things and having those diffuse out into the private sector—we all know that is not how the system works.

Mr. SCHWEIKERT. Well, particularly today, and that is the nature of my question is, you know, let us face it is, it is a turbulent—you know, you never know what the next discovery is going to be. Sometimes it is in someone's garage, sometimes it is in a lab, sometimes it is on the Internet, and I have this great fear we are still operating in this sort of silo mechanic, and besides my other great concern, which I would love others on the panel who are willing to go there in sort of a peer review process where only a small number are getting funded. Having read some of these, they almost sometimes read more like marketing pieces, and my fear—and you all know, there is literally, you know, grant-writing consultants out there that actually have marketing backgrounds helping academics write grants. So, I mean, there is something horribly wrong in the way the silo works, so what would you change today when we are working on it legislatively?

Dr. SAREWITZ. So I will just talk for a second so I can let my colleagues contribute here as well, but I actually think that the obsession with the individual investigator is a bit of a relic that we need to escape from. We are gradually escaping from it. I think NSF's move towards focus on centers, for example, is a productive way to think about it.

Mr. SCHWEIKERT. We should disclose to the group, we are both from Arizona State University, and that has actually been one of the fixations of now the largest university in the country is bringing in, you know, discipline, you know, multidiscipline——

Dr. SAREWITZ. And organizing around problems. And I think I would want to reemphasize the importance of a focus on the relationship across all sectors and between institutions rather than particular specific institutions.

I think it is the ecosystem function that matters, and it is certainly true that the weakest link in an ecosystem can compromise

its function but we focus much less on the interactions than we do on the individual components, and I think that that is the key to addressing the sort of rethinking that you are getting at, Mr. Schweikert, but I would be interested in——

Mr. SCHWEIKERT. And it is always great when you give everyone 60 seconds to answer one of the great questions of life. Doctor?

Dr. BUCKIUS. Can I just give you two principles that I would put as foundational? You have to invest in the genius of our scholars and our people. You don't want a top-down system. You want the best ideas come from the genius ideas of the people.

Mr. SCHWEIKERT. But isn't that one of the design problems we have today? We have very much sort of an ivory tower system that we are sort of trying to break apart.

Dr. BUCKIUS. But the people have the ideas and so if we start to tell them what the ideas are, we won't get the best ideas. The other principle I think is certainty. There is so much uncertainty now. We are losing a cadre of innovators that will never come back. So we need some certainty in the system.

Mr. SCHWEIKERT. Okay, in 15 seconds.

Dr. KILLEEN. Fifteen seconds? It is a great question, and I think there are many factors to it. The peer review system, it is like a garden. It needs to be tended. There are bushes and flowers and so forth. I do think there are some new historic forcing functions that have to be taken into account, and NSF, in my experience, does a fabulous job of these kind of discussions and experimentation. One would be that the first past-the-post model of peer review needs to be opened up to more collaboration, which is what your question is driving at——

Mr. SCHWEIKERT. And I know we are over time, but I have always had this curiosity of why isn't there a level of almost crowdsourcing in the reviewer process——

Dr. KILLEEN. Absolutely.

Mr. SCHWEIKERT. —on a very large scale has a purifying effect, and that is for a future round, so thank you for your tolerance, Mr. Chairman.

Chairman BUCSHON. Thank you. I will now recognize Ms. Esty for five minutes.

Ms. ESTY. Thank you, Mr. Chairman.

Mr. Brown, you haven't had a chance to speak for a while, so I think it is time for a question for you. In your testimony, you spoke about the poll finding that only one in five college students found that they were adequately prepared, well prepared in high school through the STEM disciplines, so I would like to follow up on that.

We have been researching this pretty extensively in Connecticut, and we have seen the difficulty schools are having in supporting STEM education and making it accessible to students, particularly, frankly, in the lower grades, and I have introduced something called the STEM Jobs Act, which is focused on enhancing professional development, again, especially in these lower grades where frequently our educators are not—this is not their field, this is not what they are comfortable with. And I would like from your point of view as Executive Director of a STEM ed coalition what you think the best way the Federal Government can be successful in

encouraging STEM support for the teachers, particularly in these lower grades.

Mr. BROWN. Thank you for the question. The National Science Foundation has a number of programs in this area, and if you look across the rest of the Federal agencies, the largest program in the Federal Government that deals with STEM education as a sole purpose is something called the Math and Science Partnership program at the Department of Education, and one of the challenges we face when you talk about teacher professional development is that the teaching environment is changing really fast now, technologies in the classroom we are dealing with new standards in many states and teachers are challenged to keep up with the state-of-the-art fields that didn't exist 15 years ago are now the focus of major education reform efforts. And so that landscape is changing very quickly, and one of the things that research shows that the quality of the teacher in the classroom is a really important indicator of the success of students. The corollary to that statistic of kids not feeling they are prepared in college is the statistic that only about 40 percent of the people who enter college in a STEM degree finish the degree in six years.

So I think one of the principal goals of any coordination function across the agencies or any Federal strategic plan needs to place at its center the notion that we have to recruit the best possible teachers into these jobs and we also have to make sure that the existing teaching workforce is getting all those supports that they need, and the Federal Government is not the primary provider of resources to teachers, that is the states, so we have to make sure that the Federal Government is aligning its needs to the on-the-ground truth that educational stakeholders can bring to that equation.

Ms. ESTY. Thank you. And then I would like to turn again to this innovation and ecosystem idea, which I think is tremendously important.

I was struck as you were all speaking about the fact that DOD was central to the development in Palo Alto as well as the Boston-Cambridge area, but let us look at what DOD has: virtually unlimited R&D money, long-term, no question that money is going to be there, as well as specific goals in breaking down silos to get people to focus on how to achieve specific goals. So if you could think about in this constrained budget situation we find ourselves in what lessons do we take from this as we apply it towards public-private partnerships, things like the semiconductor research corporation? How can we think about leveraging of U.S. dollars, ensuring a constant stream of dollars for basic R&D that will only come out of the Federal Government, and nevertheless recognizing that we will need help from the private sector to leverage that money, ensure that stream keeps going? So whoever wants to weigh in on that?

Dr. SAREWITZ. Just briefly, first of all, I think you have captured exactly the essence of the problem. Let me add two other things about DOD. I mean, you mentioned the mission. That is very important. Another is that it is both—it is and was both the entity that commissioned the R&D and was the user of the product so it could hold the feet of those who were doing the R&D to the fire

to produce what was necessary, and then here is another key point. They had a pretty high price point. It is not that just they spent a lot of money on R&D, which they did; they spent a lot of money on procuring things and they could do things like spend $30,000 for a 40-pound GPS receiver that was the first one that was going to be used as a prototype that then created some confidence in the producers that they could then spin this out, particularly in civilian applications. It is very difficult to reproduce that in the civilian sector. But I do think one of the keys is close understanding between the users, potential users of the information and those who are producing it, and often this gets people who are applicants for basic research a little edgy because they think it is about controlling the agenda of basic research. That is not the case. Much basic research is done in the service of particular goals. It is not controlled. It is an exploration of the fundamental science, but it is within a context, and I think it is very important to understand that much productive basic research is carried out within a context that requires communication between those doing the research or their entities and the ultimate user of the knowledge.

Dr. KILLEEN. I would just like to add if I could, it is another perceptive question. I think it is all about partnering and partnerships, and partnerships have to be authentic and they have to be conducted with integrity and all the accountability layers and transparencies that are needed. But I think there is an opportunity here to open up the throttle on our R&D enterprise largely writ in this country to close those gaps, to develop policies that allow those intellectual properties to flow and ebb and ebb and flow. This is not to take anything away from basic research. It is an "and." Basic research is absolutely essential and needed in order to enable these kinds of larger-scale public-private partnerships that can drive regional economies, and we have seen that and we have examples of that happening in our state.

Dr. BUCKIUS. Do you want more? So, just one quick comment. Partnerships other than the Federal Government are going to be important to every one of us. We have approval from the board of trustees Purdue to fundamentally change our intellectual property so that we can be what I would call true partners now with industry rather than a remote partner, and so we hope that we are going to become, well, the preferential partners in cases but our goal is to be much better partners with folks than we have been in the past.

Ms. ESTY. Thank you all very much.

Chairman BUCSHON. Thank you. I now recognize Mr. Hultgren for five minutes.

Mr. HULTGREN. Thank you, Mr. Chairman. Thank you all for being here to discuss this very important subject and important legislation that is going to be before us here. Scientific research funded through NSF, NIST, OSTP are such an important piece of America's innovative ecosystem as we have all been talking about this morning, and it is crucial, especially at a time like this fiscally challenging time, for us to ensure that our money is spent in the smartest possible ways.

I am also greatly concerned by the Administration's proposed STEM reorganization, which many of the scientific community

were equally caught off guard with. I am glad this Committee will continue working with the stakeholder communities, the people actually on the ground and in the classrooms, to ensure our STEM education proposals are in the best interest of our children and the disciplines we hope to make more accessible to them.

Mr. Brown, I wonder if I can focus this to you at first. What has been your reaction to the proposed STEM reorganization and how does this draft legislation address potential concerns in the STEM education stakeholder communities?

Mr. BROWN. Well, first I would like to thank you for stepping up this Congress and becoming one of the co-chairs of the STEM Education Caucus. It is nice that you and Mr. Lipinski are co-chairs and on this Committee. One of the things I mentioned, in our written testimony we cite a lengthy letter with views on many different aspects of the Administration's budget proposal. I think you characterized it correctly in terms of the reaction from the community. In fact, the nature of that proposal and the sort of sweeping changes that were proposed with very little stakeholder input and with very little clarity on how the missions of programs proposed for elimination would either be kept or integrated into other efforts and across agencies, across appropriations bills. I think the budget proposal itself has raised this issue of needing to create a more formal mechanism for stakeholder input into STEM education programs, which it may be somewhat of a blessing in disguise considering that despite all these concerns, if you look at how it is reflected in the appropriations process we have, it hasn't really gone very far. So if the result of that process is to create a better stakeholder mechanism, I think we made some progress there. But I would like to give the Administration credit for giving us a good example of how things can work the right way, and that is—last summer in July, the President announced, I believe in the Rose Garden, a $1 billion STEM master teacher coordination, and frankly, it is kind of hard not to default into my Austin Powers voice when I talk about something like that, but it was a really large investment and it was news to a lot of the people in this room, and, you know, that is a great challenge, but I am not sure that, you know, everybody looked at that as being vetted with the community and having the right kinds of input, and to the Administration's infinite credit, they got a large group of stakeholders together and worked on this problem for about six months and produced something in the budget proposal that was a $35 million very focused pilot program that recognizes the challenges in creating a national STEM master teacher core. That is the kind of process we like to see on a much larger scale.

Mr. HULTGREN. Thanks. I would open this up to all of you if you have some thoughts. We certainly have already discussed much about the post-secondary education STEM efforts within a formal setting, but I would like to get your perspective on the importance of utilizing informal science education institutions such as museums as an avenue for STEM engagement that cannot always be made in the classroom, especially to earlier grades. We are so spoiled, those of us who spend time here in Washington, D.C., just the incredible museums we have. I feel the same way in Chicago of just amazing museums. I was down at the Museum of Science

and Industry, just this week I was back visiting with them and seeing some of their latest exhibits, so inspiring, able to walk around and just see the faces of young people excited about science through that. I wonder if you could talk a little bit—I only have a minute left but would love to hear your thoughts if any of you have thoughts of some of those informal settings that can inspire and be a key component of the ecosystem of STEM education.

Dr. BUCKIUS. So at NSF under broader impacts, many of the proposals do talk about informal education, and so when we are funding activities in even basic research, the broader impact side can address informal education through museums, and I don't have the data but I was absolutely amazed when those folks come forward with the impact that museums and informal education can have on this country.

Dr. SAREWITZ. Very quickly, yeah. We have had fabulous interactions with museums, also with the informal science education group in education and human resources at NSF. Museums—our interest is in getting citizens engaged in discussions about science and technology and their social implications. Museums are wonderful places because they cycle through such huge numbers of people who are automatically engaged but museums are very creative. They really love this kind of stuff, and it is actually a different model of science education that I think hasn't nearly been taken seriously enough but we found to be very, very productive.

Dr. KILLEEN. I would just add, just generalizing your very astute comment, I think experiential learning in all settings at all levels of education has been shown to give better outcomes in terms of STEM competencies and just public affinity for science. Museums are great. You know, it can change people's lives to have an active, hands-on experiential opportunity post-secondary, pre-secondary, and we need to do that at an enterprise level in order to really attract the best capital, human capital to the table.

Dr. SAREWITZ. Can I add one quick point to that, which is, it has curricular implications too. We have discovered that through museums, getting students interested in the social aspects of science and technology, then get them interested in the science and technology itself in ways that they wouldn't have been beforehand.

Mr. HULTGREN. My time is expired, but I do want to just say thank you. We all agree how important this is. I do have to tell you, they are nervous again with some of the proposals that have been coming out, and just we are shocked, so I ask again, any way we can be working together, linking arms, making sure everybody understands how important this is and that we are not pulling the rug out from this key component of museums that absolutely spark interest, certainly in young people but even in parents that get to go along with their kids and things.

So with that, Chairman, thank you for your generosity and the time, and I appreciate you holding this hearing. Thank you. I yield back.

Mr. BUCSHON. I now recognize Mr. Peters for five minutes.

Mr. PETERS. Thank you very much, Mr. Chairman, and thank you, gentlemen, for being here.

I want to go back to something we talked about, an observation that there seems to be a little bit of inconsistency in the draft with

respect to streamlining and with respect to this national interest, and I guess the observation I have is that the system that we have developed for science, this peer review system, has proven so effective because it has been independent of the government, and we don't do a lot of supervising of what basic scientific research would be because— and by its nature, we don't really know where it is going to lead. So does it strike you as inconsistent with that to add this overlay of a governmental judgment on whether it is in the national interest? Does that concern you at all? Dr. Killeen, maybe?

Dr. KILLEEN. Well, If I have a concern, it is mostly the message that this bill will send out to the world. In fact, and as my testimony indicated, I hope it is vibrant, enthusiastic, let's take on the 21st century, U.S. can do kind of message rather that one that seeks to find the constraints and stiffen the sinews. I think my personal experience with NSF, it is a magnificent national asset, and we don't want to throttle it back nor do we want to have the self-policing get to a point where there are clear infractions of integrity and accountability. So this is a delicate balance that you have to face. We need to unleash the high-performance aircraft here and recognize that a lot of the flaps are going to have to be moving to keep it stable and flying and not limit the opportunity space.

Mr. PETERS. It is nice that we are the envy of the world in what we have created. We have done it, and we have respected that innovation happens outside of this building, to say the least, and for us to be putting anyone in judgment of what is in the national interest in that context seems to me to be shooting ourselves in the foot.

The other thing I will make an observation of is that with respect to streamlining, we are asking in Section 301 that the Office of Science and Technology Policy look at regulations to try to make streamlined, and now we are adding this Section 104, new requirements that would increase the administrative burden on NSF and on its researchers. So it just seems to me that we ought to be combing out of this—the interference that the government would pose on a system of scientific research, not just with NSF but across the board including things like NIH that has proven to be so innovative and productive and has set us up as the leaders in science in the world. So it does strike me as odd that we would be in this Committee trying to find ways to constrain what had been so successful.

Which bureaucratic—assuming you accept the notion that we should be asking the government to decide what the scientific value or the national interest is in this research, what would be the kind of bureaucratic setup and findings that wouldn't interfere in the way that I am expressing concern about? Do you see any way that you could set it up without interfering in what has been such a success already? Anyone?

Dr. SAREWITZ. Can I step in here? I think it is important not to—it is certainly important to protect peer review from political interference and from bureaucratic excess but it is also important not to treat it as sacrosanct and as if it is always perfect. I think—I have never administered peer reviewed programs but I have been a peer reviewer, I have been on NSF peer review panels, so I am familiar—and I have been the subject of peer review, both positive

and negative. So no one thinks it is perfect, and I think that is important to understand how to improve it especially in a time of fierce competition.

Getting back to the Economist article that I opened my statement with, I think there is evidence in fact that the peer review process is not up to some of the tasks of dealing with the challenges of a highly competitive, highly kind of hype-driven enterprise. So I think we need to take that seriously, and I think it is really important to have this discussion. As I have said, I am not particularly attracted to the specific provision of Section 104 but I do think the goal of being smarter about this is appropriate, and I think that NSF's response this summer in basically refusing to talk about what its process was did not serve it well because, in fact, they should be proud of the peer review process and should be willing to talk about how it works.

Mr. PETERS. As I understand it, the issues you have identified aren't ones that would be dealt with in this building as well as in the scientific community at large.

Dr. SAREWITZ. I am not so sure. I think——

Mr. PETERS. Publication of negative information or the way we don't make data available early in the process, those are all things that can be done without a determination of whether a specific scientific research project is in the national interest. My time is expired.

Dr. SAREWITZ. This is true, but Congress is often very good at providing signals that allow NSF to act.

Mr. PETERS. Different issue, but thank you very much for being here. I appreciate it.

Mr. COLLINS. [Presiding] Thank you. The Chair now recognizes the Congresswoman from Wyoming, Mrs. Lummis, for five minutes.

Mrs. LUMMIS. Thank you, Mr. Chairman, and I thank our witnesses for being in attendance.

My questions are going to revolve around how to create a sustainable path to fund research, especially basic research. Now, we know that under the stimulus bill, there was an additional $3 billion that was provided to the NSF. Other research agencies saw a similar injection of funding. So these were one-time funds. Is it better to have steady funding at a sustainable level or do these one-time injections help stimulate an area of research that is really cutting edge? Dr. Buckius?

Dr. BUCKIUS. Thank you. This is a great question. There is no question that the stimulus funding energized a tremendous number of activities in this country, well received, and I think the research that was performed was just superb. I am going to go back to my principles though. Certainty will help our innovators and our young people get into basic research, and if we don't have some certainty, then I am really fearful that we are going to lose a whole generation of potential discoveries. So I would argue if you gave me a yes or no to go for certainty, but when you plunk down funding and if you have a national challenge and you put funding out there to solve that problem, you are going to get great ideas too. So I don't want to say that it is an either/or but I do really worry about the future of the country, the debt we are going to have if we don't

have these folks being the true innovators. So certainty, I think, would take precedence.

Mrs. LUMMIS. Does anyone else different? Dr. Killeen, I see you nodding.

Dr. KILLEEN. I absolutely agree with that. I was at NSF when the stimulus package came, and I could cite many wonderful things that transpired from that. But if you are looking at a steady growth, I think that is the recipe for a real muscular program going forward. If success rates for proposals drop to single digits, you can imagine a young 35-year-old who has gone through all the hard classes and is ready to do things for the country in the national interesting, bringing all that to bear, and she has to write 10 proposals for a chance to get an award to liberate that energy, that is not really enough. So we need a way to manage the process so that the human capital can actually be brought to the table and these brilliant young investigators participate in the future of R&D, which I think is Dr. Buckius's point.

Mrs. LUMMIS. Anyone else wish to weigh in on that particular issue? Okay, then.

I am going to move to the notion of, how then when we have sort of a pop of money can we maximize its effect? Dr. Buckius, you mentioned earlier the notion of identifying those truly brilliant individuals and providing them with the resources they need to maximize their benefit to society. Can that be done through particular prizes? Is there a better way to identify and fund those absolutely magnificently brilliant scientists?

Dr. BUCKIUS. What I was getting at is grant challenges, so it might not even be a scientist, but your point is well taken. Prizes, I think, are an interesting approach, and I think it goes back to this crowdsourcing idea. I think we are going into kind of a new era where maybe some of these kinds of ideas could actually challenge our young people and we might see some very creative activities. I am back to this point where the genius is in the individuals, and we have got to get it out, and the way to get it ought might be some kind of a prize situation, or a moon shot, you know, another Sputnik, something that will actually challenge the young folks to actually be very, very creative and get into this business.

Mrs. LUMMIS. Anyone else?

If we had flat funding, which in this environment seems to be more realistic, and then had these little pops of additional funding, how could that be utilized most effectively, especially with regard to basic research? Anyone?

Dr. KILLEEN. Well, what comes to my mind is, the hardest decisions at NSF are the declination decisions, and if you are leaving on a cutting-room floor so many wonderful ideas, a pop sounds great, any pop sounds great if you are representing a community that is vital, that is integrated, that is moving out, that has got great ideas. So I wouldn't dismiss anything that would provide us the scientific and technical and educational communities with forward momentum. That is what we need, forward momentum to grasp the challenges that we have talked about before of economic development, of new knowledge creation, of retaining our status as first in economic competitiveness.

Mrs. LUMMIS. Thank you. My time is expired. Thank you all, gentlemen.

Mr. COLLINS. Thank you. The Chair now recognizes the Congresswoman from Florida, Ms. Wilson, for five minutes.

Ms. WILSON. Thank you, Mr. Chair.

Over the past decade, inflation-adjusted wages for the bottom 70 percent of income earners have actually fallen. A key reason for this unacceptable decline is decline of manufacturing and other sectors that offer high-paying jobs and offer good wages. There is a responsible and sustainable way to address this crisis of jobs and wages. We must invest in innovation.

While it is essential that we authorize America COMPETES, I have deep, deep concerns about the FIRST Act as it now stands. We need to maintain our focus on research to boost competitiveness but I fear that the new stipulations in this bill are focused more on regulating the efforts of scientists who do not need burdensome new Federal oversight. Can either of you speak to why the Innovation Services Initiative was eliminated under the Manufacturing Extension Partnership, MEP program, in the current draft? The initiative's purpose has been to help small and medium-sized manufacturers lower their energy consumption, greenhouse gas emissions and environmental waste. I have always believed that efficiency and cost saving were bipartisan values, and given the recent events in the Philippines and the most recent report of the Intergovernmental Panel on Climate Change, it strikes me as highly irresponsible to eliminate efforts to deal with the mounting problem of greenhouse gas emissions.

Can you speak to why you believe the Innovation Services Initiative was eliminated?

Dr. BUCKIUS. I will be very honest: I did not understand that section of this particular draft discussion.

Ms. WILSON. You do not understand what?

Dr. BUCKIUS. I didn't—so I think you are referring to 408, and I did not understand what was actually being withdrawn, so I really can't comment on that.

Ms. WILSON. So is that a secret?

Dr. SAREWITZ. I think I can speak for us and say that overall we are sympathetic with the position that you are articulating but can't speak to the specifics of the point as made in the bill.

Ms. WILSON. Oh, okay. So perhaps we need additional hearings on that particular initiative.

Okay. I believe Mr. Kilmer did speak about America COMPETES, but in the America COMPETES Reauthorization Act of 2010, this Committee authorized the Department of Commerce to partner with local communities to help spur the development of regional innovative clusters that leverage regional assets and resources around a particular niche or industry. This was an exciting provision with regard to my goal of spurring innovation that promotes job creation. As currently drafted, the FIRST Act does not reauthorize this program. This Committee has heard repeatedly that regional innovation is important for economic growth and job creation. Are you supportive of Federal efforts to spur regional clusters? If so, what should this Committee be doing to foster success in such clusters?

Dr. KILLEEN. I think I am definitely in support of regional economic development clusters. I think we have seen in New York, for example, tremendous advances in nanotechnology which are leading to new jobs in advanced manufacturing that can transform communities and that kind of thinking is I think underpinning your questions and your concerns. We talked earlier in the hearing about an innovation title to this draft discussion bill, which I think might well add value to that along the lines that you are suggesting.

Ms. WILSON. Thank you. Anyone else? No one else is supportive of the Federal efforts to foster clusters?

Dr. BUCKIUS. No, I think you heard we are supportive.

Ms. WILSON. Good.

Dr. SAREWITZ. We had, before you were able to come to the hearing, a similar colloquy with Congresswoman Esty, and I think we all indicated that we think that this is where the action is to a considerable extent.

Ms. WILSON. Okay. Thank you.

Mr. COLLINS. I would like to now ask unanimous consent that the gentlelady from Oregon, Ms. Bonamici, be recognized for five minutes. Without objection, the Chair does recognize Ms. Bonamici for five minutes.

Ms. BONAMICI. Thank you very much, Mr. Chairman, for holding this hearing, and thank you to the Ranking Member as well, and for allowing me to participate even though I am not on this Subcommittee. It is a very important issue.

In the district I represent in Oregon, innovation is key to the economy, much of which depends on STEM and high-tech fields, and even though I missed the testimony—I was in the Education Committee—I assure you, I read the testimony and the word "innovation" is mentioned multiple times, not only in your testimony but also in the proposed legislation, and business leaders often describe innovation and creativity as a key to economic growth, global competitiveness, and like my colleagues, I hear from technology companies about the need for more STEM graduates and from constituents and educators who know that keeping students interested in STEM requires interdisciplinary education. But how do we assure that we have innovators? As this Committee considers legislation to reauthorize *America COMPETES Act* and in any STEM education discussions, I urge my colleagues to consider the potential that integrating the arts and design broadly defined into STEM education and the role that that can play in developing innovative minds.

Research shows that educating and engaging both halves of the brain can help to foster innovation and do more to keep students engaged, and this potential is why our colleague, Representative Aaron Schock, and I have started a bipartisan STEM to STEAM Caucus where we promote the integration of arts and design into STEM learning, to engage students, to develop their creativity and critical-thinking skills, and to encourage them to pursue and stay in STEM careers.

There was a recent issue of Economic Development Quarterly, and they talked about a study. Here is just a part of the abstract. Government, schools and other nonprofit organizations are engaged

in critical budget discussions that may affect our economic development success. The assumption is that arts and crafts are dispensable extras. Research suggests, however, that disposing of arts and crafts may have negative consequences for the country's ability to produce innovative scientists and engineers who invent patentable products and found new companies. And that is one of the reasons why the U.S. Patent Office was at our kickoff of the caucus, very interested in this issue of assuring we have an innovative workforce.

So I want to ask Dr. Buckius—I hope I said your name right—in your testimony, you talk about Federal research and how it enables the education and training of the next generation of innovators, and you say that our STEM students and all students need a broad-based education to make a difference in the world. So can you talk about that difference that a well-rounded, broad-based education makes in fostering innovation?

Dr. BUCKIUS. Thank you for this question. I could not have asked a better one. So Purdue, when you add up our engineering graduates and our technology graduates, we graduate the most of those in the country now. Our president at Purdue has very clearly made a statement that we believe in a broad-based education. We believe that if you are going to succeed in this world today, it cannot only be the STEM disciplines—we have two A's, by the way, arts and agriculture—and we clearly support this concept. Interdisciplinary activities which you referred to are also central. People need to understand that the problems and the issues that are facing this country and facing this world aren't going to come from one discipline very much longer, and so we need to generate graduates who understand the breadth of problems that we are all going to see. I am very supportive of all your comments.

Ms. BONAMICI. Thank you.

And Dr. Killeen, you mentioned workforce development in America COMPETES and indicate you would support research into understanding how students learn STEM and how to best teach students in STEM fields. So is there room for improvement in the curriculum? And I would also like Mr. Brown to respond to that as well.

Dr. KILLEEN. Yes, I think there is also room to improve the curriculum and to improve the cognitive gain that students get, and I love your A perspective on STEM. It is all-hands-on-deck kind of world we are living in. We need to engage all primary stakeholders in solutions that are meaningful for society. I think the biggest thing I would say, though, about STEM education is, I think we know now the role of experiential learning, that that really can transform engagement. It leads to persistence when students enter undergraduate settings. We have seen that firsthand as research demonstrates that. So it is not just in the classroom hearing the pedagogy or online with online but hands-on opportunities that allow for experiential learning. I think that is definitely part of the secret sauce.

Ms. BONAMICI. Thank you. Mr. Brown?

Mr. BROWN. This is a fascinating topic about how to integrate the arts into STEM education or STEAM education, and thank you for starting your caucus and trying to integrate those efforts with

the larger STEM education conversation. I think we have a lot of issues with regard to how the term STEM is defined, and one of the things that we emphasize really strongly in our testimony, and I hope the Committee moves on this, is the notion of having a very stakeholder-based definition of the STEM subjects, and I would certainly think that the arts community would be a stakeholder in that conversation because when we talk to employers, they talk about creativity, design skills, things that fall within the arts community, and we certainly want to make sure they have a seat at the table when we talk about what, you know, the skills of the future really are.

Ms. BONAMICI. My time is expired. Thank you again, Mr. Chairman.

Mr. COLLINS. Well, thank you. That will bring our hearing to a close. I want to thank all the witnesses for your testimony. It was very appropriate and timely.

The record will remain open for two weeks for additional comments and written questions from Members.

So with that, the witnesses are excused. The hearing is adjourned.

[Whereupon, at 11:49 a.m., the Subcommittee was adjourned.]

Appendix I

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. Richard Buckius

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY

"Keeping America FIRST: Federal Investments in Research, Science, and Technology at NSF, NIST, OSTP and Interagency STEM Programs"

Questions for the Record, Dr. Richard Buckius, Vice President for Research, Purdue University

Questions submitted by Rep. Larry Bucshon, Chairman, Subcommittee on Research and Technology

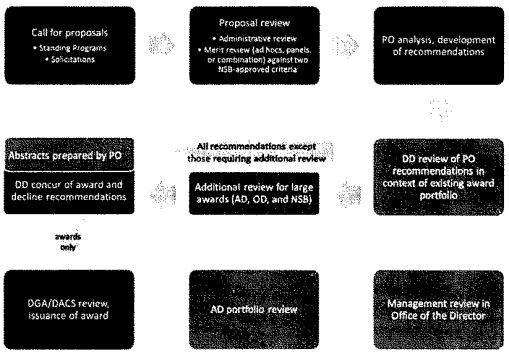
1. Several questions were raised about administrative feasibility with Section 104 in the FIRST Act discussion draft; the attached is the outline plan NSF presented to Chairman Lamar Smith and Chairman Larry Bucshon at the end of September 2013. The intent of section 104 is to parallel the NSF's plan: assuring transparency and accountability by setting forth grant justification before public announcement.

   Do you agree that NSF's proposed plans are adequate to address the concerns about accountability and transparency of NSF funded grants? In what specific ways could the language in section 104 of the FIRST discussion draft be strengthened?

   Do you agree that the NSF should act to quickly increase public transparency and accountability of all dollars spent by the agency?

   The original 1950 Act established NSF "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." These founding statements appear to encompass the listings in Section 104(b) of the FIRST Act and should be sufficient without additional legislative language. The wording in Section 104(c) will create a tremendous burden on the Foundation. As I noted during the hearing, the prior announcements of the more than 11,000 annual awards selected to be funded would invite community input from the thousands of principal investigators whose proposals were not selected and would bring the entire proposal/award process to a halt.

   The agency revised plan provided to you in September 2013 is diagrammed below:



   This revised process as diagrammed will meet the desired increase in public transparency and accountability. An increase in workload, particularly at the Program Officer level, will occur yet is warranted.

2. Does the proposed FIRST bill require a change in thinking towards attitudes concerning scientific funding? Do you think it will interfere with the current research activities and progress in scientific research?

I support the agency's diagrammed approach as indicated in the previous question. It revises the current approach and will increase public transparency and accountability. Rather than implementing the various elements of the FIRST bill, this revised NSF approach seems appropriate.

3. Do you agree that IPAs should view their time at NSF as public service to the scientific community? Do you agree that IPAs generally gain valuable contacts and experience that would help them advance their future careers? Do you agree that Universities should be involved with increased cost sharing, as was recommended by the NSF IG's March 2013 report? Do you agree that the NSF, should implement cost-controls with IPAs?

A mix of federal employees and IPAs is essential to NSF. The federal employees provide the necessary continuity to all the Foundation processes. They are the foundation of the agency. The IPAs bring active researchers into the process, providing new ideas and approaches. It is important to note that NSF is not charged with performing research internally with its budget. The annual circulation of research leaders through the Foundation through IPA appointments provides the continual input of new ideas needed to assist in keeping the Foundation evolving.

The fact that only approximately 6% of NSF's budget is used to perform its functions and complete its charge is impressive. I doubt there are many other agencies, institutions, or organizations that can match this low overhead cost. The NSF IG's report suggests that an increase in awards is possible if IPA costs were reduced. The additional awards by such cost controls would not compensate for the lost impact from the activities and contributions of the IPAs.

I served as an IPA appointee at NSF, was a unit lead who granted IPA leaves, and was an NSF Division Director and Directorate Assistant Director involved in recruiting IPAs to serve at NSF, so I have experienced all sides of IPA issues. Serving as an IPA is a public service and expands an individual's perspective, yet the service often requires a personal investment of finances due to maintaining multiple residences, significant personal time investment due to maintaining a remote research program while at NSF, and a loss of continuity with the faculty member's home unit. In some cases, there is a separation from family for extended periods. From an academic unit's perspective, the IPA will return with a broader perspective of the field and with experience directing larger research activities. The unit is also compensated via the IPA salary to handle some of the teaching responsibilities the IPA is unable to fulfill during the service period. Yet during the period that the IPA is at NSF, the unit does not have access to that faculty member's contributions to all of the unit functions, such as serving on committees, advising, supplementing the intellectual environment, etc., and the expertise in the educational activities cannot always be replaced. By attracting IPAs to NSF, the agency is able to recruit disciplinary leaders to direct the programs, divisions, directorates and other activities. Therefore it is important to ensure that serving at NSF does not significantly impact the faculty member negatively.

Although NSF IPAs are performing a public service to the community and gain valuable experience, faculty and universities are sacrificing many of their essential activities during the IPA's stay at NSF and should not be asked to increase their financial contribution.

4. I have been concerned by a recent number of articles in several high-profile magazines and journals regarding sloppy science and/or scientific fraud. Among these articles are the following:

"Reducing Our Irreproducibility" (Nature Magazine, April 2013)
"Trouble at the Lab" (The Economist, October 2013)
"Addressing Scientific Fraud" (Science Magazine, December 2011)
"A Sharp Rise in Retractions Prompts Calls for Reform" (New York Times, April 2012)
"How Science Goes Wrong" (The Economist, October 2013)
"Redefine Misconduct as Distorted Reporting" (Nature Magazine, February 2013)

These pieces were prompted by a growing concern with these issues; more importantly, if no serious policy action is taken to address this problem, the situation could potentially worsen.

Do you agree that bad science (whether it is sloppy, fraudulent, etc.) is harmful to scientific progress, especially when we need the greatest return for each individual taxpayer dollar spent? If so, do you think it is important to address this problem before it worsens and undermines confidence in the entire scientific enterprise? Do you agree that the NSF IG should continue to investigate all cases of scientific misconduct?

Sloppy, fraudulent activities are harmful to any domain and to any agency. Such activities can undermine confidence, and agency IGs should always investigate misconduct in their agencies.

The referenced articles suggest a number of approaches to handle these issues. The peer evaluation of the research results is one key approach. Ensuring that there is sufficient information provided in publications so that peers can reproduce findings is an important point. Another is to ensure there is sufficient funding to enable peer researchers to replicate the results. Open publication and access to complete methodologies coupled with independent replication are essential to handle sloppy, fraudulent activities.

Questions submitted by Rep. Dan Lipinski, Ranking Member, Subcommittee on Research, and Technology

1. Dr. Sarewitz stated that what may be holding back scientific progress is not widespread scientific misconduct, but cultural factors such as not publishing negative results. Do you agree with that statement? With respect to misconduct when it does occur:

Publishing negative results is only one step. Ensuring that there is sufficient information in publications so that peers can reproduce findings is an essential step. Another is to ensure there is sufficient funding to enable peer researchers to replicate the results. Open publication and access to complete methodologies coupled with independent replication are the essential elements. It is also important to note that NSF does not manage or have oversight of the publications generated by the research it funds.

- You were an NSF AD and as such, are knowledgeable about how the NSF Inspector General (IG) performs her duties. Do you have any reason to believe that the IG is missing any authority to investigate scientific misconduct or that the agency doesn't take these investigations seriously?

The NSF Assistant Directors are knowledgeable about how the IG functions, and the IG responsibilities are taken very seriously.

- Thanks to the 2007 *America COMPETES Act*, all universities now provide training in research ethics to students and post-docs. What does your institution do to address scientific misconduct when it does arise, and also to address the cultural challenges that have actually led to the reproducibility and reliability problems that have been highlighted frequently in the last few years?

Section 7009 of the America COMPETES Act requires that "each institution that applies for financial assistance from the [National Science] Foundation for science and engineering research or education describe in its grant proposal a plan to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduate students, graduate students, and postdoctoral researchers participating in the proposed research project."

NSF's implementation plan for this requirement [74 FR 42126-42128 (August 20, 2009)] states the following:

"Effective January 4, 2010, NSF will require that, at the time of proposal submission to NSF, a proposing institution's Authorized Organizational Representative certify that the institution has a plan to provide appropriate training and oversight in the responsible and ethical conduct of research undergraduates, graduate students, and postdoctoral researchers who will be supported by NSF to conduct research. While training plans are not required to be included in proposals submitted to NSF, institutions are advised that they are subject to review upon request. NSF will formally implement the new RCR requirement via an update to the NSF Proposal and Award Policies and Procedures Guide (PAPPG). It is anticipated that the revisions to the PAPPG will be issued on October 1, 2009. NSF also will modify its standard award conditions to clearly stipulate that institutions are responsible for verifying that undergraduate students, graduate students, and postdoctoral researchers supported by NSF to conduct research have received RCR training."

Purdue's Training Plan to Satisfy the NSF Requirement for Responsible Conduct in Research Education [http://www.purdue.edu/research/vpr/rschadmin/rcr/index.php] includes the following elements:

1. Administration
   The Vice President for Research and Dean of the Graduate School have assigned responsibility to the Office of Research Administration to coordinate implementation and oversee compliance with the NSF Requirement for RCR Education. A faculty advisory committee will periodically review and recommend improvements to this University Responsible Conduct of Research Education Plan. This faculty advisory committee will include representation from the college/school Associate Deans for Graduate Education (Graduate School GEA Committee) and NSF-supported faculty whose projects are subject to the Education Plan.

2. Undergraduates
   Undergraduates to be supported from an NSF project submitted to the sponsor on or after January 4, 2010 must successfully complete online undergraduate core training in the responsible conduct of research (RCR) consisting of online CITI modules on research misconduct, conflict of interest, and data acquisition and management. This requirement must be completed and documentation provided to the hiring department prior to employment. Undergraduates are encouraged to complete the remainder of the CITI online RCR curriculum and to attend seminars/workshops on the responsible conduct of research offered at Purdue University.

3. Graduate Students and Postdoctoral Researchers
   During the first month of support, graduate students and postdoctoral researchers supported by funds from the NSF must successfully complete online graduate core training in RCR. This core training will consist of successful completion of one of the four CITI online RCR courses: Biomedical, Physical Science, Social and Behavioral, or Humanities. Each of these courses consists of modules on research misconduct, conflict of interest, data acquisition and management, responsible authorship, responsible peer review, collaborative research, mentoring, and Purdue University policies and procedures (to be developed). In addition, graduate students and postdoctoral researchers supported by NSF funds are required to engage in additional discussion-based RCR education during the first year of support by NSF funds. The specific method to satisfy this requirement for discussion-based RCR education will be determined by the student's graduate program or by the postdoctoral researcher's mentor. Graduate programs and postdoctoral mentors, respectively, will be responsible for maintaining auditable documentation of each graduate student's or postdoctoral researcher's completion of discussion-based RCR education.

4. Resources
   Information about Purdue courses and workshops addressing the ethical and responsible conduct of research can be found on the Graduate School's Responsible Conduct of Research web site. CITI online courses in the Responsible Conduct of Research referenced in the Purdue RCR Education Plan, Recordkeeping Assistance RCR Tracking Form 2012, Direction for Online RCR Training, RCR Quick Reference Card.

Purdue's Director of Research Regulatory Compliance, Ianthe Bryant-Gawthrop, receives a monthly report identifying all undergraduates, graduate students, and postdoctoral scholars supported from NSF funds and tracks completion of the online CITI course in Responsible Conduct of Research (RCR). She contacts the PIs of NSF grants to ensure that they are aware of this requirement.

Each semester, the Graduate School offers a series of workshops on RCR topics which may be used to satisfy the discussion-based supplementation requirement. Attendance is taken at these workshops.

A small number of formal graduate courses (also open to postdocs) have been created as alternate ways to satisfy the RCR supplemental training requirement. For example, GRAD 61200 Responsible Conduct in Research (1 credit) offers four sections taught every fall and spring semester. GRAD 61200 sections reach approximately 240 graduate students (not all supported by NSF) each year. Several departmental and interdisciplinary graduate programs and training grants currently require their students to complete GRAD 61200.

Regarding Purdue's response to allegations of research misconduct, Purdue's Policy on Research Misconduct [Policy III.A.2: http://www.purdue.edu/policies/ethics/iiia2.html] creates and defines the role of the Research Integrity Officer and specifies procedures for the receipt and initial assessment of allegations of potential research misconduct, and for subsequent inquiries and investigations if the allegations satisfy defined conditions. Individuals found to have committed research misconduct are subject to sanctions determined by the Provost.

- Section 112 of the draft bill concerns me because, without basis, it implies that scientific misconduct is rampant and I worry about the message this sends to the scientific community. Scientists should certainly double and triple check their results before sharing them and when necessary have a statistician look them over, especially if the results are surprising. But I worry about additional unintended consequences of Sec. 112, for example discouraging scientists from sharing surprising results early and thus impeding the progress of science. Do you share my concerns? Can you anticipate any benefits from the requirement in Sec. 112 that may outweigh these concerns?

Misrepresentation of results is harmful to any domain and to any agency. Such activities need to be appropriately considered and investigated. Rather than the approach proposed in Section 112, I would recommend the approach recommended by many others – open publication and access to complete methodologies coupled with independent replication of results as the essential elements.

2. I have concerns about the consequences of the artificially low cap put on rotating personnel in Sec. 118 of the draft bill. For one thing, it doesn't allow for a travel allowance for the rotator to continue his or her program of independent research at his home institution. But even if travel was accounted for, I fear this salary cap would make it impossible for NSF to recruit top talent for some of its leadership positions. You served in a senior leadership positions at NSF. First, why is it important for NSF to be able to attract highly experienced and respected leaders from the scientific community into senior leadership positions in the agency? Second, what do you believe is the right balance here? How does NSF continue to recruit top scientific and management talent whiles still setting reasonable limits on how much they will pay for such leaders to spend 3-4 years with the agency?

A mix of federal employees and IPAs is essential to NSF. The federal employees provide the necessary continuity to all the Foundation processes. They are the foundation of the agency. The IPAs bring the active researchers into the process, with new ideas and approaches. It is important to note that NSF is not charged with performing research with its budget. The annual circulation of research leaders through the Foundation through IPA appointments provides the continual input of the new ideas needed to keep the Foundation evolving.

Since only approximately 6% of NSF's budget is used to perform its functions and complete its charge and this includes the IPA appointment costs, the current level or even an increase is appropriate. The additional awards that might be provided by reducing NSF's investment in IPA appointment would not compensate for the lost

impact from the activities and contributions of the IPAs.

If NSF intends to continue to recruit top scholars to serve in its programs, all the barriers need to be minimized. Faculty are willing to serve in these positions and incur some personal financial loss, increased investment of their personal time, a break in academic continuity, and possible separations from family. Academic units are also willing to enable IPA appointments by accommodating some disruption to the unit functions during their absence. Since faculty and universities are sacrificing many of their essential activities during the IPA's stay at NSF, it is important to reduce their financial contribution.

3. I have serious concerns about the data access requirements in Sec. 302 of the draft bill. We all believe in general that sharing data promotes the progress of science. But the draft language does not appear to reflect the complexity of the problem. The 60-day post- publication requirement would also seem to do great harm to researchers who publish more than one paper from a single data set. I would also like to see strong privacy and IP protections in any requirement on sharing data. Do you share my concerns? Can you discuss some of the technical and cultural challenges to making research data not just more widely available, but also standardized and interoperable in a way that enables scientific progress? What about the economic costs of managing and archiving such data for the long-term. Who should do it and who should pay for it? Should your university? What about NCAR, as suggested in the draft bill? Is the 18-month deadline in the draft bill for addressing all of these challenges realistic?

As I noted in my testimony, I can appreciate the various reasoned arguments on all sides of the public access to research findings, yet it is important to proceed with the implementation of the open public access policy with a shorter time delay. I recommend immediate implementation of the policy that would restrict access to federally funded research articles to no more than six to 12 months. It is important to note that this recommendation is consistent with NIH's Public Access Policy, as well as the success of its PubMed Central repository and research submission process.

Also, I recommend three additional points. It is important that the policies between the agencies be consistent with one another and the procedures for submission and access be harmonized to enhance efficiency and effectiveness of compliance. The policy should meet the full requirements for public accessibility, productive reuse, interoperability with other online repositories housing federally funded scientific publications, and allow for long-term public stewardship and preservation. And finally, it is important for publications to be well-described using metadata that makes it possible to locate and retrieve them.

The data access delays and associated restrictions can be managed. I would recommend data access be handled like patent disclosures with carefully managed delays in publications related to disclosure timing. The 60-day posting is after the "no more than six to 12 months" publication embargo, so this seems reasonable.

Purdue is currently supporting our data repository through institutional funds. Since this is a developing activity, institutional support seems appropriate. In the out years, possible options would be a direct charge to grants and contracts, embedding such costs into university indirect costs, a cost sharing model with institutions and funding sources, or a combination of such approaches.

Questions submitted by Rep. Eddie Bernice Johnson, Ranking Member, Committee on Science, Space, and Technology

Women experience significant attrition in many STEM fields as they move through their studies and careers, especially in the physical sciences, engineering, and computer sciences. Ethnic and racial minority groups are significantly underrepresented across all levels and fields of STEM. In the meantime, the demographics of our country are rapidly shifting. In 30 years, when today's kindergarteners are supporting families of their own,

minorities will comprise 50 percent of our population. At the same time, the marketplace is increasingly requiring technical skills, even for entry-level manufacturing jobs. We cannot continue to leave behind an increasingly large majority of our population.

Broadening participation in STEM to women and minorities has always been part of NSF's mission. Yet, section 102 of the discussion draft appears to have the intent of striking from current law two short paragraphs that describe broadening participation in STEM as policy objectives for NSF.

- Do you agree that broadening participation in STEM is and should remain an important part of NSF's mission? Why?

Broadening participation is central to NSF programs and is clearly evidenced by many of the activities developed for the "Broader Impacts" merit review criteria. Broadening the participation of women and all underrepresented groups is a very important element of NSF activities, as well as expanding the participation of diverse institutions from all geographic regions. To ensure US future strength, a diverse approach in terms of people and ideas is needed to ensure a creative populous and be a competitive nation.

- Do you support repealing current law that lists broadening participation as one among many policy objectives for NSF?

Broadening participation has become an important element of NSF's impact on our country, and should be expanded and not reduced.

Questions submitted by Rep. Zoe Lofgren

In your testimony you support public access to federally funded research and describe Purdue's expertise:

> *We fully support the public access to the results of federally-funded research which is central to the mission of higher education. For nearly a decade, Purdue University, together with others in the higher education community, have promoted open access policies for federally- and state-funded research output to better manage the intellectual assets of higher education in support of teaching and learning (see Purdue e-Pubs for articles http://docs.lib.purdue.edu/ and Purdue [University Research Repository (PURR) for data sets https://purr.purdue.edu/). The publication delay time for public access is a key point and various sound arguments have been provided, yet it is important to proceed with the implementation and a shorter delay. We applaud the open public access directive and are eager to see it succeed.*

I agree with the importance of expanding access to the results of federally funded research, but I am concerned that the FIRST Act might be a move in the wrong direction.

1) Could you please clarify, when you say "it is important to proceed with the implementation and a shorter delay." What do you consider a "shorter delay?"
   a. It is my understanding that the Office of Science and Technology Policy (OSTP) process which was initiated by the previous COMPETES Act suggests a one-year delay, such as the one-year delay which has already proven successful for NIH-funded research. This bill would mandate a two to three-year delay. Are you aware of any verifiable, persuasive evidence that suggests an embargo period of longer than 12 months is necessary?

The NIH Public Access Policy, as well as the success of its PubMed Central repository and research submission process model, has been successful and should be implemented at a minimum. I recommend immediate implementation of the policy that would restrict access to federally funded research articles to no more than six

to 12 months. Although longer delays are often suggested by independent publishers and professional societies, the "no more than six to 12 months" approach is an appropriate balance between finances and access.

Also, I recommend three additional points. It is important that the policies between the agencies be consistent with one another and the procedures for submission and access be harmonized to enhance efficiency and effectiveness of compliance. The policy should meet the full requirements for public accessibility, productive reuse, interoperability with other online repositories housing federally funded scientific publications, and allow for long-term public stewardship and preservation. And finally, it is important for publications to be well-described using metadata that makes it possible to locate and retrieve them.

2) The FIRST Act restarts the process that seems to be well underway in response to the OSTP memo. Are you aware of specific failings of the current process that would necessitate an 18-month or longer delay in announcing and implementing these plans?

No.

3) As both open-access proponents and academic publishers have been willing to participate in the OSTP process to develop workable access policies, are you aware of other groups: be they academic institutions, scientists, the public, or others, who are advocating for a new, slower and potentially much more limiting process?
   a. If so, can you provide specific entities and the arguments they offer in support of Sec. 302?

No.

Responses by Dr. Daniel Sarewitz

"Keeping American FIRST: Federal Investments in Research, Science, and Technology at NSF, OSTP and Interagency STEM Programs."

Responses to Questions for the Record

Daniel Sarewitz
Arizona State University
December 18, 2013

Questions submitted by Rep. Larry Bucshon, Chairman, Subcommittee on Research and Technology

1. Several questions were raised about administrative feasibility with Section 104 in the FIRST Act discussion draft; the attached is the outline plan NSF presented to Chairman Lamar Smith and Chairman Larry Bucshon at the end of September 2013. The intent of section 104 is to parallel the NSF's plan: assuring transparency and accountability by setting forth grant justification before public announcement.

   Do you agree that NSF's proposed plans are adequate to address the concerns about accountability and transparency of NSF funded grants? In what specific ways could the language in section 104 of the FIRST discussion draft be strengthened?

   Do you agree that the NSF should act to quickly increase public transparency and accountability of all dollars spent by the agency?

NSF's proposed initiative looks reasonable and responsive and appears to meet the Committee's main concerns about accountability as I understand them. Pending NSF's provision to the Science Committee of additional details of the "overarching implementation plan," as mentioned in NSF's September 27 email to Committee staff, the proposed initiative looks appropriate. In particular, as indicated in the charts provided by NSF, the emphasis on the hierarchy of priorities (agency, directorate, portfolio), and on the "context of existing award portfolio," in establishing assessment criteria and implementing assurance processes, make clear that accountability at the individual project level can only be effectively evaluated in the context of mid-level goals. Put somewhat differently, in general the only way to meaningfully understand whether a specific funded project has any connection to very high level goals like "the national interest" is to view it in the context of mid-level goals such as portfolio objectives and directorate priorities. If NSF implements the proposed approach, the Committee's efforts to assure accountability in research funding should thus be advanced because it will be better positioned to assess and understand the links between projects and explicit mid-level objectives; indeed I believe the Committee's interests in this regard will be better served than through the language in Title 1, Sec. 104 in the draft bill. In turn, NSF will be better positioned to both ensure the public value of its investments, and to articulate this

value to the Committee. Thus, NSF's proposed plan does seem to address the Committee's intent as expressed through Title 1 of the FIRST draft.

2. Does the proposed FIRST bill require a change in thinking towards attitudes concerning scientific funding? Do you think it will interfere with the current research activities and progress in scientific research?

The FIRST draft includes many diverse provisions. Even in limiting my own assessment to Title 1, it's hard to predict what they might add up to in terms of effect on the progress of research. As I indicated in my oral and written testimony, I support the Committee's efforts to improve accountability and the public value of NSF and other federally funded science, and I believe this can be done without adversely affecting the conduct of science. However, as I also indicated, I believe that the draft act would not reach through to the science system itself to address some of the most important challenges to the effectiveness and integrity of the science enterprise. For example, the need to ensure that peer panels have appropriate expertise for assessing Criteria 2, and the related need to guard against inappropriate hype in the proposal process, seem to me to be issues that the FIRST draft does not address. In my written testimony I suggested a number of specific approaches that the Committee might explore in addressing these and other issues that could help improve the accountability and public value of the publicly funded science enterprise.

3. Do you agree that IPAs should view their time at NSF as public service to the scientific community? Do you agree that IPAs generally gain valuable contacts and experience that would help them advance their future careers? Do you agree that Universities should be involved with increased cost sharing, as was recommended by the NSF IG's March 2013 report? Do you agree that the NSF should implement cost-controls with IPAs?

IPA "rotators" at NSF provide a public service to the agency, the nation, and the scientific community. They also likely benefit the rotator her/himself. I am not familiar with the IG report referenced in the question, but some degree of cost-sharing does not seem unreasonable, especially in meeting some of the increment between the government salary level commensurate with a given IPA's seniority, position and responsibility, and any higher salary that the IPA might regularly earn in her/his academic position.

4. I have been concerned by a recent number of articles in several high-profile magazines and journals regarding sloppy science and/or scientific fraud. Among these articles are the following:

"Reducing Our Irreproducibility" (Nature Magazine, April 2013)

"Trouble at the Lab" (The Economist, October 2013)
"Addressing Scientific Fraud" (Science Magazine, December 2011)
"A Sharp Rise in Retractions Prompts Calls for Reform" (New York Times, April 2012)
"How Science Goes Wrong" (The Economist, October 2013)
"Redefine Misconduct as Distorted Reporting" (Nature Magazine, February 2013)
These pieces were prompted by a growing concern with these issues; more importantly, if no serious policy action is taken to address this problem, the situation could potentially worsen.

Do you agree that bad science (whether it is sloppy, fraudulent, etc.) is harmful to scientific progress, especially when we need the greatest return for each individual taxpayer dollar spent? If so, do you think it is important to address this problem before it worsens and undermines confidence in the entire scientific enterprise? Do you agree that the NSF IG should continue to investigate all cases of scientific misconduct?

As I emphasized in my oral and written testimony, I think the question of the reproducibility, reliability, and relevance of the science base is enormously important and poses a significant challenge to the integrity and public value of the Nation's science enterprise. As I also emphasized, I think it is crucial that the Committee not view this as mainly a problem of misconduct, fraud, or even simple sloppiness. Science is almost never definitive, and cutting edge science even less so. Complex problems that increasingly occupy the science enterprise take researchers even further from any notion of definitive proof, and in most areas of research uncertainty, often considerable, is always present. This means that judgment and bias are inescapable aspects of scientific practice—problems that are exacerbated when research is "high risk," carried out under great pressure to publish or "make breakthroughs," and so on. I do think that this is a domain that the Committee could productively investigate, and that appropriate policies, judiciously developed and applied, could help ameliorate. But simply focusing on misconduct won't do the trick. Progress will require a mix of action on several different fronts: closer attention to good statistical practice; reduced incentives for hyping projects and results; greater patience about how long it takes for complex problems to get solved; greater attention to institutional structure, especially to strengthening the ties between knowledge creators and knowledge users; and so on. Certainly it is important to discourage, uncover, and punish misconduct, but a singular focus in that direction won't do the trick, and moreover is likely to waste resources by focusing attention, investigation, and policy in the wrong places.

I would be pleased to discuss these and related issues further with Committee staff.

Responses by Dr. Timothy Killeen

Dr. Timothy Killeen, President, The Research Foundation for the State University of New York (SUNY) and Vice Chancellor for Research, SUNY
Answers to Questions for the Record from the
House Science, Space and Technology Committee
Subcommittee on Research and Technology

Hearing: Keeping America FIRST: Federal Investments in Research, Science, and Technology at NSF, NIST, OSTP and Interagency STEM Programs
November 13, 2013

Questions from Rep. Larry Buschon, Chairman, Subcommittee on Research and Technology

1. Several questions were raised about administrative feasibility with Section 104 in the FIRST Act discussion draft: the attached is the outline plan NSF presented to Chairman Lamar Smith and Chairman Larry Bucshon at the end of September 2013. The intent of Section 104 is to parallel the NSF's plan; assuring transparency and accountability by setting forth grant justification before public announcement. Do you agree that NSF's proposed plans are adequate to address the concerns about accountability and transparency of NSF funded grants? In what specific ways could language in Section 104 of the FIRST discussion draft be strengthened? Do you agree that the NSF should act to quickly increase public transparency and accountability of all dollars spent by the agency?

   Dr. Killeen: Transparency and accountability are both vitally important when it comes to the expenditure of public resources to support the conduct of research and education activities in science and engineering. It is essential that NSF management remain vigilant and act in a robust, timely, and prudent manner to safeguard public confidence whenever that trust is threatened while maintaining the strong and independent stewardship of the basic research program in the United States – one that has proved incredibly successful for many decades. I have reviewed the NSF response and believe that it does provide for thoughtful and responsive adjustments that will yield greater confidence in the overall performance of the portfolio of grants in serving the national interest. I particularly applaud the portfolio analysis to be performed at the Assistant Director (AD) level. Such regular analyses will complement other processes, such as the Committee of Visitor (COV) reviews which examine individual grant decisions and processes. This portfolio analysis will help to demonstrate and articulate overall performance in addressing the key national goals listed in Section 104.

   Section 104 lays out a number of criteria, beyond the existing NSF criteria related to merit and broader impacts. The additional criteria in the draft bill are proposed to be applied to each and every proposal recommended for funding. They include the questions of whether the project is in the national interest, whether the project is worthy of Federal funding; and does it achieve one or more of the following goals:

   - *increased economic competitiveness of the United States;*
   - *advancement of the health and welfare of the American public;*

- *development of a STEM workforce and increased public scientific literacy in the United States;*
- *increased partnerships between academia and industry in the United States;*
- *promotion of the progress of science in the United States; and*
- *support for the national defense.*

These are essential national objectives that are helpful to list explicitly in the bill. I believe that they are naturally embedded within the meaning of the NSF organic act, and therefore inform the decision making process currently employed by the Foundation. The benefits are connected to the two broad review criteria that all grant application reviewers are asked to consider for each proposal received at NSF. Potential progress towards these goals therefore, informs the decisions that NSF division directors (DD's) make when they approve program directors' documented recommendations for awards. They are also considered by the various disciplinary advisory committees when they are called upon to review programs and advise NSF on how best to maintain the health of science and engineering research and education in the respective areas.

These goals are also discussed by NSF's committees of visitors (COV's) when they review both the overall portfolios and the decisional integrity for individual awards made within NSF programs. COV reviews regularly provide NSF with external expert judgments in two areas: (1) assessments of the quality and integrity of program operations and program-level technical and managerial matters pertaining to proposal decisions; and (2) comments on how the results generated by awardees have contributed to the attainment of NSF's mission and strategic outcome goals.

Finally, these are also the goals that the National Science Board considers as it reviews and makes policy regarding the NSF research and education portfolio – consistent with the NSF organic act.

I certainly support inclusion of these specific objectives in the draft bill. It is my view, however that, rather than attempting to apply them to each and every individual recommended award, they should be considered in the context of the overall portfolio of awards made by the various programs, divisions, and directorates of the Foundation. The progress and contributions from the public investment in science and engineering comes about from the accumulation of new knowledge over time and its application. Assessing the collective body of knowledge developed over time against the criteria in Section 104 of the draft FIRST bill would be a more meaningful way to measure NSF investment decisions against important national objectives and would be less prone to "gaming" or rote application, with a not insignificant bureaucratic overhead.

2. Does the proposed FIRST bill require a change in thinking towards attitudes concerning scientific funding? Do you think it will interfere with the current research activities and progress in scientific research?

Dr. Killeen: The FIRST bill provides an important opportunity to strengthen and foster research and education activities in science and engineering and to accelerate progress in scientific and engineering research. I believe that the emphasis on transparency and accountability will send an important message to the research community and to the public that supports the scientific enterprise. However the FIRST bill provides an even more important opportunity for messaging that should be more fully exploited -- it should send a clear and unmistakable message to our international competitors that the U.S. will do what is necessary to continue to lead the world in the conduct of science and engineering research and its use for both ensuring this nation's national and economic security and the health and welfare of our citizens. The proposed bill links science and engineering directly to the national interest and this impetus will help secure the trust of the public in the wisdom of these very significant public expenditures. However, the language of the draft bill, in my opinion, does not sufficiently support the essential value proposition of NSF - or indeed the development of the future resource base needed - for a continued vibrant and world-leading scientific, engineering and educational enterprise attractive to American youth from diverse backgrounds that recognizes the essential exploratory nature of basic research. I encourage the committee to consider such framing to complement the accountability and transparency provisions.

3. Do you agree that IPAs should view their time at NSF as public service to the scientific community? Do you agree that IPA's generally gain valuable contacts and experience that would help them advance their future careers? Do you agree that Universities should be involved with increased cost sharing as was recommended by the NSF IG's March 2013 report? Do you agree that the NSF should implement cost-controls with IPAs?

Dr. Killeen: I agree that IPAs should view their time at NSF as a public service. I believe, from my own experience, that that is the overwhelming case today. In my opinion, NSF's active participation in the IPA program provides important benefits to the national science, engineering and education enterprise, to NSF, to the individuals who participate, and to the partnering institutions.

First, NSF gains the invaluable perspective and talents of an extraordinary cadre of leading researchers and educators who bring fresh perspectives, important insights, and innovative ideas to the management and future direction of NSF programs. This regular fresh insertion of energy, experience and ideas keeps NSF at the cutting edge of science and technology. The most important public service these IPA's provide is through their expert knowledge, experiences, and capabilities – all of which ensure that the limited (and efficiently deployed) NSF resources are used to ensure NSF programs continually evolve to keep pace with the progress and needs of science.

In addition, the IPA assignee, the partnering institution, and other institutions that the assignee may interact with during the assignment become better informed about NSF's programs and practices. This information can help the partner in subsequent dealings with NSF, such as in participating in NSF programs. During a term of appointment at NSF, it must be said that an IPA must place his or her own research career somewhat "on hold" and this does not always lead to the garnishing of a competitive resume for future jobs. However,

NSF is held in such high national and international regard that IPA stints are generally viewed as important contributing factors to being able to compete for future job opportunities. I admit to having a bias towards hiring individuals who have had the opportunity to serve nationally and thereby broaden their perspectives.

I recommend that, if the committee believes legislation regarding NSF's use of IPA authority is needed, it should not make it more difficult than it already is for NSF to attract the services of leading scientists and engineers, educators, and research administrators – all of whom are vitally needed to enable NSF to support cutting edge research and education activities. There should be reasonable and defensible financial limitations in place that appropriately reflect the competitive market for US-based world-class academic talent. It would be a mistake, for example, to have a recruitment policy that greatly lessened the influx to NSF of IPA's with significant academic management experience and/or large-scale grant or cooperative agreement experience.

As far as the cost sharing recommendation is concerned, management flexibility should remain here. Not all institutions can afford to lose the services of a teaching faculty member for several years, and continue to pay significantly for the salary during the extended absence – and perhaps even a permanent separation. A fixed cost sharing approach could, in my mind, tilt the participation "playing field" in a certain type of institutional direction, with consequent loss of diversity in the IPA cohort. The current situation allows for NSF-institution negotiations as part of the recruitment process and the committee might consider developing some criteria to inform management processes and/or develop normatives here.

4. I have been concerned by a recent number of articles in high-profile magazines and journals regarding sloppy science and/or scientific fraud. Among these articles are the following:
   - "Reducing Our Irreproducibility" (Nature Magazine, April 2013)
   - "Trouble at the Lab" (The Economist, October 2013)
   - "Addressing Scientific Fraud" (Science Magazine, December 2011)
   - "A Sharp rise in Retractions Prompts Calls for Reform" (New York Times, April 2012)
   - "How Science Goes Wrong" (The Economist, October 2013)
   - "Redefine Misconduct as Distorted Reporting" (Nature Magazine, February 2013)

   These pieces were prompted by a growing concern with these issues; more importantly if no serious policy action is taken to address this problem, the situation could potentially worsen. Do you agree that bad science (whether it is sloppy, fraudulent, etc.) is harmful to scientific progress, especially when we need the greatest return for each individual taxpayer dollar spent? If so, do you think it is important to address this problem before it worsens and undermines confidence in the entire scientific enterprise? Do you agree that the NSF IG should continue to investigate all cases of scientific misconduct?

   Dr. Killeen: I certainly agree that poor or sloppy science damages our research enterprise and endangers the public's support of scarce taxpayer resources for the conduct of research. A major benefit of the peer review process is to, over time, act to reduce or eliminate sloppy science. But careful and sustained managerial attention is also needed to avoid any complacency and ensure that these kinds of problems do not worsen over time. I also agree

that the Inspector General (IG) should continue to be vigilant and work closely with both the Foundation and research institutions to reduce – even eliminate – actual misconduct in science. I believe that the NSF IG procedures in this regard are sound and extremely important.

The development and reinforcement of ethical guidelines and the preservation of institutional cultures that support and enhance scientific integrity are equally important to vigorous and effective scientific misconduct investigation and sanctions. The combination of increasing scarce research dollars and the competitive pressures to publish can encourage bad behavior which must be resisted through effective training and mentoring, good role modeling, visible and supported institutional commitments, and vigilant oversight and policy development. For example, I am very proud of the Statement on Research Integrity that was approved unanimously by the 64-campus SUNY Board of Trustees earlier this year. Based on my own observations, I do not believe that scientific misconduct is rampant or growing out of control within the NSF research community, though neither is it negligible nor to be ignored with complacency.

While an important activity, I believe the message sent by the draft FIRST bill on scientific misconduct goes beyond what I believe is necessary to address the above issues. If I was a scientific competitor in another country reading this bill, I might think that the message being sent is that the U.S. research enterprise is perhaps fraught with major management weaknesses that only legislation can rectify. I do not believe that to be the case. As I have said before, the FIRST bill should send a clear and unmistakable message to our international competitors that the U.S. will do what is necessary to continue to lead the world in the conduct of science and engineering research and its use for both ensuring this nation's national and economic security and the health and welfare of our citizens in the 21st Century knowledge economy.

Thank you for the opportunity to address these important questions.

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Questions from Rep. Dan Lipinski, Ranking Member, Subcommittee on Research and Technology

1. Dr. Sarewitz stated that what may be holding back scientific progress is not widespread scientific misconduct, but cultural factors such as not publishing negative results. Do you agree with that statement? With respect to misconduct when it does occur?

Dr. Killeen: I have no doubt that some scientific progress fails to occur because of the some of the factors cited by Dr. Sarewitz. But I believe that these are minor - there are other forces playing far more significant roles in hindering research progress and innovation.

According to the Task Force on American Innovation, there are strong indications that the health of the U.S. research enterprise is faltering. First, the stagnation of the American K-12 education system and the inadequate numbers of U.S. students entering the STEM (science, technology, engineering, and mathematics) disciplines are threatening the nation's ability to recruit, train, and retain the scientists and engineers required to create new products and systems. On this subject, key findings from the Task Force on American Innovation include:

- *In 2009, the U.S. ranked 27th among developed nations in the proportion of college students receiving undergraduate degrees in science or engineering.*
- *China now produces nearly an equal number of natural science and engineering doctoral degrees compared to the U.S., having increased from approximately 5,000 in 1997 to over 20,000 in 2006.*
- *In 2007, China became second only to the U.S. in the estimated number of people engaged in scientific and engineering R&D.*

Second, the U.S. is not sending a clear signal that the country is supporting its science and engineering innovators. Years of boom-and-bust cycles of federal funding for scientific research have disrupted the ability of researchers to obtain funding for projects, scared away private sector investments, and sent a possibly chilling signal to young people considering careers in STEM fields. In this tenuous economy, students need greater assurance that jobs will be available when they complete their degrees. Similarly, researchers must know that the infrastructure and federal funding to support their current and future research will be preserved and strengthened. To maintain its global competitiveness and world leadership, the U.S. must and can both achieve fiscal discipline and build a better America through scientific research and education.

Consider the following findings by the Task Force:

- *Since the 1960s, when the U.S. devoted 17 percent of the federal budget to R&D for agencies like NASA and DARPA, outlays have fallen to around nine percent of the discretionary budget.*
- *The U.S. share of worldwide scientific publications and citations has declined. Europe has surpassed the U.S. in science and engineering publications, and Asia is rapidly catching up.*
- *Utility patents (issued for the invention of a new and useful process, machine, manufacture, or composition of matter, or a new and useful improvement) of foreign origin have surpassed patents of U.S. origin. Researchers have found strong correlations*

between public R&D investment and the number of new patents across a variety of energy technologies, including wind, fuel cells, nuclear fission and fusion, and photovoltaics.

Finally, the stability of our investments in basic scientific and engineering research strongly influences vital sectors of the U.S. economy, including energy and manufacturing. Federal investments in research precipitate additional private sector research investments, as demonstrated by the pharmaceutical industry, which significantly expanded its own R&D on the heels of increased federal investments in biomedical research.

- You were an NSF AD and as such, are knowledgeable about how the NSF Inspector General (IG) performs her duties. Do you have any reason to believe that the IG is missing any authority to investigate scientific misconduct or that the agency doesn't take these investigations seriously?

Dr. Killeen: *When I served as the Assistant Director for Geosciences, I had many opportunities to interact with and observe the work of the Office of the Inspector General. In my view, the office of the IG has the authority it needs to investigate scientific misconduct. I also know that from the NSF Director down to the program directors throughout the Foundation -- NSF takes these investigations seriously and acts accordingly when circumstances warrant.*

- Thanks to the 2007 *America COMPETES Act*, all universities now provide training in research ethics to students and post-docs. What does your institution do to address scientific misconduct when it does arise, and also to address the cultural challenges that have actually led to the reproducibility and reliability problems that have been highlighted frequently in the last few years?

Dr. Killeen: *Thank you for this question. The State University of New York (SUNY) and the Research Foundation for SUNY (RF) have specific policies governing ethics and conflicts of interest. We have focused on establishing policies and processes to create a culture of compliance specifically during the past few years in response to the concerns you cite. The SUNY Board of Trustees and the RF Board of Directors adopted a Statement on Research Integrity in 2013, which outlines the values that SUNY expects of faculty related to the integrity in the conduct of scholarly research, and lists sixteen Principles of Research Integrity. These principles make it clear that appropriate research methods should be used, that research is conducted with appropriate levels of transparency, independence and open communications. They also outline expectations for peer review, and for protecting against external pressures and bias.*

In 2012, SUNY established a Compliance Steering Committee to review and develop policy in areas that include research integrity and research misconduct throughout the system's 64 campuses. During the same year, the RF appointed its first Chief Compliance Officer to ensure that a robust compliance program exists.

SUNY campuses also have their own policies governing Research and Scholarly Misconduct. As an example, Stony Brook University has a policy that addresses the assessment, inquiry, and investigation of misconduct, as well as restoration of reputation and protections again retaliation.

When scientific misconduct is alleged, there is a clear process for review and sanctions up to and including termination have been applied in the past. Our policies also call for retraction of any falsified publications. I am happy to report that only a relatively small number of scientific misconduct cases occur annually, especially given the size of the research enterprise within the SUNY system.

- Section 112 of the draft bill concerns me because, without basis, it implies that scientific misconduct is rampant and I worry about the message this sends to the scientific community. Scientists should certainly double and triple check their results before sharing them and when necessary have a statistician look them over, especially if the results are surprising. But I worry about additional unintended consequences of Sec. 112, for example discouraging scientists from sharing surprising results early and thus impeding the progress of science. Do you share my concerns? Can you anticipate any benefits from the requirement in Sec. 112 that may outweigh these concerns?

Dr. Killeen: I do share your concerns. I certainly also agree that misrepresentation of research results damages our research enterprise and endangers the public's support of scarce taxpayer resources for the conduct of research. I also agree that the Inspector General should continue to be vigilant and work closely with both NSF and research institutions to reduce – even eliminate the blatant misrepresentation of research results. While an important activity, I believe the message sent by the draft FIRST bill on scientific misconduct, misrepresentation of research results, the arbitrary limitation of the number of citations of a principal investigator's (PI's) published works within the PI's proposal, and the prescriptive focus on research grant conditions, sends a message that something is seriously wrong with the quality of science being conducted in this country. Based on my own experience, I think such a message is not justified given that, while scientific misconduct is certainly not a negligible phenomenon, it is not a dominant or limiting factor in the pursuit of knowledge. With that said, it is of course, absolutely essential to avoid any sense of complacency in addressing such issues, especially because of the possible erosion of public support for science and technology that would follow lax oversight.

If I was a scientific competitor in another country reading this bill, I might think the message being sent is that the U.S. research enterprise is not only fraught with major management weaknesses that only legislation can rectify, but that it also conveys an incremental "business as usual" approach to the support of the U.S. research enterprise. As I said in my written testimony, the bill should send a clear and unmistakable message to our international competitors that the U.S. will do what is necessary to continue to lead the world in the conduct of science and engineering research and its use for both ensuring this nation's national and economic security and the health and welfare of our citizens. Such a vibrant scientific enterprise will be, as you imply, very supportive of surprising results being

published and examined – and then again reexamined to see where the new leads take us. This is how science progresses.

2. I have concerns about the consequences of the artificially low cap put on rotating personnel in Sec. 118 of the draft bill. For one thing, it doesn't allow for a travel allowance for the rotator to continue his or her program of independent research at his home institution. But even if travel was accounted for, I fear this salary cap would make it impossible for NSF to recruit top talent for some of its leadership positions. You served in a senior leadership positions at NSF. First, why is it important for NSF to be able to attract highly experienced and respected leaders from the scientific community into senior leadership positions in the agency? Second, what do you believe is the right balance here? How does NSF continue to recruit top scientific and management talent whiles still setting reasonable limits on how much they will pay for such leaders to spend 3-4 years with the agency?

   Dr. Killeen: In my opinion, NSF's active participation in the IPA program provides critically important benefits to NSF, to the individuals who participate, and to the partnering institutions. The NSF gains invaluable access to the talents of an extraordinary cadre of leading researchers and educators who bring fresh perspectives, important insights, and innovative ideas to the management and future direction of NSF programs. The IPA's should view their service at NSF as a public service to the scientific community. But the real public service these IPA's provide is access to their expert knowledge, experiences, and capabilities –all of which help make certain that scarce NSF resources are used to ensure that NSF programs continually evolve to keep pace with the progress and needs of science. Because of this, I strongly believe that the IPA program should continue to be used to attract top world-class talent to this top world-class agency.

   I believe that the current balance is about right. At NSF, you will find individuals who have been deans or directors of large research institutions, senior seasoned researchers who have tremendous practical experience bases on which to draw, mid-career faculty who have reached a stage in their career where they want to "give back", and more junior researchers who may be motivated by gaining managerial experience and a broader perspective of their particular field. This diversity adds immeasurably to the vitality and strength of NSF. Any changes should be carefully reviewed to ensure that no unintended imbalances occur: either, for example, by creating a geographic or institutional bias or by limiting the number of senior academics with managerial expertise and/or principal investigators who know what it takes to build large successful interdisciplinary teams. I agree that a tight salary cap would make it impossible to recruit a certain type of talent. Although reasonable restrictions on salaries should be implemented based on an analysis of current salaries in academia, I would favor preserving significant management flexibility to facilitate the (already tricky) process of recruiting top talent to NSF, particularly at the more senior levels where management experience is very important and individuals may not be in family positions (children in college, etc.) to leave their posts for extended periods while encumbering very significant salary reductions. I also believe that eliminating travel support for IPA's to periodically return to their home institutions (for example, to interact with graduate students or to maintain a level of research currency) would severely limit NSF's ability to attract the needed talent.

3. I have serious concerns about the data access requirements in Sec. 302 of the draft bill. We all believe in general that sharing data promotes the progress of science. But the draft language does not appear to reflect the complexity of the problem. The 60-day post-publication requirement would also seem to do great harm to researchers who publish more than one paper from a single data set. I would also like to see strong privacy and IP protections in any requirement on sharing data. Do you share my concerns? Can you discuss some of the technical and cultural challenges to making research data not just more widely available, but also standardized and interoperable in a way that enables scientific progress? What about the economic costs of managing and archiving such data for the long-term. Who should do it and who should pay for it? Should your university? What about NCAR, as suggested in the draft bill? Is the 18-month deadline in the draft bill for addressing all of these challenges realistic?

   Dr. Killeen: I share your concerns about the language of Section 302 concerning access to data and I completely agree with your comment about the great complexity of the topic. The issues of privacy, IP protection and interoperability that you cite as examples are all critical but they are not the only ones. The rise of data-enabled science and engineering discovery in all fields, and the exciting vista of transformative science flowing from the interrogation of "big data" sets are, without a doubt, disruptively changing the modalities of scientific inquiry and enabling the rapid crossing of new frontiers of knowledge. We are also increasingly awash in a "sea of data", with exponential volumetric increases of data and data sets concerning the natural and living world. This growth is giving rise to significant technical challenges of access, storage, distribution, visualization, data mining, data fusion, metadata standardization, and interoperability that together represent a very challenging research arena all of its own.

   And, of course, the need for scientific validation and the demonstration of reproducibility of evidence-based results call out for greater access, sharing, and interoperability of data records on a timely basis. I agree that scientific researchers who publish results based on data sets gained with support from federal agencies such as NSF should not be able to have exclusive rights to those data for indefinite periods. Yet, in different fields and in different research settings, the time frame for exclusive rights should probably differ. One only has to look at the "rules of the road" for large international science projects like the hunt for the Higgs Boson to recognize the complexity of this question.

   And there are other questions which make simple solutions to data access legislation problematic. Examples that come to mind include: what criteria can be used to define the "unit" of raw data – does that mean all possible digital records or just the key published subsets? Are calibration data records that describe an observing instruments performance also required, given that they may be central to reproducibility considerations? What happens when a new version of a particular published data set supersedes an older version of reduced data – are all versions kept forever and who has the responsibility to flag when a particular data set is not longer applicable? Who has the responsibility to ensure upward compatibility of access to data sets as specific storage media become obsolete? The list of

questions to be addressed is a long one and, while much discussion is taking place, I do not feel that the central issues have been fully resolved.

Since there are so many unanswered and even, as yet, possibly unanswerable questions, I believe that we must address this major challenge with a robust, yet probably more gradual and phased approach, and establish a shared community-based governance structure for data citation, access norms, and the long-term curation of important data records. In my own thinking about this challenge when I was at NSF, I became convinced that a first step, albeit a modest one, could be to set expectations, or possibly even requirements, for data citation in publications, using standard approaches. I came to this position after reviewing the quite small percentage of authors that actively used data citation methodologies in published work in the geosciences. A "cultural" move to more extensive use of data citation tools would provide a number of benefits: authors who were primarily data generators would get more academic credit for their important contributions and citation records could be used to evaluate the inherent value (and perhaps set requirements for sustainable curation) for key important data sets. More extensive data citation utilization would also improve validation and reproducibility prospects and would naturally allow for some of the domain-specific experiments to go forward to address some of the questions listed above. Emphasis on data citation as a norm would bring the publishing houses into the shared governance system mentioned above, as well as funding agencies and institutions who would take pride in specific data sets. A next step beyond citation could be the development of clear data interoperability standards, allowing for the future (often initially unanticipated) data fusion activities.

With regard to data fusion efforts, the EarthCube program at NSF was initiated to design and create the cyber infrastructure to allow for the interoperability of often inhomogeneous and disparate data sets held in different institutional settings – each describing different, yet interlocking, aspects of the complex earth system. EarthCube has already shown the complexity of this challenge which requires the combined efforts of domain scientists and computational and computer scientists. This work (in my view) will require the establishment of computer-generated ontologies and community governance schemes allowing for data discovery and fusion of data sets generated in different settings. But the potential benefits of such data "interworkability" for scientific progress are enormous.

The data challenge is certainly a sobering one, yet is one of critical importance to future scientific progress. The financial models are still immature, particularly for work at the scale and with the longevity suggested in the draft language. I personally anticipate that the model going forward will out of necessity have to be a distributed one, rather than monolithic and any solution set will have to be managed with a distributed and community-driven governance system. I am greatly encouraged by the clear interest on the part of Congress to take progressive steps, but do share the concerns you have expressed about the pace and complexity involved. As far as the question concerning NCAR is involved, as a previous director of that institution, I can say that NCAR has deep experience with large data sets and effective community distribution and governance schemes, yet would certainly need additional significant resources to become a scalable national facility with the long-term stability and authority to guarantee access over the time frames envisioned.

I thank you for the opportunity to address these important questions.

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Questions Submitted by Rep. Eddie Bernice Johnson, Ranking Member, Committee on Science, Space, and Technology

1. Women experience significant attrition in many STEM fields as they move through their studies and careers, especially in the physical sciences, engineering, and computer sciences. Ethnic and racial minority groups are significantly underrepresented across all levels and fields of STEM. In the meantime, the demographics of our country are rapidly shifting. In 30 years, when today's kindergarteners are supporting families of their own, minorities will comprise 50 percent of our population. At the same time, the marketplace is increasingly requiring technical skills, even for entry-level manufacturing jobs. We cannot continue to leave behind an increasingly large majority of our population.

   Broadening participation in STEM to women and minorities has always been part of NSF's mission. Yet, section 102 of the discussion draft appears to have the intent of striking from current law two short paragraphs that describe broadening participation in STEM as policy objectives for NSF.

   - Do you agree that broadening participation in STEM is and should remain an important part of NSF's mission? Why?
   - Do you support repealing current law that lists broadening participation as one among many policy objectives for NSF?

   Dr. Killeen: *The Nation's universities are vital institutions both for maintaining the strength of the U.S. basic research enterprise and for producing individuals with advanced S&E competencies to serve in the workforce. The Nation has done less well in tapping the potential of underrepresented minorities, women, and persons with disabilities. Developing this potential, especially to advance underrepresented minorities, will lead to expanded opportunities for individuals and will improve our national competitiveness and prosperity. In fact I would argue that such inclusiveness is absolutely essential for future prosperity.*

   Guided by the NSF Strategic Plan, NSF established a performance area focused on broadening participation: to expand efforts to increase participation from underrepresented groups and diverse institutions throughout the United States in all NSF activities and programs. NSF defines broadening participation in terms of individuals from underrepresented groups as well as institutions and geographic areas that do not participate in NSF research programs at rates comparable to others. Broadening participation is part of the overall merit review process used at NSF. Some NSF programs, however, have a particular focus or emphasis on broadening participation, and these comprise NSF's Broadening Participation Portfolio.

   To integrate broadening participation with NSF's core processes, such as merit review and award oversight, NSF developed a framework for implementing the broadening objective which included: broadening the pool of reviewers; training NSF staff and reviewers; communicating guidance and promising activities widely; and maintaining a portfolio of

relevant programs. Following the development of this framework, NSF then held a workshop involving approximately 60 participants who sought to develop and validate a strategy by which to assess the value of NSF's investment in broadening participation across all directorates and programs.

During my tenure at NSF, I was very much involved in developing and institutionalizing the broadening concept because of the continued vitality of our research enterprise depends on attracting and retaining those who are under-represented in science and engineering.

I firmly believe that it would be a major mistake to enact legislation that could in any way be interpreted as lessening the importance of the long-standing commitment to broadening participation.

Thank you for the opportunity to address these questions.

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Responses by Mr. James Brown

STEM Education Coalition Responses to Questions for the Record
House Science, Space, and Technology Committee
December 20, 2013

Questions submitted by Rep. Larry Bucshon, Chairman, Subcommittee on Research and Technology

Q: Your testimony noted that the Advisory Panel, established in the Discussion Draft, could be improved by providing more specificity and transparency on the types of inputs and issue areas where the panel would be expected to weigh in. What are your thoughts about the specific areas for which the Panel could provide the most useful expertise? What would the transparency measures look like?

In our written testimony we argued extensively that it was critical to build more robust mechanisms into federal STEM plans and policymaking processes to incorporate the inputs of relevant stakeholders, and especially from those "on the ground" in education – the educators both in and out of school, administrators, and their relevant associations. On this front, there are two specific aspects of stakeholder input that deserve further attention.

First, it is important for there to be a more systematic means of soliciting, collecting, and incorporating such input into educational plans. The Advisory Panel needs to be empowered to hold appropriate public events, engage directly with individual stakeholders and stakeholder groups, and be able to interface with "on the ground" educators in meaningful ways. This process needs to go well beyond postings in the Federal Register and other mechanistic and traditional means of soliciting such input. It is also important that policies developed that impact federal STEM education programs also demonstrate how they reflect stakeholder input in visible and recognizable ways.

Secondly, there are many specific policy questions where outside stakeholders could assist the government in addressing specific challenges. Some examples of this include:

- Informing the broad government-wide policy goals for federal STEM programs, such as the relevant balance of agency programs across the K-12, Higher Education, and informal learning spectrums.
- Developing measures and means to evaluate federal programs that are not easily evaluated by standard educational metrics such as standardized test performance. This is especially applicable to many of the smaller federal STEM programs that reach limited target populations.
- Better aligning efforts to develop education content and research agendas in science mission agencies with the needs of "on the ground" educators. There are myriad efforts underway within federal agencies to align their content with educational needs that could be better informed by such efforts.
- Developing mechanisms to help disseminate the proceeds and products of federal STEM programs to a wider education audience. The federal agencies are filled with programs that only reach a narrow target audience, but would be useful to a wider range of students, educators, parents, and STEM professionals.

Q: The STEM Education Coalition supports an inclusive definition of the term "STEM" that embraces engineering and technology and includes all STEM fields and unique needs. Why does the definition of the term "STEM" need to be strengthened? How is the term currently being defined so that it is not inclusive? What can be done to ensure that technology and engineering and all related fields of science and mathematics are treated equally?

As we mentioned in our previous written testimony, our Coalition does support an inclusive definition and use of the term "STEM education" by federal and state programs that is not limited to only math and science, but also embraces the myriad variety of other STEM-related fields. As the nature of skills demanded by the modern workforce has and will continue to change rapidly, this is especially necessary so that education programs can change and adjust to these changing needs.

A big part of the challenge in this area is the reality that many different federal agencies, from the Department of Education to the myriad of science mission agencies, employ different operational definitions of the "STEM" fields. Some of these definitions are written into statute, some are established by regulations, and some are aspects of individual grant programs. For example, at the Department of Education definitions of "STEM" fields vary in impactful ways between higher education programs and K-12 programs. This is further exacerbated by the fact that federal K-12 accountability systems primarily emphasize math and reading, so that science and other STEM subjects often receive less attention and funding, with many subdiscliplines such as computer or environmental science, often not even being considered eligible for federal grants by individual program officers.

We see your Committee as having a primary role in helping to resolve many of these issues by establishing a better mechanism and rational for defining the STEM subjects, either agency by agency or in a more global fashion. Our experience has shown that there are at least two viable ways of reaching this goal, either: 1) by establishing a rigorous process for agencies to establish and adjust their definitions for "STEM" fields in a way that requires that they solicit input from the various STEM disciplinary stakeholders and workforce and employers entities and they document how their definitions reflect this input and have adapted to changes in these inputs over time, or 2) by establishing a more explicit and broadly inclusive statutory definition of STEM subjects directly in authorizing legislation that would be based on extensive input from the relevant stakeholders. Both routes contain tradeoffs, as the former is potentially very difficult to legislate effectively, while the later would likely be very static, could miss rapidly emerging fields, and would have to be amended periodically by Congress.

Question submitted by Rep. Eddie Bernice Johnson, Ranking Member, Committee on Science, Space, and Technology

Q: Women experience significant attrition in many STEM fields as they move through their studies and careers, especially in the physical sciences, engineering, and computer sciences. Ethnic and racial minority groups are significantly underrepresented across all levels and fields of STEM. In the meantime, the demographics of our country are rapidly shifting. In 30 years, when today's kindergarteners are supporting families of their own, minorities will comprise 50 percent of our population. At the same time, the marketplace is increasingly requiring technical skills, even for entry-level manufacturing jobs. We cannot continue to leave behind an increasingly large majority of our population.

Broadening participation in STEM to women and minorities has always been part of NSF's mission. Yet, section 102 of the discussion draft appears to have the intent of striking from current law two short paragraphs that describe broadening participation in STEM as policy objectives for NSF.

- **Do you agree that broadening participation in STEM is and should remain an important part of NSF's mission? Why?**
- **Do you support repealing current law that lists broadening participation as one among many policy objectives for NSF?**

Our Coalition supports comprehensive efforts to expand the capacity and diversity of the STEM workforce pipeline, including targeted initiatives to promote the inclusion of underrepresented minorities, women, veterans, and rural populations in STEM fields. We have aggressively advocated for a strong role for NSF in broadening the participation of underrepresented groups in the STEM field and agree that this mission should remain a priority for the foundation. We would be opposed to any policy that either indirectly or overtly would compromise NSF's ability to advance this critical element of its mission.

Question submitted by Rep. Zoe Lofgren

Q: While it is not the specific focus of this hearing, I want to thank you and the STEM Education Coalition for being a very early supporter of the US Science Laureate legislation that I introduced with many of my colleagues from the Science Committee. Could you briefly speak to the importance, in promoting and supporting STEM education, of such approaches to increase the visibility and recognition of American scientists?

Our Coalition has long held the view that STEM education must be elevated as a national priority as reflected through education reforms, policies to drive innovation, and federal and state spending priorities. We also know that STEM education is closely linked with our nation's economic prosperity in the modern global economy and that strong STEM skills are a central element of a well-rounded education and are essential to effective citizenship. Recognizing the accomplishments of outstanding scientists, engineers, and other forms of STEM professionals –

from technicians to university researchers – is an incredibly important part of elevating these fields in the national dialog and in the view of students, parents, and educators.

Appendix II

Additional Material for the Record

SUBMITTED STATEMENT LAMAR S. SMITH, CHAIRMAN, COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

Fundamental scientific research is critical to maintain American innovation and competitiveness. American researchers have developed new technologies that save lives, increase economic productivity, jump-start new industries and improve the quality of life for all Americans.

Our challenge today is to ensure America remains first in the global marketplace of ideas and products.

Today we consider a discussion draft of the Frontiers in Innovation, Research, Science, and Technology Act or FIRST Act. The FIRST Act helps ensure that American researchers remain number one in the global marketplace for innovations that change our communities and advance our understanding of the world.

The FIRST Act reauthorizes the National Science Foundation (NSF), the National Institute of Standards and Technology (NIST) and makes changes to improve coordination of STEM education programs. This discussion draft is, in part, a result of discussions with stakeholders in the R&D community.

Federally-funded R&D is one of the best investments we can make in our nation's future. We can't have innovation without research and development. We must continue to support the fundamental R&D that creates jobs, encourages innovations and establishes scientific bridges to next generation technologies.

The FIRST Act affirms our commitment to high-integrity science and prioritizes national R&D to ensure that American tax dollars are used effectively and efficiently in funding federal research. We must focus scientific funding on high priority research like developing technologies to help wounded warriors or creating a high-performance supercomputer to rival China's.

The FIRST Act ensures that our nation stays on the cutting edge of new technology and strengthens technology transfer and commercialization of federally funded R&D. Not only does the FIRST Act help us remain globally competitive in the present, it ensures stakeholder input in STEM programs so that we remain the world leader in innovative research and technology for years to come. Our draft legislation also increases transparency within federally funded science and research. Americans want and deserve to know what their money is paying for.

The FIRST Act requires federally funded research data to be made available to the public. It also requires that federally-funded researchers certify that what they publish is based on accurate representation of research results.

The FIRST Act stresses quality over quantity for publication citations used in NSF grant applications. This provision will ensure that only quality science that is vital to American innovation and competitiveness receives funding.

The bill also directs the NSF to assure that each grant application is relevant to the national interest. The bill requires that NSF staff provide clear justifications for why grants are awarded federal funds.

Government employees and their program managers should be accountable to the American taxpayer for their funding decisions. They should explain why grants that receive taxpayer funding are important research that has the potential to benefit the national interest. It's not the government's money; it's the people's money.

Enhanced transparency and accountability isn't a burden; it will ultimately make NSF's grant award process more effective.

Eight of the 13 Nobel Prize winners in 2013 received support from NSF. We want to continue NSF's success of supporting high-quality research. Making more information available to the American public about awarded grants and requiring that they promote the national interest will help NSF to continue to produce first-rate scientific research.

At a time of budget cuts, Congress has a responsibility to ensure that taxpayer dollars are spent wisely and are focused on national priorities. The FIRST Act will ensure that federally funded research is conducted in a transparent and responsible manner in order to ensure that America remains "FIRST" in all areas of science and research.

[DISCUSSION DRAFT]

NOVEMBER 1, 2013

113TH CONGRESS
1ST SESSION

H. R. _____

To provide for investment in innovation through scientific research and development, to improve the competitiveness of the United States, and for other purposes.

IN THE HOUSE OF REPRESENTATIVES

M__. _____ introduced the following bill; which was referred to the Committee on _____

A BILL

To provide for investment in innovation through scientific research and development, to improve the competitiveness of the United States, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE; TABLE OF CONTENTS.

(a) SHORT TITLE.—This Act may be cited as the "Frontiers in Innovation, Research, Science, and Technology Act of 2013" or the "FIRST Act of 2013".

(b) TABLE OF CONTENTS.—The table of contents for this Act is as follows:

TITLE I—NATIONAL SCIENCE FOUNDATION

SEC. 101. FINDINGS.

Congress finds the following:

(1) The Foundation has made major contributions for more than 50 years to strengthen and sustain the Nation's academic research enterprise.

(2) The economic strength and national security of the United States, and the quality of life of all Americans, are grounded in the Nation's scientific and technological capabilities.

(3) The Foundation carries out important functions in supporting basic research in all science and engineering disciplines and in supporting science, mathematics, engineering, and technology education at all levels.

(4) The research and education activities of the Foundation promote the discovery, integration, dissemination, and application of new knowledge in service to society and prepare future generations of scientists, mathematicians, and engineers who will be necessary to ensure America's leadership in the global marketplace.

(5) The Foundation is charged with the responsibilities—

(A) to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences;

(B) to initiate, support, and conduct basic scientific research and to appraise the impact of research upon industrial development and the general welfare;

(C) to initiate, support, and conduct scientific research activities in connection with matters relating to the national defense, at the request of the Secretary of Defense;

(D) to award scholarships and graduate fellowships in the sciences;

(E) to foster the interchange of scientific information among scientists;

(F) to evaluate scientific research programs undertaken by agencies of the Federal Government, and to correlate the Foundation's scientific research with those undertaken by individuals and by public and private research groups;

(G) to establish such special commissions as the Board my deem necessary; and

(H) to maintain a register of scientific and technical personnel in the United States.

(6) The emerging global economic, scientific, and technical environment challenges long-standing assumptions about domestic and international policy, requiring the Foundation to play a more proactive role in sustaining the competitive advantage of the United States through superior research capabilities.

(7) Commercial application of the results of Federal investment in basic and computing science is consistent with longstanding United States technology transfer policy for cybersecurity and other homeland security applications, because of the urgent needs of commercial, academic, and individual users as well as the Federal and State Governments.

SEC. 102. POLICY OBJECTIVES.

In allocating resources made available under this subtitle, the Foundation shall have the following policy objectives:

(1) To strengthen the Nation's lead in science and technology by—

(A) increasing the national investment in general scientific research and increasing investment in strategic areas vital to the national interest;

(B) balancing the Nation's research portfolio among the life sciences, mathematics, the physical sciences, computer and information science, geosciences, engineering, and social, behavioral, and economic sciences, all of which are important for the continued development of enabling technologies necessary for sustained international competitiveness;

(C) expanding the pool of scientists and engineers in the United States;

(D) modernizing the Nation's research infrastructure; and

(E) establishing and maintaining cooperative international relationships with premier research institutions.

(2) To increase overall workforce skills by—

(A) improving the quality of and access to mathematics and science education, particularly in kindergarten through grade 12; and

(B) expanding STEM training opportunities at institutions of higher education.

(3) To strengthen innovation by expanding the focus of competitiveness and innovation policy at the regional and local level.

SEC. 103. DEFINITIONS.

In this title:

(1) BOARD.—The term "Board" means the National Science Board.

(2) DIRECTOR.—The term "Director" means the Director of the Foundation.

(3) FOUNDATION.—The term "Foundation" means the National Science Foundation established under section 2 of the National Science Foundation Act of 1950 (42 U.S.C. 1861).

(4) INSTITUTION OF HIGHER EDUCATION.—The term "institution of higher education" has the meaning given such term in section 101(a) of the Higher Education Act of 1965 (20 U.S.C. 1001(a)).

(5) STATE.—The term "State" means one of the several States, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands,

Guam, American Samoa, the Commonwealth of the Northern Mariana Islands, or any other territory or possession of the United States.

(6) STEM.—The term "STEM" means science, technology, engineering, and mathematics.

(7) UNITED STATES.—The term "United States" means the several States, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, American Samoa, the Commonwealth of the Northern Mariana Islands, and any other territory or possession of the United States.

SEC. 104. GREATER ACCOUNTABILITY IN FEDERAL FUNDING FOR RESEARCH.

(a) STANDARD FOR AWARD OF GRANTS.—The Foundation may award Federal funding for basic research and education in the sciences through a new research grant or cooperative agreement only if an affirmative determination is made under subsection (b) and a written justification relating thereto is published under subsection (c).

(b) DETERMINATION.—A determination referred to in subsection (a) is a determination by the Director as to why the research grant or cooperative agreement—

(1) is in the national interest;

(2) is worthy of Federal funding; and

(3) achieves one or more of the following goals:

(A) Increased economic competitiveness of the United States.

(B) Advancement of the health and welfare of the American public.

(C) Development of a STEM workforce and increased public scientific literacy in the United States.

(D) Increased partnerships between academia and industry in the United States.

(E) Promotion of the progress of science in the United States.

(F) Support for the national defense.

(c) WRITTEN JUSTIFICATION.—Prior to any award of Federal funding described in subsection (a), the Foundation shall publish on its public website a written justification relating to the determination under subsection (b), along with the name of the employee or employees who made the determination and any other information about the research proposal the Director considers appropriate.

(d) IMPLEMENTATION.—A determination under subsection (b) shall be made after a research grant or cooperative agreement proposal has satisfied the Foundation's reviews for Merit and Broader Impacts.

(e) EMPLOYEE TRAINING.—The Director shall ensure that employees of the Foundation are aware of the restriction in subsection (a), and that the employees are trained in how to make a determination and provide written justification as required under this section.

(f) ANNUAL AUDITS.—The Director shall ensure that the standard in subsection (a) is properly applied by an annual audit of the research grants and cooperative agreements awarded by the Foundation for the previous fiscal year. The Director shall annually report the results of this audit to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate by February of the following fiscal year.

SEC. 105. SOCIAL AND BEHAVIORAL SCIENCES.

A directorate of the Foundation other than the Directorate for Social, Behavioral, and Economic Sciences may fund social and behavioral science research focused on its mission areas if such research is determined to be a higher priority than other research in that directorate's mission portfolio.

SEC. 106. OBLIGATION OF MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION FUNDS.

No funds may be obligated for Major Research Equipment and Facilities Construction for the Foundation

until 30 days after the report required with respect to each such fiscal year under section 14(a)(2) of the National Science Foundation Authorization Act of 2002 (42 U.S.C. 1862n–4(a)(2)) is transmitted to the Congress.

SEC. 107. GRADUATE STUDENT SUPPORT.

Section 510(b) of the America COMPETES Reauthorization Act of 2010 (42 U.S.C. 1869 note) is amended to read as follows:

"(b) EQUAL TREATMENT OF IGERT AND GRF.—

"(1) RATE OF FUNDING INCREASES.—For any fiscal year, the Director may only increase funding for the Foundation's Graduate Research Fellowship program (or any successor thereto) over the previous fiscal year's funding level at the same rate as a corresponding funding increase for the Foundation's Integrative Graduate Education and Research Traineeship program (or any successor thereto).

"(2) ESSENTIAL ELEMENTS OF IGERT.—The essential elements of the Foundation's Integrative Graduate Education and Research Traineeship program (or any successor thereto) shall be maintained, including—

"(A) collaborative research that transcends traditional disciplinary boundaries to solve large

and complex research problems of significant scientific and societal importance; and

"(B) providing students the opportunity to become leaders in the science and engineering of the future.".

SEC. 108. PROHIBITION.

The Foundation may not implement any STEM education program and activity changes proposed for the Foundation in the budget for fiscal year 2014 transmitted to Congress under section 1105(a) of title 31, United States Code.

SEC. 109. REVIEW OF EDUCATION PROGRAMS.

(a) IN GENERAL.—The Director shall review the education programs of the Foundation that are in operation as of the date of enactment of this Act to determine—

(1) whether any of such programs duplicate target groups, services provided, fields of focus, or objectives; and

(2) how those programs are being evaluated and assessed for outcome-oriented effectiveness.

(b) REPORT.—Not later than 1 year after the date of enactment of this Act, and annually thereafter as part of the annual budget submission to Congress, the Director shall complete a report on the review carried out under this section and shall submit the report to the Committee

on Science, Space, and Technology and the Committee on Appropriations of the House of Representatives, and to the Committee on Commerce, Science, and Transportation, the Committee on Health, Education, Labor, and Pensions, and the Committee on Appropriations of the Senate.

SEC. 110. RECOMPETITION OF AWARDS.

(a) FINDINGS.—The Congress finds that—

(1) the merit-reviewed competition of grant and award proposals is a hallmark of the Foundation grant and award making process;

(2) the majority of Foundation-funded multiuser facilities have transitioned to five-year cooperative agreements, and every five years the program officer responsible for the facility makes a recommendation to the National Science Board as to the renewal, recompetition, or termination of support for the facility; and

(3) requiring expiring awards to be recompeted follows from the conviction that competition is the process most likely to ensure the effective stewardship of Foundation funds for supporting research and education.

(b) RECOMPETITION.—The Director shall ensure that the system for recompetition of Maintenance and Oper-

ations of facilities, equipment and instrumentation is fair, consistent, and transparent and is applied in a manner that renews grants and awards in a timely manner. The Director shall periodically evaluate whether the criteria of the system are being applied in a manner that is transparent, reliable, and valid.

SEC. 111. SENSE OF THE CONGRESS REGARDING INDUSTRY INVESTMENT IN STEM EDUCATION.

It is the sense of Congress that—

(1) in order to bolster the STEM workforce pipeline, many industry sectors are becoming involved in K-12 initiatives and supporting undergraduate and graduate work in STEM subject areas and fields;

(2) partnerships with education providers, STEM focused competitions, and other opportunities have become important pieces of private sector efforts to strengthen the STEM workforce;

(3) understanding the work private sector organizations are undertaking in the STEM fields will inform the Federal Government's role in STEM education; and

(4) industry initiatives that support STEM education should be encouraged and supported by the Foundation.

SEC. 112. MISREPRESENTATION OF RESEARCH RESULTS.

(a) CERTIFICATION.—As a condition of receiving a research grant from the Foundation, a principal investigator shall sign a statement certifying that the findings and conclusions of any article authored by such principal investigator, using the results of the research conducted under the grant, that is published in a peer-reviewed publication will be based on an accurate and truthful representation of the research results.

(b) INVESTIGATION.—The Inspector General of the Foundation shall investigate suspected violations of a certification signed under subsection (a), and shall submit to the Director the results of such investigation, along with a recommendation with respect to whether a violation has occurred.

(c) DETERMINATION.—

(1) IN GENERAL.—Based on the results of the investigation conducted under subsection (b), the Director shall make a determination of whether the principal investigator knowingly misrepresented the results of research conducted with funding from the Foundation.

(2) PUBLICATION.—The Director shall make publicly available any determination made under paragraph (1), which shall include the name of the principal investigator.

(d) 10-YEAR BAN.—The Foundation may not, for a period of 10 years, provide a research grant or grant extension to a principal investigator who has knowingly misrepresented the results of research through—

(1) publication in a peer-reviewed publication;

(2) submission of data to the repository established under section 306(a)(1); or

(3) an application for a research grant or grant extension from the Foundation.

(e) APPEAL.—The Director shall establish a process by which a principal investigator may appeal a determination made under subsection (c) and a ban under subsection (c). If the Director determines that the determination made under subsection (c) was not correct, the Director shall make that correction publicly available. The Director may shorten the period of a ban under subsection (d) based on information provided in the appeal process under this subsection.

SEC. 113. CITATIONS SUPPORTING RESEARCH GRANT APPLICATIONS.

A peer-reviewed research grant proposal application to the Foundation may not include, with respect to a principal investigator, more than 5 citations to articles published by the principal investigator in a peer-reviewed publication. The Foundation may not consider more than 5

citations to such articles in determining whether to award such a research grant.

SEC. 114. RESEARCH GRANT CONDITIONS.

The Foundation shall establish procedures to ensure that—

(1) a research grant awarded by the Foundation to a principal investigator does not duplicate the scientific aims and scope of any grant awarded to the same investigator by another Federal agency;

(2) a principal investigator includes in any application for a research grant awarded by the Foundation a list of all Federal research funding received by the principal investigator, as well as any funding that is being requested as of that time;

(3) unpublished research results used to support a grant proposal made to the Foundation do not include any knowing misrepresentations of data;

(4) principal investigators who have received more than 5 years of Foundation funding at any point in their careers, other than graduate and postdoctoral traineeship awards, are only awarded additional research grants by the Foundation if they will be contributing substantial original research under the grant; and

(5) principal investigators who receive Foundation research grant funding under more than one grant at the same time have sufficient resources to conduct the proposed research under each of those grants appropriately under the terms of the grant.

SEC. 115. COMPUTING RESOURCES STUDY.

Not later than 1 year after the date of enactment of this Act, the Comptroller General shall transmit to the Congress a report detailing the results of a study on the use of computing resources funded by the Foundation at institutions of higher education. Such study shall assess—

(1) efficiencies that can be achieved by using shared computing resources for projects that have similar scientific computing requirements or projects where specialized software solutions could be shared with other practitioners in the scientific community;

(2) efficiencies that can be achieved by using shared hardware that can be cost effectively procured from cloud computing services;

(3) efficiencies that can be achieved by using shared software from an open source repository or platform; and

(4) cost savings that could be achieved by potential sharing of computing resources across all Foundation grants.

SEC. 116. ALTERNATIVE RESEARCH FUNDING MODELS.

(a) IN GENERAL.—The Director of the Office of Science and Technology Policy, in consultation with the Director of the Foundation, shall identify and conduct appropriate pilot programs to validate alternative research funding models, including scientific breakthrough prize programs.

(b) REPORT.—Not later than 1 year after the date of enactment of this Act, and annually thereafter as part of the annual budget submission to Congress, the Director of the Office of Science and Technology Policy shall transmit to the Congress a report on programs identified and conducted under subsection (a).

SEC. 117. REPEAL OF SUSTAINABLE CHEMISTRY BASIC RESEARCH PROGRAM.

Section 509 of the America COMPETES Reauthorization Act of 2010 (42 U.S.C. 1862p–3) is repealed.

SEC. 118. ROTATING PERSONNEL.

The Director shall ensure that the cost to the Foundation of employing individuals who are not permanent employees of the Foundation, including individuals employed pursuant to the Intergovernmental Personnel Act of 1970 (42 U.S.C. 4701 note), does not exceed the cost of employing permanent employees of the Foundation to perform the same functions.

SEC. 119. REPORT OF THE NSB TASK FORCE ON ADMINISTRATIVE BURDEN.

The National Science Board Task Force on Administrative Burden shall provide a report to Congress on its activities, findings, and recommendations within 90 days after the date of enactment of this Act.

SEC. 120. STUDY TO EVALUATE FEDERAL SCIENTIFIC FUNDING OF NON-UNITED STATES CITIZENS.

Not later than 18 months after the date of enactment of this Act, the Comptroller General shall transmit to the Congress a report detailing the results of a study, based on quantifiable metrics, on non-United States citizens, including students, postdoctoral researchers, research associates, and tenure-track faculty, funded by Federal science agencies that—

(1) evaluates their importance to the United States scientific enterprise;

(2) quantifies their economic value and impact to the United States; and

(3) assesses the Nation's economic opportunity cost of those who return to their home countries, in particular, quantifying contributions to the scientific, technological, industrial, and educational base of their final country of residence.

TITLE II—SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS

SEC. 201. FINDINGS; SENSE OF CONGRESS.

(a) FINDINGS.—Congress finds the following:

(1) According to the National Science Board's Science and Engineering Indicators, the science and engineering workforce has shown sustained growth for more than half a century and workers with science and engineering degrees tend to earn more than other comparable workers.

(2) According to the Program for International Student Assessment 2009 results, America lags behind many other nations when it comes to STEM education. American students rank 23d in science and 31st in math.

(3) Junior Achievement USA and ING recently found a decrease of 25 percent in the number of teens interested in STEM careers.

(4) According to a 2007 report from the Department of Labor, industries and firms dependent upon a strong science and math workforce pipeline have launched a variety of programs that target K-12 students and undergraduate and graduate students in STEM fields.

(5) While the Federal Government spends nearly $3 billion annually on STEM education related programs and activities, finding ways to improve STEM education activities beyond the scope of the Federal Government is key to the future technical and economic competitiveness of our Nation.

(b) SENSE OF CONGRESS.—It is the sense of Congress that—

(1) more must be done to ensure that Federal investment in STEM education is going to provide a substantial return;

(2) leveraging private and nonprofit investments in STEM education will be essential to strengthening the Federal STEM portfolio;

(3) strengthening the Federal STEM portfolio may result in program consolidations and terminations, but those changes should be made based on evidence with stakeholder input;

(4) the President's fiscal year 2014 budget proposal did not adequately explain proposed consolidations and cuts in the Federal STEM portfolio and did not utilize outside expertise in making those critical decisions, resulting in the need for Congress to limit the Administration's forward movement on that proposal; and

(5) coordinating STEM programs and activities across the Federal Government in order to limit duplication and engage stakeholders will strengthen the results of our Federal STEM education programs and activities and in turn strengthen the United States economy.

SEC. 202. STEM EDUCATION ADVISORY PANEL.

(a) ESTABLISHMENT.—The President shall establish or designate a STEM Education Advisory Panel that incorporates key stakeholders from the education and industry sectors within the President's Council of Advisors on Science and Technology.

(b) QUALIFICATIONS.—The Advisory Panel established or designated by the President under subsection (a) shall consist primarily of members from academic institutions and industry. Members of the Advisory Panel shall be qualified to provide advice and information on STEM education research, development, training, implementation, interventions, professional development, or workforce needs or concerns. In selecting or designating an Advisory Panel, the President may also seek and give consideration to recommendations from the Congress, industry, the scientific community (including the National Academy of Sciences, scientific professional societies, and academia),

State and local governments, and other appropriate organizations.

(c) DUTIES.—The Advisory Panel shall advise the President, the committee on STEM education established under the National Science and Technology Council, and the STEM Education Coordinating Office on matters relating to STEM education, and shall each year provide general guidance to every Federal agency with STEM education programs or activities, including in the preparation of requests for appropriations for activities related to STEM education. The Advisory Panel shall also assess—

(1) trends and developments in STEM education;

(2) progress made in STEM education;

(3) ways to encourage public private-partnerships to strengthen STEM education;

(4) ways to leverage private and nonprofit investments and utilize expertise resulting from STEM-related competitions to help build the STEM education and workforce pipeline;

(5) ways to incorporate workforce needs into Federal STEM education programs;

(6) the management, coordination, implementation, and activities of the STEM Education Coordinating Office and the committee on STEM edu-

cation established under the National Science and Technology Council; and

(7) whether societal and workforce concerns are adequately addressed by current Federal STEM education programs and activities.

(d) REPORTS.—The Advisory Panel shall report, not less frequently than once every 2 fiscal years, to the President and Congress on its assessments under subsection (c) and its recommendations for ways to improve Federal STEM education programs. The first report under this subsection shall be submitted within 1 year after the date of enactment of this Act.

(e) TRAVEL EXPENSES OF NON-FEDERAL MEMBERS.—Non-Federal members of the Advisory Panel, while attending meetings of the Advisory Panel or while otherwise serving at the request of the head of the Advisory Panel 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 Panel 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.

SEC. 203. COMMITTEE ON STEM EDUCATION.

Section 101 of the America COMPETES Reauthorization Act of 2010 (42 U.S.C. 6621) is amended to read as follows:

"SEC. 101. COORDINATION OF FEDERAL STEM EDUCATION.

"(a) MAINTENANCE OF THE COMMITTEE ON STEM EDUCATION.—The Director of the Office of Science and Technology Policy shall maintain the committee on STEM education established under the National Science and Technology Council, including the Office of Management and Budget, National Science Foundation, the Department of Energy, the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the National Institute of Standards and Technology, and all other Federal agencies with STEM education programs or activities.

"(b) RESPONSIBILITIES.—The committee described in subsection (a) shall develop recommendations for the STEM Education Coordinating office to consider. These recommendations shall focus on—

"(1) priority areas for Federal funding in STEM education, which may include student engagement, student retention, informal education, and teaching;

"(2) access to innovations and expertise derived from agency activities across the Federal Government;

"(3) significant links among K-12 education, higher education, and industry; and

"(4) the teaching of innovation and entrepreneurship as part of STEM education activities.

"(c) REPORT.—The Director of Office of Science and Technology Policy shall transmit a report annually to Congress at the time of the President's budget request describing the work, findings, and recommendations of the committee described in subsection (a).".

SEC. 204. STEM EDUCATION COORDINATING OFFICE.

(a) ESTABLISHMENT.—The Director of the Foundation shall establish within the Directorate for Education and Human Resources a STEM Education Coordinating Office, which shall have a Director.

(b) RESPONSIBILITIES.—The STEM Education Coordinating Office shall—

(1) coordinate the STEM education activities and programs of the Federal Government, including at the National Science Foundation, the Department of Energy, the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the National Institute of Standards

and Technology, the Environmental Protection Agency, and any other Federal agency with STEM education programs or activities;

(2) coordinate STEM education activities and programs with the Office of Management and Budget;

(3) review STEM education activities and programs to ensure they are not redundant, overlapping or duplicative of similar efforts within the Federal Government;

(4) periodically update and maintain the inventory of federally sponsored STEM education programs and activities conducted by the committee on STEM education established under the National Science and Technology Council, including documentation of assessments of the outcome-oriented effectiveness of such programs and activities and metrics used to evaluate those programs and activities;

(5) provide technical and administrative support to the committee on STEM education established under the National Science and Technology Council and the Advisory Panel established under section 202; and

(6) serve as the point of contact on Federal STEM education activities for government agencies, academia, industry, professional societies, State STEM education programs, interested citizen groups, and other STEM stakeholders to exchange technical and programmatic information.

(c) 3-YEAR STRATEGIC PLAN.—

(1) IN GENERAL.—The STEM Education Coordinating Office shall—

(A) at the time of the President's budget request, and every 3 years thereafter, in consultation with Federal agencies having STEM education programs or activities, the committee on STEM education established under the National Science and Technology Council, and the Advisory Panel established under section 202, update the Federal Government STEM education strategic plan established in May 2013 by the committee on STEM education established under the National Science and Technology Council; and

(B) coordinate the implementation of such plan through such agencies.

(2) CONTENTS.—The strategic plan shall—

(A) specify and prioritize annual and long-term objectives, including a description of the role of each agency in supporting programs and activities designed to achieve the objectives;

(B) specify the common metrics that will be used to assess progress toward achieving the objectives; and

(C) describe the approaches that will be taken by each agency to assess the effectiveness of its STEM education programs and activities.

(d) REPORT.—The Director of the STEM Education Coordinating Office shall transmit a report annually to Congress at the time of the President's budget request. The annual report shall include—

(1) a description of the STEM education programs and activities across the Federal Government for the previous and current fiscal years, and the proposed programs and activities under the President's budget request, of every Federal agency with STEM education programs or activities;

(2) an evaluation of the extent of duplication and fragmentation of the programs and activities described under paragraph (1), and any recommendations for consolidations or terminations to remedy those problems;

(3) a description of ways the Federal Government is leveraging private and nonprofit investments and utilizing expertise resulting from STEM-related competitions to build the STEM education workforce pipeline; and

(4) a description of the progress made in carrying out the 3-year strategic plan, including a description of the outcome of any program assessments completed in the previous year, and any changes made to that plan since the previous annual report.

(e) RESPONSIBILITIES OF NSF.—The Director of the National Science Foundation shall encourage and monitor the efforts of the STEM Education Coordinating Office to ensure that the strategic plan under subsection (c) is implemented effectively and that the objectives of the strategic plan are met.

TITLE III—OFFICE OF SCIENCE AND TECHNOLOGY POLICY

SEC. 301. REGULATORY EFFICIENCY.

(a) IN GENERAL.—The Director of the Office of Science and Technology Policy shall establish a working group under the authority of the National Science and Technology Council, to include the Office of Management and Budget The working group shall be responsible for reviewing Federal regulations affecting research and re-

search universities and making recommendations on how to—

(1) harmonize, streamline, and eliminate duplicative Federal regulations and reporting requirements; and

(2) minimize the regulatory burden on United States institutions of higher education performing federally funded research while maintaining accountability for Federal tax dollars.

(b) REPORT.—Not later than 1 year after the date of enactment of this Act, and annually thereafter for 3 years, the Director shall report to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate on what steps have been taken to carry out the recommendations of the working group established under subsection (a).

SEC. 302. PUBLIC ACCESS TO RESEARCH ARTICLES AND DATA.

(a) PUBLIC ACCESS POLICIES AND PROCEDURES.—

(1) ESTABLISHMENT.—Not later than 18 months after the date of enactment of this Act, the National Science and Technology Council, in consultation with the Federal science agencies, shall establish policies, procedures, and standards for the

Federal science agencies to enable archiving and retrieving covered material in digital form for public availability in perpetuity.

(2) REQUIREMENTS.—Such policies, procedures, and standards shall—

(A) use existing information technology infrastructure to the extent practicable, including infrastructure of the National Center for Biotechnology Information, the National Center for Atmospheric Research, and the private sector that facilitate public access to covered material;

(B) minimize the cost of storing, archiving, and retrieving articles and data;

(C) minimize the burden of providing articles and data archiving, and of retrieving articles and data; and

(D) facilitate maximum access to covered material by clearly linking articles and data.

(3) STAKEHOLDER INPUT.—In developing policies, procedures, and standards under paragraph (1), the National Science and Technology Council shall use a transparent process for soliciting views from stakeholders, including federally funded researchers, institutions of higher education, libraries,

publishers, users of federally funded research results, and civil science society groups.

(b) GRANT RECIPIENT REQUIREMENTS.—A recipient of a research grant made by a Federal science agency shall make, or enable others on their behalf to make, covered material associated with such grant available consistent with the policies, procedures, and standards established under subsection (a).

(c) FEDERAL SCIENCE AGENCY REQUIREMENTS.—In implementing the policies, procedure, and standards established pursuant to subsection (a), each Federal science agency shall provide for—

(1) submission of, or linking to, an electronic version of covered material by or on behalf of recipients of research grants made by the agency;

(2) free online public access to such covered material—

(A) in the case of a research article, not later than 24 months after publication of the research article in a peer-reviewed publication; and

(B) in the case of data used to support the findings and conclusions of such article, not later than 60 days after the article is published in a peer-reviewed publication;

(3) a searchable archive for long-term preservation and productive use of covered material;

(4) production of an online bibliography of all research papers that are publicly accessible in its repository, with each entry linking to the corresponding free online full text; and

(5) inclusion in its repository of all data that is used directly or indirectly by the agency to support the promulgation of a Federal regulation.

(d) REVIEW.—At least once every 5 years, the National Science and Technology Council shall review the policies, procedures, and standards established under subsection (a) and revise such policies, procedures, and standards as appropriate.

(e) EXTENSION.—Each Federal science agency may extend the time period specified in subsection (c)(2) by 6 to 12 months, in consultation with the stakeholders described in subsection (a)(3), if the agency head, or designee, determines that the scientific field and stakeholders described in subsection (a)(3) will be uniquely harmed without such extension.

(f) PATENT OR COPYRIGHT LAW.—Except as provided in this section, nothing in this section shall be construed to affect any right under the provisions of title 17 or title 35, United States Code.

(g) DEFINITIONS.—For purposes of this section:

(1) COVERED MATERIAL.—The term "covered material" means—

(A) a manuscript of an article accepted for publication in a peer-reviewed publication that results from research funded in whole or in majority part by a grant from a Federal science agency; and

(B) data that was used to support the findings and conclusions of such article, except for data that is protected from disclosure under section 552 of title 5, United States Code.

(2) DATA.—The term "data" includes raw data, computer code, and algorithms, but does not include—

(A) commercially available software used to analyze the data or code;

(B) preliminary work and analyses;

(C) drafts of scientific papers not accepted or intended for publication; or

(D) plans for future research.

(3) FEDERAL SCIENCE AGENCY.—The term "Federal science agency" means an Executive agency, as defined in section 105 of title 5, United States

Code, that is a member of the National Science and Technology Council.

(4) PEER-REVIEWED PUBLICATION.—The term "peer-reviewed publication" means a publication for which articles are assigned to at least 1 external viewer to assess the validity of the articles' scientific findings and conclusions.

TITLE IV—INNOVATION AND TECHNOLOGY TRANSFER

Subtitle A—NIST Reauthorization

SEC. 401. STANDARDS AND CONFORMITY ASSESSMENT AND OTHER TRANSACTION AUTHORITY.

Section 2 of the National Institute of Standards and Technology Act (15 U.S.C. 272) is amended—

(1) in subsection (b)—

(A) in the matter preceding paragraph (1), by striking "authorized to take" and inserting "authorized to serve as the President's principal adviser on standards policy pertaining to the Nation's technological competitiveness and innovation ability and to take";

(B) in paragraph (3), by striking "compare standards" and all that follows through "Federal Government" and inserting "facilitate

standards-related information sharing and cooperation between Federal agencies";

(C) by striking paragraph (4) and inserting the following:

"(4) to enter into and perform such contracts, cooperative research and development arrangements, grants, cooperative agreements, leases, or other transactions as may be necessary in the conduct of its work and on such terms as it may consider appropriate in furtherance of the purposes of this Act;"; and

(D) in paragraph (13), by striking "Federal, State, and local" and all that follows through "private sector" and inserting "technical standards activities and conformity assessment activities of Federal, State, and local governments with private sector"; and

(2) in subsection (c)—

(A) in paragraph (21), by striking "and" after the semicolon;

(B) by redesignating paragraph (22) as paragraph (25); and

(C) by inserting after paragraph (21) the following:

"(22) participate in and support scientific and technical conferences;

"(23) collect and retain fees for conferences and use such fees to pay for expenses of such conferences, notwithstanding section 1345 of title 31, United States Code;

"(24) perform pre-competitive measurement science and technology research in partnership with institutions of higher education and industry to promote United States industrial competitiveness; and".

SEC. 402. VISITING COMMITTEE ON ADVANCED TECHNOLOGY.

Section 10 of the National Institute of Standards and Technology Act (15 U.S.C. 278) is amended—

(1) in subsection (a)—

(A) by striking "15 members" and inserting "not fewer than 9 members";

(B) by striking "at least 10" and inserting "at least three-fifths"; and

(C) by adding at the end the following: "The Committee may consult with the National Research Council in making recommendations regarding general policy for the Institute."; and

(2) in subsection (h)(1), by striking ", including the Program established under section 28,".

SEC. 403. POLICE AND SECURITY AUTHORITY.

Section 15 of the National Institute of Standards and Technology Act (15 U.S.C. 278e) is amended—

(1) by striking "of the Government; and" and inserting "of the Government;"; and

(2) by striking "United States Code." and inserting "United States Code; and (i) for the protection of Institute buildings and other plant facilities, equipment, and property, and of employees, associates, visitors, or other persons located therein or associated therewith, notwithstanding any other provision of law, the direction of such of the officers and employees of the Institute as the Secretary considers necessary in the public interest to carry firearms while in the conduct of their official duties, and the authorization of employees of contractors and subcontractors of the Institute who are engaged in the protection of property owned by the United States, and located at facilities owned by, leased by, used by, or under the control of the United States, to carry firearms while in the conduct of their official duties, and, under regulations prescribed by the Secretary and approved by the Attorney General, the authorization of officers and employees of the Institute and of its contractors and subcontractors authorized to carry firearms to arrest without warrant

for any offense against the United States committed in their presence, or for any felony cognizable under the laws of the United States if they have reasonable grounds to believe that the person to be arrested has committed or is committing such felony, provided that such authority to make arrests may be exercised only while guarding and protecting buildings and other plant facilities, equipment, and property owned or leased by, used by, or under the control of the United States under the administration and control of the Secretary".

SEC. 404. INTERNATIONAL ACTIVITIES.

Section 17(a) of the National Institute of Standards and Technology Act (15 U.S.C. 278g(a)) is amended—

(1) by striking "financial assistance," and inserting "financial and logistical assistance,"; and

(2) by adding at the end the following: "Financial and logistical assistance may include transportation to and from the Institute of foreign dignitaries and representatives of foreign national metrology institutes."

SEC. 405. EDUCATION AND OUTREACH.

(a) IN GENERAL.—The National Institute of Standards and Technology Act is (15 U.S.C. 271 et seq.) is

amended by striking sections 18, 19, and 19A and inserting the following:

"SEC. 18. EDUCATION AND OUTREACH.

"(a) IN GENERAL.—The Director may support, promote, and coordinate activities and efforts to enhance public awareness and understanding of measurement sciences, standards, and technology by the general public, industry, and academia in support of the Institute's mission.

"(b) RESEARCH FELLOWSHIPS.—

"(1) IN GENERAL.—The Director may award research fellowships and other forms of financial and logistical assistance, including direct stipend awards, to—

"(A) students at institutions of higher education within the United States who show promise as present or future contributors to the mission of the Institute; and

"(B) United States citizens for research and technical activities of the Institute.

"(2) SELECTION.—The Director shall select persons to receive such fellowships and assistance on the basis of ability and of the relevance of the proposed work to the mission and programs of the Institute.

"(3) DEFINITION.—For the purposes of this subsection, financial and logistical assistance includes, notwithstanding section 1345 of title 31, United States Code, or any contrary provision of law, temporary housing and transportation to and from the Institute facilities.

"(c) POST-DOCTORAL FELLOWSHIP PROGRAM.—The Director shall establish and conduct a post-doctoral fellowship program, subject to the availability of appropriations, that shall include not less than 20 nor more than 120 new fellows per fiscal year. In evaluating applications for fellowships under this subsection, the Director shall give consideration to the goal of promoting the participation of underrepresented minorities in research areas supported by the Institute.".

(b) PROHIBITION.—

(1) IN GENERAL.—The National Institute of Standards and Technology may not implement any STEM education program and activity changes proposed for the Institute in the budget for fiscal year 2014 transmitted to Congress under section 1105(a) of title 31, United States Code.

(2) DEFINITION.—The term "STEM" means science, technology, engineering, and mathematics.

SEC. 406. PROGRAMMATIC PLANNING REPORT.

Section 23(d) of the National Institute of Standards and Technology Act (15 U.S.C. 278i(d)) is amended by adding at the end the following: "The 3-year programmatic planning document shall also describe how the Director is addressing recommendations from the Visiting Committee on Advanced Technology established under section 10.".

SEC. 407. ASSESSMENTS BY THE NATIONAL RESEARCH COUNCIL.

Section 24 of the National Institute of Standards and Technology Act (15 U.S.C. 278j) is amended to read as follows:

"SEC. 24. ASSESSMENTS BY THE NATIONAL RESEARCH COUNCIL.

"(a) IN GENERAL.—The Institute shall contract with the National Research Council to perform and report on assessments of the technical quality and impact of the work conducted at Institute laboratories.

"(b) SCHEDULE.—Individual assessments shall be completed biennially by conducting annual assessments of at least 3 laboratories.

"(c) SUMMARY REPORT.—In the second year of each biennial period under subsection (b), the Institute shall contract with the National Research Council to prepare

a report that summarizes the findings common across the individual assessment reports.

"(d) ADDITIONAL ASSESSMENTS.—The Institute, at the discretion of the Director, also may contract with the National Research Council to conduct additional assessments of Institute programs and projects that involve collaboration across the Institute laboratories and centers and assessments of selected scientific and technical topics.

"(e) CONSULTATION WITH VISITING COMMITTEE ON ADVANCED TECHNOLOGY.—The National Research Council may consult with the Visiting Committee on Advanced Technology established under section 10 in performing the assessments under this section.

"(f) REPORTS.—Not later than 30 days after the completion of each assessment, the Institute shall transmit the report on such assessment to the Committee on Science, Space, and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate.".

SEC. 408. HOLLINGS MANUFACTURING EXTENSION PARTNERSHIP.

Section 25 of the National Institute of Standards and Technology Act (15 U.S.C. 278k) is amended to read as follows:

"SEC. 25. HOLLINGS MANUFACTURING EXTENSION PARTNERSHIP.

"(a) ESTABLISHMENT AND PURPOSE.—

"(1) IN GENERAL.—The Secretary, through the Director and, if appropriate, through other officials, shall provide assistance for the creation and support of manufacturing extension centers, to be known as the 'Hollings Manufacturing Extension Centers', for the transfer of manufacturing technology and best business practices (in this Act referred to as the 'Centers'). The program under this section shall be known as the 'Hollings Manufacturing Extension Partnership'.

"(2) AFFILIATIONS.—Such Centers shall be affiliated with any United States-based public or nonprofit institution or organization, or group thereof, that applies for and is awarded financial assistance under this section.

"(3) OBJECTIVE.—The objective of the Centers is to enhance competitiveness, productivity, and technological performance in United States manufacturing through—

"(A) the transfer of manufacturing technology and techniques developed at the Institute to Centers and, through them, to manufacturing companies throughout the United States;

"(B) the participation of individuals from industry, institutions of higher education, State governments, other Federal agencies, and, when appropriate, the Institute in cooperative technology transfer activities;

"(C) efforts to make new manufacturing technology and processes usable by United States-based small and medium-sized companies;

"(D) the active dissemination of scientific, engineering, technical, and management information about manufacturing to industrial firms, including small and medium-sized manufacturing companies;

"(E) the utilization, when appropriate, of the expertise and capability that exists in Federal laboratories other than the Institute; and

"(F) the provision to community colleges of information about the job skills needed in small and medium-sized manufacturing businesses in the regions they serve.

"(b) ACTIVITIES.—The activities of the Centers shall include—

"(1) the establishment of automated manufacturing systems and other advanced production tech-

nologies, based on Institute-supported research, for the purpose of demonstrations and technology transfer; and

"(2) the active transfer and dissemination of research findings and Center expertise to a wide range of companies and enterprises, particularly small and medium-sized manufacturers.

"(c) OPERATIONS.—

"(1) FINANCIAL SUPPORT.—The Secretary may provide financial support to any Center created under subsection (a) for a period not to exceed 6 years. The Secretary may not provide to a Center more than 50 percent of the capital and annual operating and maintenance funds required to create and maintain such Center.

"(2) REGULATIONS.—The Secretary shall implement, review, and update the sections of the Code of Federal Regulations related to this section at least once every 3 years.

"(3) APPLICATION.—

"(A) IN GENERAL.—Any nonprofit institution, or consortium thereof, may submit to the Secretary an application for financial support under this section, in accordance with the procedures established by the Secretary.

"(B) COST-SHARING.—In order to receive assistance under this section, an applicant for financial assistance under subparagraph (A) shall provide adequate assurances that non-Federal assets obtained from the applicant and the applicant's partnering organizations will be used as a funding source to meet not less than 50 percent of the costs incurred for the first 3 years and an increasing share for each of the last 3 years. For purposes of the preceding sentence, the costs incurred means the costs incurred in connection with the activities undertaken to improve the competitiveness, management, productivity, and technological performance of small and medium-sized manufacturing companies.

"(C) AGREEMENTS WITH OTHER ENTITIES.—In meeting the 50 percent requirement, it is anticipated that a Center will enter into agreements with other entities such as private industry, institutions of higher education, and State governments to accomplish programmatic objectives and access new and existing resources that will further the impact of the Federal in-

vestment made on behalf of small and medium-sized manufacturing companies.

"(D) LEGAL RIGHTS.—Each applicant under subparagraph (A) shall also submit a proposal for the allocation of the legal rights associated with any invention which may result from the proposed Center's activities.

"(4) MERIT REVIEW.—The Secretary shall subject each such application to merit review. In making a decision whether to approve such application and provide financial support under this section, the Secretary shall consider, at a minimum, the following:

"(A) The merits of the application, particularly those portions of the application regarding technology transfer, training and education, and adaptation of manufacturing technologies to the needs of particular industrial sectors.

"(B) The quality of service to be provided.

"(C) Geographical diversity and extent of service area.

"(D) The percentage of funding and amount of in-kind commitment from other sources.

"(5) EVALUATION.—

"(A) IN GENERAL.—Each Center that receives financial assistance under this section shall be evaluated during its third year of operation by an evaluation panel appointed by the Secretary.

"(B) COMPOSITION.—Each such evaluation panel shall be composed of private experts, none of whom shall be connected with the involved Center, and Federal officials.

"(C) CHAIR.—An official of the Institute shall chair the panel.

"(D) PERFORMANCE MEASUREMENT.—Each evaluation panel shall measure the involved Center's performance against the objectives specified in this section.

"(E) POSITIVE EVALUATION.—If the evaluation is positive, the Secretary may provide continued funding through the sixth year at declining levels.

"(F) PROBATION.—The Secretary shall not provide funding for the fourth through the sixth years of a Center's operation unless the evaluation is positive. A Center that has not received a positive evaluation by the evaluation

panel shall be notified by the panel of the deficiencies in its performance and shall be placed on probation for one year, after which time the panel shall reevaluate the Center. If the Center has not addressed the deficiencies identified by the panel, or shown a significant improvement in its performance, the Director shall conduct a new competition to select an operator for the Center or may close the Center.

"(G) ADDITIONAL FINANCIAL SUPPORT.—After the sixth year, a Center may receive additional financial support under this section if it has received a positive evaluation through an independent review, under procedures established by the Institute. Such an independent review shall be required at least every two years after the sixth year of operation. Funding received for a fiscal year under this section after the sixth year of operation shall not exceed one third of the capital and annual operating and maintenance costs of the Center under the program.

"(6) PATENT RIGHTS.—The provisions of chapter 18 of title 35, United States Code, shall apply, to the extent not inconsistent with this section, to

the promotion of technology from research by Centers under this section except for contracts for such specific technology extension or transfer services as may be specified by statute or by the Director.

"(7) PROTECTION OF CENTER CLIENT CONFIDENTIAL INFORMATION.—Section 552 of title 5, United States Code, shall apply to the following information obtained by the Federal Government on a confidential basis in connection with the activities of any participant involved in the Hollings Manufacturing Extension Partnership:

"(A) Information on the business operation of any participant in a Hollings Manufacturing Extension Partnership program or of a client of a Center.

"(B) Trade secrets possessed by any client of a Center.

"(8) ADVISORY BOARDS.—Each Center's advisory boards shall institute a conflict of interest policy, approved by the Director, that ensures the Board represents local small and medium-sized manufacturers in the Center's region. Board Members may not be current clients of the Center they serve, may not serve as a vendor or provide services to the

Center, nor may they serve on more than one Center's oversight board simultaneously.

"(d) ACCEPTANCE OF FUNDS.—

"(1) IN GENERAL.—In addition to such sums as may be appropriated to the Secretary and Director to operate the Hollings Manufacturing Extension Partnership, the Secretary and Director also may accept funds from other Federal departments and agencies and, under section 2(c)(7), from the private sector for the purpose of strengthening United States manufacturing.

"(2) ALLOCATION OF FUNDS.—

"(A) FUNDS ACCEPTED FROM OTHER FEDERAL DEPARTMENTS OR AGENCIES.—The Director shall determine whether funds accepted from other Federal departments or agencies shall be counted in the calculation of the Federal share of capital and annual operating and maintenance costs under subsection (c).

"(B) FUNDS ACCEPTED FROM THE PRIVATE SECTOR.—Funds accepted from the private sector under section 2(c)(7), if allocated to a Center, may not be considered in the calculation of the Federal share under subsection (c) of this section.

"(e) MEP ADVISORY BOARD.—

"(1) ESTABLISHMENT.—There is established within the Institute a Manufacturing Extension Partnership Advisory Board (in this subsection referred to as the 'MEP Advisory Board').

"(2) MEMBERSHIP.—

"(A) IN GENERAL.—The MEP Advisory Board shall consist of not fewer than 10 members broadly representative of stakeholders, to be appointed by the Director. At least 2 members shall be employed by or on an advisory board for the Centers, and at least 5 other members shall be from United States small businesses in the manufacturing sector. No member shall be an employee of the Federal Government.

"(B) TERM.—Except as provided in subparagraph (C) or (D), the term of office of each member of the MEP Advisory Board shall be 3 years.

"(C) VACANCIES.—Any member appointed to fill a vacancy occurring prior to the expiration of the term for which his predecessor was appointed shall be appointed for the remainder of such term.

"(D) SERVING CONSECUTIVE TERMS.—Any person who has completed two consecutive full terms of service on the MEP Advisory Board shall thereafter be ineligible for appointment during the one-year period following the expiration of the second such term.

"(3) MEETINGS.—The MEP Advisory Board shall meet not less than 2 times annually and shall provide to the Director—

"(A) advice on Hollings Manufacturing Extension Partnership programs, plans, and policies;

"(B) assessments of the soundness of Hollings Manufacturing Extension Partnership plans and strategies; and

"(C) assessments of current performance against Hollings Manufacturing Extension Partnership program plans.

"(4) FEDERAL ADVISORY COMMITTEE ACT APPLICABILITY.—

"(A) IN GENERAL.—In discharging its duties under this subsection, the MEP Advisory Board shall function solely in an advisory capacity, in accordance with the Federal Advisory Committee Act.

"(B) EXCEPTION.—Section 14 of the Federal Advisory Committee Act shall not apply to the MEP Advisory Board.

"(5) REPORT.—The MEP Advisory Board shall transmit an annual report to the Secretary for transmittal to Congress within 30 days after the submission to Congress of the President's annual budget request in each year. Such report shall address the status of the program established pursuant to this section and comment on the relevant sections of the programmatic planning document and updates thereto transmitted to Congress by the Director under subsections (c) and (d) of section 23.

"(f) COMPETITIVE GRANT PROGRAM.—

"(1) ESTABLISHMENT.—The Director shall establish, within the Hollings Manufacturing Extension Partnership, a program of competitive awards among participants described in paragraph (2) for the purposes described in paragraph (3).

"(2) PARTICIPANTS.—Participants receiving awards under this subsection shall be the Centers, or a consortium of such Centers.

"(3) PURPOSE.—The purpose of the program under this subsection is to add capabilities to the Hollings Manufacturing Extension Partnership, in-

cluding the development of projects to solve new or emerging manufacturing problems as determined by the Director, in consultation with the Director of the Hollings Manufacturing Extension Partnership program, the MEP Advisory Board, and small and medium-sized manufacturers. One or more themes for the competition may be identified, which may vary from year to year, depending on the needs of manufacturers and the success of previous competitions. Centers may be reimbursed for costs incurred under the program.

"(4) APPLICATIONS.—Applications for awards under this subsection shall be submitted in such manner, at such time, and containing such information as the Director shall require, in consultation with the MEP Advisory Board.

"(5) SELECTION.—Awards under this subsection shall be peer reviewed and competitively awarded. The Director shall endeavor to have broad geographic diversity among selected proposals. The Director shall select proposals to receive awards that will—

"(A) improve the competitiveness of industries in the region in which the Center or Centers are located;

"(B) create jobs or train newly hired employees; and

"(C) promote the transfer and commercialization of research and technology from institutions of higher education, national laboratories, and nonprofit research institutes.

"(6) PROGRAM CONTRIBUTION.—Recipients of awards under this subsection shall not be required to provide a matching contribution.

"(7) GLOBAL MARKETPLACE PROJECTS.—In making awards under this subsection, the Director, in consultation with the MEP Advisory Board and the Secretary, may take into consideration whether an application has significant potential for enhancing the competitiveness of small and medium-sized United States manufacturers in the global marketplace.

"(8) DURATION.—Awards under this subsection shall last no longer than 3 years.

"(g) EVALUATION OF OBSTACLES UNIQUE TO SMALL MANUFACTURERS.—The Director shall—

"(1) evaluate obstacles that are unique to small manufacturers that prevent such manufacturers from effectively competing in the global market;

"(2) implement a comprehensive plan to train the Centers to address such obstacles; and

"(3) facilitate improved communication between the Centers to assist such manufacturers in implementing appropriate, targeted solutions to such obstacles.

"(h) COMMUNITY COLLEGE DEFINED.—In this section, the term 'community college' means an institution of higher education (as defined under section 101(a) of the Higher Education Act of 1965 (20 U.S.C. 1001(a))) at which the highest degree that is predominately awarded to students is an associate's degree."

SEC. 409. ELIMINATION OF OBSOLETE REPORTS.

(a) ENTERPRISE INTEGRATION STANDARDIZATION AND IMPLEMENTATION ACTIVITIES REPORT.—Section 3 of the Enterprise Integration Act of 2002 (15 U.S.C. 278g-5) is amended—

(1) by striking subsection (c); and

(2) by redesignating subsections (d) and (e) as subsections (c) and (d), respectively.

(b) TIP REPORTS.—Section 28 of the National Institute of Standards and Technology Act (15 U.S.C. 278n) is amended—

(1) by striking subsection (g); and

(2) in subsection (k), by striking paragraph (5).

SEC. 410. MODIFICATIONS TO GRANTS AND COOPERATIVE AGREEMENTS.

Section 8(a) of the Stevenson-Wydler Technology Innovation Act of 1980 (15 U.S.C. 3706(a)) is amended by striking "The total amount of any such grant or cooperative agreement may not exceed 75 percent of the total cost of the program.".

Subtitle B—Innovative Approaches to Technology Transfer

SEC. 421. INNOVATIVE APPROACHES TO TECHNOLOGY TRANSFER.

Section 9(jj) of the Small Business Act (15 U.S.C. 638(jj)) is amended to read as follows:

"(jj) INNOVATIVE APPROACHES TO TECHNOLOGY TRANSFER.—

"(1) GRANT PROGRAM.—

"(A) IN GENERAL.—Each Federal agency required by subsection (n) to establish an STTR program shall carry out a grant program to support innovative approaches to technology transfer at institutions of higher education (as defined in section 101(a) of the Higher Education Act of 1965 (20 U.S.C. 1001(a)), nonprofit research institutions and Federal laboratories in order to accelerate the commercialization of federally funded research and technology

by small business concerns, including new businesses.

"(B) AWARDING OF GRANTS AND AWARDS.—

"(i) IN GENERAL.—Each Federal agency required by subparagraph (A) to participate in this program, shall award, through a competitive, merit-based process, grants, in the amounts listed in subparagraph (C) to institutions of higher education, technology transfer organizations that facilitate the commercialization of technologies developed by one or more such institutions of higher education, Federal laboratories, other public and private nonprofit entities, and consortia thereof, for initiatives that help identify high-quality, commercially viable federally funded research and technologies and to facilitate and accelerate their transfer into the marketplace.

"(ii) USE OF FUNDS.—Activities supported by grants under this subsection may include—

"(I) providing early-stage proof of concept funding for translational research;

"(II) identifying research and technologies at recipient institutions that have the potential for accelerated commercialization;

"(III) technology maturation funding to support activities such as prototype construction, experiment analysis, product comparison, and collecting performance data;

"(IV) technical validations, market research, clarifying intellectual property rights position and strategy, and investigating commercial and business opportunities; and

"(V) programs to provide advice, mentoring, entrepreneurial education, project management, and technology and business development expertise to innovators and recipients of technology transfer licenses to maximize commercialization potential.

"(iii) SELECTION PROCESS AND APPLICATIONS.—Qualifying institutions seeking a grant under this subsection shall submit an application to a Federal agency required by subparagraph (A) to participate in this program at such time, in such manner, and containing such information as the agency may require. The application shall include, at a minimum—

"(I) a description of innovative approaches to technology transfer, technology development, and commercial readiness that have the potential to increase or accelerate technology transfer outcomes and can be adopted by other qualifying institutions, or a demonstration of proven technology transfer and commercialization strategies, or a plan to implement proven technology transfer and commercialization strategies, that can achieve greater commercialization of federally funded research and technologies with program funding;

"(II) a description of how the qualifying institution will contribute to local and regional economic development efforts; and

"(III) a plan for sustainability beyond the duration of the funding award.

"(iv) PROGRAM OVERSIGHT BOARDS.—

"(I) IN GENERAL.—Successful proposals shall include a plan to assemble a Program Oversight Board, the members of which shall have technical, scientific, or business expertise and shall be drawn from industry, start-up companies, venture capital, technical enterprises, financial institutions, and business development organizations.

"(II) PROGRAM OVERSIGHT BOARDS RESPONSIBILITIES.—Program Oversight Boards shall—

"(aa) establish award programs for individual projects;

"(bb) provide rigorous evaluation of project applications;

"(cc) determine which projects should receive awards, in accordance with guidelines established under subparagraph (C)(ii);

"(dd) establish milestones and associated award amounts for projects that reach milestones;

"(ee) determine whether awarded projects are reaching milestones; and

"(ff) develop a process to reallocate outstanding award amounts from projects that are not reaching milestones to other projects with more potential.

"(C) GRANT AND AWARD AMOUNTS.—

"(i) GRANT AMOUNTS.—Each Federal agency required by subparagraph (A) to carry out a grant program may make grants to a qualifying institution for up to $1,000,000 per year for up to 3 years.

"(ii) AWARD AMOUNTS.—Each qualifying institution that receives a grant under subparagraph (B) shall provide awards for individual projects of not more than $150,000, to be provided in phased amounts, based on reaching the milestones established by the qualifying institution's Program Oversight Board.

"(D) AUTHORIZED EXPENDITURES FOR INNOVATIVE APPROACHES TO TECHNOLOGY TRANSFER GRANT PROGRAM.—

"(i) PERCENTAGE.—The percentage of the extramural budget each Federal agency required by subsection (n) to establish an STTR program shall expend on the Innovative Approaches to Technology Transfer Grant Program shall be—

"(I) 0.05 percent for each of fiscal years 2014 and 2015; and

"(II) 0.1 percent for each of fiscal years 2016 and 2017.

"(ii) TREATMENT OF EXPENDITURES.—Any portion of the extramural budget expended by a Federal agency on the Innovative Approaches to Technology

Transfer Grant Program shall apply towards the agency's expenditure requirements under subsection (n).

"(2) PROGRAM EVALUATION AND DATA COLLECTION AND DISSEMINATION.—

"(A) EVALUATION PLAN AND DATA COLLECTION.—Each Federal agency required by paragraph (1)(A) to establish an Innovative Approaches to Technology Transfer Grant Program shall develop a program evaluation plan and collect annually such information from grantees as is necessary to assess the Program. Program evaluation plans shall require the collection of data aimed at identifying outcomes resulting from the transfer of technology with assistance from the Innovative Approaches to Technology Transfer Grant Program, such as—

"(i) specific follow-on funding identified or obtained, including follow-on funding sources, such as Federal sources or private sources;

"(ii) number of projects which result in a license to a start-up company or an established company with sufficient resources for effective commercialization

within 5 years of receiving an award under paragraph (1);

"(iii) invention disclosures and patents;

"(iv) number of projects supported by qualifying institutions receiving a grant under paragraph (1) that secure Phase I or Phase II SBIR or STTR awards;

"(v) available information on revenue, sales or other measures of products that have been commercialized as a result of projects awarded under paragraph (1);

"(vi) number and location of jobs created resulting from projects awarded under paragraph (1); and

"(vii) other data as deemed appropriate by a Federal agency required by this subparagraph to develop a program evaluation plan.

"(B) EVALUATIVE REPORT TO CONGRESS.—The head of each Federal agency that participates in the Innovative Approaches to Technology Transfer Grant Program shall submit to the Committee on Science, Space, and Technology and the Committee on Small Busi-

ness of the House of Representatives and the Committee on Small Business and Entrepreneurship of the Senate an evaluative report regarding the activities of the program. The report shall include—

"(i) a detailed description of the implementation of the program;

"(ii) a detailed description of the grantee selection process;

"(iii) an accounting of the funds used in the program; and

"(iv) a summary of the data collected under subparagraph (A).

"(C) DATA DISSEMINATION.—For the purposes of program transparency and dissemination of best practices, the Administrator shall include on the public database under subsection (k)(1) information on the Innovative Approaches to Technology Transfer Grant Program, including—

"(i) the program evaluation plan required under subparagraph (A);

"(ii) a list of recipients of awards under paragraph (1); and

"(iii) information on the use of grants under paragraph (1) by recipient institutions.".

TITLE V—NETWORKING AND INFORMATION TECHNOLOGY RESEARCH AND DEVELOPMENT

SEC. 501. SHORT TITLE.

This title may be cited as the "Advancing America's Networking and Information Technology Research and Development Act of 2013".

SEC. 502. PROGRAM PLANNING AND COORDINATION.

(a) PERIODIC REVIEWS.—Section 101 of the High-Performance Computing Act of 1991 (15 U.S.C. 5511) is amended by adding at the end the following new subsection:

"(d) PERIODIC REVIEWS.—The agencies identified in subsection (a)(3)(B) shall—

"(1) periodically assess the contents and funding levels of the Program Component Areas and restructure the Program when warranted, taking into consideration any relevant recommendations of the advisory committee established under subsection (b); and

"(2) ensure that the Program includes large-scale, long-term, interdisciplinary research and development activities, including activities described in section 104.".

(b) DEVELOPMENT OF STRATEGIC PLAN.—Section 101 of such Act (15 U.S.C. 5511) is amended further by adding after subsection (d), as added by subsection (a) of this Act, the following new subsection:

"(e) STRATEGIC PLAN.—

"(1) IN GENERAL.—The agencies identified in subsection (a)(3)(B), working through the National Science and Technology Council and with the assistance of the National Coordination Office described under section 102, shall develop, within 12 months after the date of enactment of the Advancing America's Networking and Information Technology Research and Development Act of 2013, and update every 3 years thereafter, a 5-year strategic plan to guide the activities described under subsection (a)(1).

"(2) CONTENTS.—The strategic plan shall specify near-term and long-term objectives for the Program, the anticipated time frame for achieving the near-term objectives, the metrics to be used for

assessing progress toward the objectives, and how the Program will—

"(A) foster the transfer of research and development results into new technologies and applications for the benefit of society, including through cooperation and collaborations with networking and information technology research, development, and technology transition initiatives supported by the States;

"(B) encourage and support mechanisms for interdisciplinary research and development in networking and information technology, including through collaborations across agencies, across Program Component Areas, with industry, with Federal laboratories (as defined in section 4 of the Stevenson-Wydler Technology Innovation Act of 1980 (15 U.S.C. 3703)), and with international organizations;

"(C) address long-term challenges of national importance for which solutions require large-scale, long-term, interdisciplinary research and development;

"(D) place emphasis on innovative and high-risk projects having the potential for sub-

stantial societal returns on the research investment;

"(E) strengthen all levels of networking and information technology education and training programs to ensure an adequate, well-trained workforce; and

"(F) attract more women and underrepresented minorities to pursue postsecondary degrees in networking and information technology.

"(3) NATIONAL RESEARCH INFRASTRUCTURE.—The strategic plan developed in accordance with paragraph (1) shall be accompanied by milestones and roadmaps for establishing and maintaining the national research infrastructure required to support the Program, including the roadmap required by subsection (a)(2)(E).

"(4) RECOMMENDATIONS.—The entities involved in developing the strategic plan under paragraph (1) shall take into consideration the recommendations—

"(A) of the advisory committee established under subsection (b); and

"(B) of the stakeholders whose input was solicited by the National Coordination Office, as required under section 102(b)(3).

"(5) REPORT TO CONGRESS.—The Director of the National Coordination Office shall transmit the strategic plan required under paragraph (1) to the advisory committee, the Committee on Commerce, Science, and Transportation of the Senate, and the Committee on Science, Space, and Technology of the House of Representatives.".

(c) ADDITIONAL RESPONSIBILITIES OF DIRECTOR.—Section 101(a)(2) of such Act (15 U.S.C. 5511(a)(2)) is amended—

(1) in subparagraph (A) by inserting "education," before "and other activities";

(2) by redesignating subparagraphs (E) and (F) as subparagraphs (F) and (G), respectively; and

(3) by inserting after subparagraph (D) the following new subparagraph:

"(E) encourage and monitor the efforts of the agencies participating in the Program to allocate the level of resources and management attention necessary to ensure that the strategic plan under subsection (e) is developed and executed effectively and that the objectives of the Program are met;".

(d) ADVISORY COMMITTEE.—Section 101(b)(1) of such Act (15 U.S.C. 5511(b)(1)) is amended—

(1) after the first sentence, by inserting the following: "The co-chairs of the advisory committee shall meet the qualifications of committee membership and may be members of the President's Council of Advisors on Science and Technology."; and

(2) in subparagraph (D), by striking "high-performance" and inserting "high-end".

(e) REPORT.—Section 101(a)(3) of such Act (15 U.S.C. 5511(a)(3)) is amended—

(1) in subparagraph (B)—

(A) by redesignating clauses (vii) through (xi) as clauses (viii) through (xii), respectively; and

(B) by inserting after clause (vi) the following:

"(vii) the Department of Homeland Security;";

(2) in subparagraph (C)—

(A) by striking "is submitted," and inserting "is submitted, the levels for the previous fiscal year,"; and

(B) by striking "each Program Component Area;" and inserting "each Program Compo-

nent Area and research area supported in accordance with section 104;";

(3) in subparagraph (D)—

(A) by striking "each Program Component Area," and inserting "each Program Component Area and research area supported in accordance with section 104,";

(B) by striking "is submitted," and inserting "is submitted, the levels for the previous fiscal year,"; and

(C) by striking "and" after the semicolon;

(4) by redesignating subparagraph (E) as subparagraph (G); and

(5) by inserting after subparagraph (D) the following new subparagraphs:

"(E) include a description of how the objectives for each Program Component Area, and the objectives for activities that involve multiple Program Component Areas, relate to the objectives of the Program identified in the strategic plan required under subsection (e);

"(F) include—

"(i) a description of the funding required by the National Coordination Office to perform

the functions specified under section 102(b) for the next fiscal year by category of activity;

"(ii) a description of the funding required by such Office to perform the functions specified under section 102(b) for the current fiscal year by category of activity; and

"(iii) the amount of funding provided for such Office for the current fiscal year by each agency participating in the Program; and".

(f) DEFINITION.—Section 4 of such Act (15 U.S.C. 5503) is amended—

(1) by redesignating paragraphs (1) through (7) as paragraphs (2) through (8), respectively;

(2) by inserting before paragraph (2), as so redesignated, the following new paragraph:

"(1) 'cyber-physical systems' means physical or engineered systems whose networking and information technology functions and physical elements are deeply integrated and are actively connected to the physical world through sensors, actuators, or other means to perform monitoring and control functions;

(3) in paragraph (3), as so redesignated, by striking "high-performance computing" and inserting "networking and information technology";

(4) in paragraph (4), as so redesignated—

(A) by striking "high-performance computing" and inserting "networking and information technology"; and

(B) by striking "supercomputer" and inserting "high-end computing";

(5) in paragraph (6), as so redesignated, by striking "network referred to as" and all that follows through the semicolon and inserting "network, including advanced computer networks of Federal agencies and departments;"; and

(6) in paragraph (7), as so redesignated, by striking "National High-Performance Computing Program" and inserting "networking and information technology research and development program".

SEC. 503. LARGE-SCALE RESEARCH IN AREAS OF NATIONAL IMPORTANCE.

Title I of such Act (15 U.S.C. 5511) is amended by adding at the end the following new section:

"SEC. 104. LARGE-SCALE RESEARCH IN AREAS OF NATIONAL IMPORTANCE.

"(a) IN GENERAL.—The Program shall encourage agencies identified in section 101(a)(3)(B) to support large-scale, long-term, interdisciplinary research and development activities in networking and information tech-

nology directed toward application areas that have the potential for significant contributions to national economic competitiveness and for other significant societal benefits. Such activities, ranging from basic research to the demonstration of technical solutions, shall be designed to advance the development of research discoveries. The advisory committee established under section 101(b) shall make recommendations to the Program for candidate research and development areas for support under this section.

"(b) CHARACTERISTICS.–

"(1) IN GENERAL.—Research and development activities under this section shall—

"(A) include projects selected on the basis of applications for support through a competitive, merit-based process;

"(B) involve collaborations among researchers in institutions of higher education and industry, and may involve nonprofit research institutions and Federal laboratories, as appropriate;

"(C) when possible, leverage Federal investments through collaboration with related State initiatives; and

"(D) include a plan for fostering the transfer of research discoveries and the results of technology demonstration activities, including from institutions of higher education and Federal laboratories, to industry for commercial development.

"(2) COST-SHARING.—In selecting applications for support, the agencies shall give special consideration to projects that include cost sharing from non-Federal sources.

"(3) AGENCY COLLABORATION.—If 2 or more agencies identified in section 101(a)(3)(B), or other appropriate agencies, are working on large-scale research and development activities in the same area of national importance, then such agencies shall strive to collaborate through joint solicitation and selection of applications for support and subsequent funding of projects.

"(4) INTERDISCIPLINARY RESEARCH CENTERS.—Research and development activities under this section may be supported through interdisciplinary research centers that are organized to investigate basic research questions and carry out technology demonstration activities in areas described in subsection (a). Research may be carried out through

existing interdisciplinary centers, including those authorized under section 7024(b)(2) of the America COMPETES Act (Public Law 110–69; 42 U.S.C. 1862o–10) ''

SEC. 504. CYBER-PHYSICAL SYSTEMS.

(a) ADDITIONAL PROGRAM CHARACTERISTICS.—Section 101(a)(1) of such Act (15 U.S.C. 5511(a)(1)) is amended—

(1) in subparagraph (H), by striking ''and'' after the semicolon;

(2) in subparagraph (I)—

(A) by striking ''improving the security'' and inserting ''improving the security, reliability, and resilience''; and

(B) by striking the period at the end and inserting a semicolon; and

(3) by adding at the end the following new subparagraphs:

''(J) provide for increased understanding of the scientific principles of cyber-physical systems and improve the methods available for the design, development, and operation of cyber-physical systems that are characterized by high reliability, safety, and security; and

"(K) provide for research and development on human-computer interactions, visualization, and big data.".

(b) WORKSHOP.—Title I of such Act (15 U.S.C. 5511) is amended further by adding after section 104, as added by section 503 of this Act, the following new section:

"SEC. 105. UNIVERSITY/INDUSTRY WORKSHOP.

"(a) ESTABLISHMENT.—Not later than 1 year after the date of enactment of the Advancing America's Networking and Information Technology Research and Development Act of 2013, the Director of the National Coordination Office shall convene a workshop, with participants from institutions of higher education, Federal laboratories, and industry, to explore mechanisms for carrying out collaborative research and development activities for cyber-physical systems, including the related technologies required to enable these systems, and to develop grand challenges in cyber-physical systems research and development.

"(b) FUNCTIONS.—The workshop participants shall—

"(1) develop options for models for research and development partnerships among institutions of higher education, Federal laboratories, and industry,

including mechanisms for the support of research and development carried out under these partnerships;

"(2) develop options for grand challenges in cyber-physical systems research and development that would be addressed through such partnerships;

"(3) propose guidelines for assigning intellectual property rights and for the transfer of research results to the private sector; and

"(4) make recommendations for how Federal agencies participating in the Program can help support research and development partnerships in cyber-physical systems, including through existing or new grant programs.

"(c) PARTICIPANTS.—The Director of the National Coordination Office shall ensure that participants in the workshop are individuals with knowledge and expertise in cyber-physical systems and that participants represent a broad mix of relevant stakeholders, including academic and industry researchers, cyber-physical systems and technologies manufacturers, cyber-physical systems and technologies users, and, as appropriate, Federal Government regulators.

"(d) REPORT.—Not later than 18 months after the date of enactment of the Advancing America's Networking

and Information Technology Research and Development Act of 2013, the Director of the National Coordination Office shall transmit 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 describing the findings and recommendations resulting from the workshop required under this section.".

SEC. 505. CLOUD COMPUTING SERVICES FOR RESEARCH.

Title I of such Act (15 U.S.C. 5511) is amended further by adding after section 105, as added by section 504(b) of this Act, the following new section:

"SEC. 106. CLOUD COMPUTING SERVICES FOR RESEARCH.

"(a) INTERAGENCY WORKING GROUP.—Not later than 180 days after the date of enactment of the Advancing America's Networking and Information Technology Research and Development Act of 2013, the Director of the National Coordination Office, working through the National Science and Technology Council, shall convene an interagency working group to examine—

"(1) the research and development needed—

"(A) to enhance the effectiveness and efficiency of cloud computing environments;

"(B) to increase the trustworthiness of cloud applications and infrastructure; and

"(C) to enhance the foundations of cloud architectures, programming models, and interoperability; and

"(2) how Federal science agencies can facilitate the use of cloud computing for federally funded science and engineering research, including—

"(A) making recommendations on changes in funding mechanisms, budget models, and policies needed to remove barriers to the adoption of cloud computing services for research and for data preservation and sharing; and

"(B) providing guidance to organizations and researchers on opportunities and guidelines for using cloud computing services for federally supported research and related activities.

"(b) CONSULTATION.—In carrying out the tasks in paragraphs (1) and (2) of subsection (a), the working group shall consult with academia, industry, Federal laboratories, and other relevant organizations and institutions, as appropriate.

"(c) REPORT.—Not later than 1 year after the date of enactment of the Advancing America's Networking and Information Technology Research and Development Act of 2013, the Director of the National Coordination Office 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 report describing the findings and any recommendations of the working group.

"(d) TERMINATION.—The interagency working group shall terminate upon transmittal of the report required under subsection (c).".

SEC. 506. NATIONAL COORDINATION OFFICE.

Section 102 of such Act (15 U.S.C. 5512) is amended to read as follows:

"SEC. 102. NATIONAL COORDINATION OFFICE.

"(a) OFFICE.—The Director shall continue a National Coordination Office with a Director and full-time staff.

"(b) FUNCTIONS.—The National Coordination Office shall—

"(1) provide technical and administrative support to—

"(A) the agencies participating in planning and implementing the Program, including such support as needed in the development of the strategic plan under section 101(e); and

"(B) the advisory committee established under section 101(b);

"(2) serve as the primary point of contact on Federal networking and information technology activities for government organizations, academia, industry, professional societies, State computing and networking technology programs, interested citizen groups, and others to exchange technical and programmatic information;

"(3) solicit input and recommendations from a wide range of stakeholders during the development of each strategic plan required under section 101(e) through the convening of at least 1 workshop with invitees from academia, industry, Federal laboratories, and other relevant organizations and institutions;

"(4) conduct public outreach, including the dissemination of findings and recommendations of the advisory committee, as appropriate; and

"(5) 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.

"(c) SOURCE OF FUNDING.—

"(1) IN GENERAL.—The operation of the National Coordination Office shall be supported by

funds from each agency participating in the Program.

"(2) SPECIFICATIONS.—The portion of the total budget of such Office that is provided by each agency for each fiscal year shall be in the same proportion as each such agency's share of the total budget for the Program for the previous fiscal year, as specified in the report required under section 101(a)(3).".

SEC. 507. IMPROVING NETWORKING AND INFORMATION TECHNOLOGY EDUCATION.

Section 201(a) of such Act (15 U.S.C. 5521(a)) is amended—

(1) by redesignating paragraphs (2) through (4) as paragraphs (3) through (5), respectively; and

(2) by inserting after paragraph (1) the following new paragraph:

"(2) the National Science Foundation shall use its existing programs, in collaboration with other agencies, as appropriate, to improve the teaching and learning of networking and information technology at all levels of education and to increase participation in networking and information technology fields, including by women and underrepresented minorities;".

SEC. 508. CONFORMING AND TECHNICAL AMENDMENTS.

(a) SECTION 3.—Section 3 of such Act (15 U.S.C. 5502) is amended—

(1) in the matter preceding paragraph (1), by striking "high-performance computing" and inserting "networking and information technology";

(2) in paragraph (1)—

(A) in the matter preceding subparagraph (A), by striking "high-performance computing" and inserting "networking and information technology";

(B) in subparagraphs (A), (F), and (G), by striking "high-performance computing" each place it appears and inserting "networking and information technology"; and

(C) in subparagraph (H), by striking "high-performance" and inserting "high-end"; and

(3) in paragraph (2)—

(A) by striking "high-performance computing and" and inserting "networking and information technology and"; and

(B) by striking "high-performance computing network" and inserting "networking and information technology".

(b) TITLE I.—The heading of title I of such Act (15 U.S.C. 5511) is amended by striking "**HIGH-PERFORMANCE COMPUTING**" and inserting "**NETWORKING AND INFORMATION TECHNOLOGY**".

(c) SECTION 101.—Section 101 of such Act (15 U.S.C. 5511) is amended—

(1) in the section heading, by striking "**HIGH-PERFORMANCE COMPUTING**" and inserting "**NETWORKING AND INFORMATION TECHNOLOGY RESEARCH AND DEVELOPMENT**";

(2) in subsection (a)—

(A) in the subsection heading, by striking "NATIONAL HIGH-PERFORMANCE COMPUTING" and inserting "NETWORKING AND INFORMATION TECHNOLOGY RESEARCH AND DEVELOPMENT";

(B) in paragraph (1) of such subsection—

(i) in the matter preceding subparagraph (A), by striking "National High-Performance Computing Program" and inserting "networking and information technology research and development program";

(ii) in subparagraph (A), by striking "high-performance computing, including networking" and inserting "networking and information technology";

(iii) in subparagraphs (B) and (G), by striking "high-performance" each place it appears and inserting "high-end"; and

(iv) in subparagraph (C), by striking "high-performance computing and networking" and inserting "high-end computing, distributed, and networking"; and

(C) in paragraph (2) of such subsection—

(i) in subparagraphs (A) and (C)—

(I) by striking "high-performance computing" each place it appears and inserting "networking and information technology"; and

(II) by striking "development, networking," each place it appears and inserting "development,"; and

(ii) in subparagraphs (F) and (G), as redesignated by section 2(c)(1) of this Act, by striking "high-performance" each place it appears and inserting "high-end";

(3) in subsection (b)—

(A) in paragraph (1), in the matter preceding subparagraph (A), by striking "high-performance computing" both places it appears and inserting "networking and information technology"; and

(B) in paragraph (2), in the second sentence, by striking "2" and inserting "3"; and

(4) in subsection (c)(1)(A), by striking "high-performance computing" and inserting "networking and information technology".

(d) SECTION 201.—Section 201(a)(1) of such Act (15 U.S.C. 5521(a)(1)) is amended by striking "high-performance computing" and all that follows through "networking;" and inserting "networking and information research and development;".

(e) SECTION 202.—Section 202(a) of such Act (15 U.S.C. 5522(a)) is amended by striking "high-performance computing" and inserting "networking and information technology".

(f) SECTION 203.—Section 203(a) of such Act (15 U.S.C. 5523(a)(1)) is amended—

(1) in paragraph (1), by striking "high-performance computing and networking" and inserting "networking and information technology"; and

(2) in paragraph (2)(A), by striking "high-performance" and inserting "high-end".

(g) SECTION 204.—Section 204 of such Act (15 U.S.C. 5524) is amended—

(1) in subsection (a)(1)—

(A) in subparagraph (A), by striking "high-performance computing systems and networks" and inserting "networking and information technology systems and capabilities";

(B) in subparagraph (B), by striking "interoperability of high-performance computing systems in networks and for common user interfaces to systems" and inserting "interoperability and usability of networking and information technology systems"; and

(C) in subparagraph (C), by striking "high-performance computing" and inserting "networking and information technology"; and

(2) in subsection (b)—

(A) in the heading, by striking "HIGH-PERFORMANCE COMPUTING AND NETWORK" and inserting "NETWORKING AND INFORMATION TECHNOLOGY"; and

(B) by striking "sensitive".

(h) SECTION 205.—Section 205(a) of such Act (15 U.S.C. 5525(a)) is amended by striking "computational" and inserting "networking and information technology".

(i) SECTION 206.—Section 206(a) of such Act (15 U.S.C. 5526(a)) is amended by striking "computational research" and inserting "networking and information technology research".

(j) SECTION 207.—Section 207(b) of such Act (15 U.S.C. 5527(b)) is amended by striking "high-performance computing" and inserting "networking and information technology".

(k) SECTION 208.—Section 208 of such Act (15 U.S.C. 5528) is amended—

(1) in the section heading, by striking "**HIGH-PERFORMANCE COMPUTING**" and inserting "**NETWORKING AND INFORMATION TECHNOLOGY**"; and

(2) in subsection (a)—

(A) in paragraph (1), by striking "High-performance computing and associated" and inserting "Networking and information";

(B) in paragraph (2), by striking "high-performance computing" and inserting "networking and information technologies";

(C) in paragraph (3), by striking "high-performance" and inserting "high-end";

(D) in paragraph (4), by striking "high-performance computers and associated" and inserting "networking and information"; and

(E) in paragraph (5), by striking "high-performance computing and associated" and inserting "networking and information".